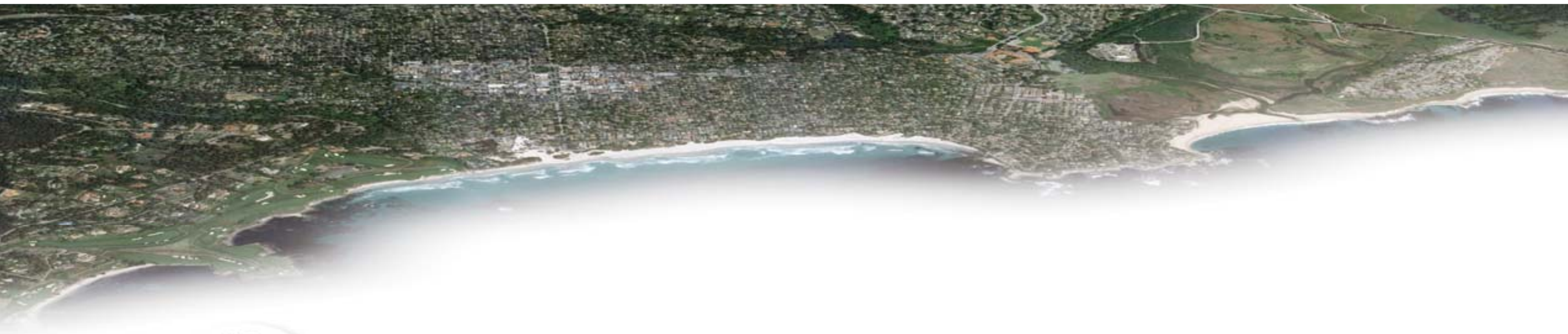

# Carmel Area Wastewater District Wastewater Treatment
# Capital Improvement Program 15-year Master Plan

**Kennedy/Jenks Consultants**

**April 2013**
**K/J #1268007**

**Kennedy/Jenks Consultants**

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# Capital Improvement Program 15-year Master Plan

April 2013


Prepared for

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K/J Project No. 1268007*01

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## List of Technical Memoranda

The following Technical Memoranda were produced in support of the 15-Year CIP Master Plan. Each Technical Memorandum is included in the following sections of this report.

**Pre-Design Technical Memoranda**



**Asset Management Technical Memoranda**

# Carmel Area Wastewater District Wastewater Treatment
# Capital Improvement Program 15-year Master Plan

Kennedy/Jenks Consultants

# Section 1: Executive Overview

## 1.1 Introduction

In March 2012, the Carmel Area Wastewater District (CAWD) retained Kennedy/Jenks Consultants, (Kennedy/Jenks) to perform a condition survey of the assets at the wastewater treatment plant (WWTP), and to develop an asset database to document and analyze the asset condition data. The results of the survey were described in a Technical Memorandum (TM) dated April 11, 2012. It was apparent from the survey results that the rate of renewal of the aging assets had not kept up pace with the rate of deterioration, resulting in the noticeable physical condition deficiencies of assets currently at the WWTP. When investment in asset renewal lags behind the rate of consumption of the assets, this is referred to as "mining of assets". The net result is that many of the treatment plant assets are in need of significant repairs to preserve the ability of these assets to reliably meet their service levels. Based on these findings CAWD has initiated an asset management program to improve the management of the WWTP assets. In April 2012, CAWD authorized Kennedy/Jenks to expand the asset data for the WWTP and develop a 15-year capital improvement program (CIP) plan based on the asset management data developed.

The 15-year CIP plan that is presented herein is based on asset data developed over the past year and on detailed pre-design work for several major process areas. Kennedy/Jenks conducted onsite training sessions and collaborative work sessions with CAWD staff to refine the projects in the CIP. The District's goal in implementing the CIP is to efficiently utilize capital to upgrade its assets and reduce risk. The data used to develop this report provides a foundation for CAWD to continue to apply asset management and develop asset management best practices within the organization.

## 1.2 Scope

The scope of this 15-year Capital Improvement Program Plan for the Carmel Area Wastewater District (CAWD) includes evaluation of assets which are part of the following areas of the Secondary Treatment Plant:

- Primary treatment
- Secondary treatment
- Solids treatment/disposal
- Liquid disinfection/disposal
- Site utilities/yard piping
- Operations building and other miscellaneous buildings

Specific areas which are not evaluated as part of this planning document include: tertiary treatment, lab facilities, supervisory control and data acquisition, and civil site work such as site paving/grading and landscaping. Furthermore, the CAWD collection system, and administration building were not included in this planning effort. Capital improvements and maintenance of these assets will be needed over the next 15 years, and these expenditures would be in addition to the budgets described in this report.

## 1.3 Methodology

This CIP plan was developed using an asset management approach centered on key data for the assets including: condition, replacement cost, consequences of failure, and the current relative risk of failure associated with each asset. The functional requirements for the assets (level of service) were reviewed to determine if assets were performing adequately to meet regulatory requirements, and customer and staff expectations. Furthermore, financially inefficient assets were identified where investment in replacing the asset would result in a financial payback over the life cycle of the asset. Financial payback on initial investment typically occurs when a more efficient asset or set of assets reduces operating costs such that the operational savings over the life cycle pay for the initial investment and provide additional savings beyond the initial investment.

The data developed for each asset was analyzed to provide an objective diagnosis of the relative risk of failure of each asset. Subsequently, the relative risk associated with each asset was used to prioritize the recommended capital improvement projects to reduce CAWD's business risk. Risk management strategies include not only capital improvement projects, but also include regular maintenance activities and maintenance-repair activities. Many assets were not included for rehabilitation or replacement as part of capital improvement projects but were instead assigned with one of several maintenance risk management strategies which would fall under a "maintenance and repairs" budget. Therefore, the capital improvement project plan budget was developed with a corresponding maintenance and repairs budget as these two program budgets are inextricably linked.

The distinction between a "capital improvement project" and a "maintenance and repair activity" is a function of how projects are defined and executed. For this CIP plan, "capital improvement projects" are defined as major non-routine projects that involve improvements to numerous related assets that are combined into a single project to reduce risk and improve operational efficiency. "Maintenance and repair activities" are defined as planned and unplanned activities that generally focus on a single asset (or a small set of assets) at any given time to either maintain the asset or address minor failures. Maintenance and repair activities are relatively small in scale when compared to capital improvement projects and therefore this report includes annual budget estimates for ongoing maintenance and repair in-lieu of defining individual maintenance and repair projects.

### 1.3.1 Asset Database

An asset database for the WWTP was developed with data for over 600 identified assets in the Secondary Treatment Plant. Each asset was classified by process area (i.e. Primary Clarifiers, Aeration Basis, Digesters, etc.) and asset class (i.e. structure, electrical, process equipment, pipe, etc.).

The Asset Database contained the data for each asset as shown in Table 1.

Table 1: Data Compiled in Asset Database

| | |
|---|---|
| Process Area | Estimated Residual Life |
| Asset Class | Estimated Replacement Cost (Installation and Materials) |
| Asset Description | Probability of Failure (PoF) |
| Year Built | Consequence of Failure (CoF) |
| Condition Rating | Relative Risk Category (High, Medium, Low) |
| Average Useful Life | Risk Management Strategy |

Data was developed via field investigations, review of WWTP design and as-built drawings, discussions with CAWD staff, and Kennedy/Jenks' wastewater treatment engineering industry knowledge. CAWD staff is planning to continue to update and use the asset database to improve data quality, and to evaluate budgets, asset risks, and other data as conditions at the plant change over time. Continued data management is essential to keep the database up-to-date so that CAWD has the most accurate asset information to use in making future asset management decisions.

## 1.4 Technical Memoranda

Kennedy/Jenks completed asset management and predesign evaluations to support the development of this CIP and these evaluations are summarized in Technical Memoranda (TM) included in Section 5 of this report. In the Asset Management Technical Memoranda the asset management approaches used to analyze and review assets are described. In the Pre-Design Technical Memoranda alternatives and pre-design level cost estimates are evaluated for several high value projects which were identified for major capital improvements.

Asset management evaluations included:

- *TM-1 Preliminary Capital Projections – "Replace Assets at the End of Estimated Residual Life"*
- *TM-6 Levels of Service – Wastewater Treatment Plant*
- *TM-7 Assessment of WWTP Asset Failure Modes Other than Physical Mortality*
- *TM-8 WWTP Assets Business Risk Evaluations*
- *TM-9 WWTP Asset Risk Management Strategies*

Pre-design evaluations included:

- *TM-2 Evaluation of Alternatives for Disinfection System*
- *TM-3 Evaluation of Alternatives for WWTP Effluent Pump Station Reliability Improvements*
- *TM-4 Digestion System Improvements Pre-Design*
- *TM-5 Standby Dewatering Evaluation of Alternatives*

## 1.5 Budget Overview

### 1.5.1 CIP and Maintenance Budget

The budget projections for the 15-year CIP plan and associated ongoing 15-year maintenance and repairs are summarized in Table 2 and 3 below and are described in more detail in Sections 2 and 3 of this report. The average annual CIP budget projected for the Secondary Treatment Plant over 15 years is estimated to be in the range of $2,000,000 per year. The average annual maintenance and repairs budget projected for the Secondary Treatment Plant over 15 years is estimated to be in the range of $650,000 per year.

The budgetary estimates in Tables 2 and 3 include: asset materials and installation costs, construction markups, contingency, and engineering costs. The construction markup used was 30% added to the materials and installation cost to account for taxes, contractor bonds, mobilization, overhead, and profit. An additional 25% contingency was added in addition to the construction markups to account for unforeseen conditions and construction conflicts associated with construction within an already developed area. A 20% engineering markup was then added to account for costs associated with engineering pre-design, design, construction permitting, construction support engineering, and construction management.

Table 2: 15-year Estimated Secondary Treatment Plant CIP Budget Projection

| | -15% Estimate[(a)] | Estimated | +25% Estimate[(a)] |
|---|---|---|---|
| 15-Year CIP Budget[(b)] | $26,000,000 | $29,800,000 | $38,000,000 |

**Notes:**

(a) -15% to +25% estimate range is based on Association for Advancement of Cost Engineering (AACE) recommended practice.
(b) Includes Materials and Installation, Construction Markups, Contingency, and Engineering costs.

Table 3: 15-year Estimated Secondary Treatment Plant Maintenance Budget Projection

| | -15% Estimate[(a)] | Estimated | +25% Estimate[(a)] |
|---|---|---|---|
| 15-Year Maintenance and Repairs Budget[(b)] | $8,400,000 | $9,800,000 | $12,300,000 |

**Notes:**

(a) -15% to +25% estimate range is based on AACE recommended practice.
(b) Includes Materials and Installation, Construction Markups, Contingency, and Engineering costs.

### 1.5.2 Total Replacement Cost vs. CIP/Maintenance Budget

On a percentage basis, the 15-year average annual investment in capital improvement projects contained in this 15-year CIP plan is estimated to range between 2% and 4% annually of the total estimated replacement cost of the Secondary Treatment Plant. The corresponding maintenance budget contained in this 15-year CIP plan is estimated to equate to between 0.60% to 1.4% of the total estimated replacement cost of the Secondary Treatment Plant. These percentages are reasonable renewal and maintenance budgets. An annual renewal budget of 3% assumes that the assets are renewed at a rate of once every 33 years; 4% assumes a renewal rate of once every 25 years. The average of all assets average useful life listed in the asset database is about 38 years. Given that asset renewal was minimized over the past decade it is reasonable that the current asset renewal rate would be accelerated compared to the overall average useful life of the assets.

# Carmel Area Wastewater District Wastewater Treatment

# Capital Improvement Program 15-year Master Plan

CIP and Maintenance Budget Projections

Kennedy/Jenks Consultants

# Section 2: CIP and Maintenance Budget Projections

## 2.1 Introduction

This section provides a synopsis of the budget projections produced from the data in the Asset Database. The data in the Asset Database is dynamically linked to the budget projection calculations and therefore budgets can be automatically updated by changing the estimated materials and installation cost for individual assets or by changing the risk management strategy selection for individual assets. The following explains how the risk management strategies were used to develop the budget projections.

## 2.2 Risk Management

### 2.2.1 Risk Management Strategies

The District's business risk associated with asset failures can be managed by three main strategies: Capital Improvement Strategies, Maintenance Strategies, and Non-Asset Strategies (see Table 4). The appropriate risk management strategy to use for any given asset is dependent on the risk profile of the asset. A specific risk management strategy was selected for each asset in the asset registry based on the risk profile of each asset. As a result, each asset was categorized into either a capital improvement budget or a maintenance and repairs budget depending on the risk profile of the particular asset. By separating assets into a capital improvement budget or a maintenance budget, the budget estimates directly reflect the current risk profile of the assets. The approach to applying risk management strategies to assets based on risk is described in more detail later in this section and in TM-9 *Asset Risk Management Strategies*. TM-9 contains definitions of each of the risk management strategies shown in Table 4.

Table 4: Asset Risk Management Strategies

<table>
<tr><th>Capital Improvements Strategies</th><th>Maintenance Strategies</th><th>Non Asset Strategies</th></tr>
<tr><td>Plan Rehabilitation/ Replacement (Improve Condition)</td><td>Predictive Maintenance (Failure Prediction) and Preventative Maintenance (Maintain Condition)</td><td>Take Asset Out of Service</td></tr>
<tr><td>Moderate Repair (Improve Condition)</td><td>Preventative Maintenance (Maintain Condition)</td><td rowspan="2">Strategic Changes to Capacity Requirements or Level of Service (LOS)</td></tr>
<tr><td>Add Backup/Redundancy (Improve Reliability)</td><td>Corrective Maintenance (Fix it When it Breaks)</td></tr>
</table>

### 2.2.2 Reducing Risk of High Risk Assets through Capital Improvements

Business risk evaluations were conducted for each asset in the asset registry, and this work is summarized in *TM-8 WWTP Assets Business Risk Evaluations*. Assets were rated for probability of failure (PoF) and Consequence of Failure (CoF) and graphed on a Risk Graph similar to the graph shown in Figure 1. From their position on the Risk Graph assets were identified as either high risk, medium risk, or low risk. High risk assets were those which had a high PoF and high CoF. Capital improvement strategies were selected for the District's high risk assets because these strategies would best address the District's risk. In rare cases, maintenance strategies were deemed adequate to manage the risk of high risk assets. Non-asset risk management strategies were not identified as viable alternatives for the vast majority of assets and therefore capital improvement strategies and maintenance strategies were selected for the vast majority of assets.

In Figure 1, it is illustrated how capital improvement risk management strategies reduce the risk of an asset failure. For example, by improving the condition of an asset through renewal projects, the probability of failure can be reduced such that the asset's risk becomes a medium or low relative risk. Furthermore, by adding backup equipment the consequence of failure of a particular asset can be reduced, because if it fails there is a readily available backup to maintain service during failure of the primary asset. Through utilization of these risk reduction strategies capital improvement projects were selected to decrease the risk of asset failures.

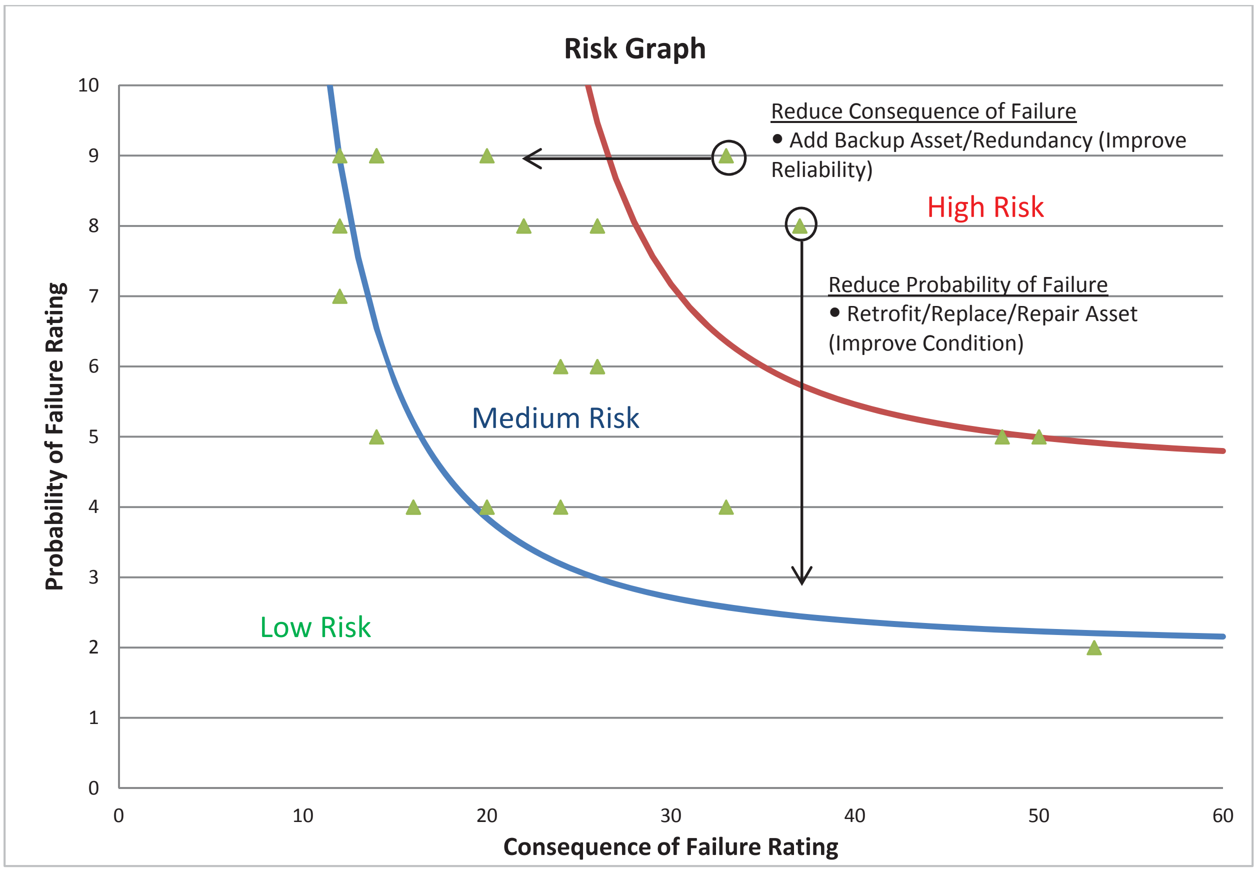



Figure 1: Reducing Risk Of High Risk Assets through Capital Improvements

The opinions of probable cost of capital improvements were calculated based on each individual asset's estimated material cost and installation cost. Construction markups, contingency, and engineering costs were added to the estimated material cost and installation cost to establish an estimated CIP budget for each asset selected for capital improvements. Table 5 contains information on how estimated costs were determined with markups for each of the capital improvement risk management strategies.

Table 5: Capital Improvement Budget Calculations

| Capital Improvement Strategy | Percent of Asset Materials and Installation | Construction Contractor Markups | Contingency | Engineering |
|---|---|---|---|---|
| Plan Rehabilitation/ Replacement (Improve Condition) | 100% | 30% | 25% | 20% |
| Moderate Repair (Improve Condition) | 50% | 30% | 25% | 20% |
| Add Backup/Redundancy (Improve Reliability) | 100% | 30% | 25% | 20% |

As part of the CIP budgeting process pre-design evaluations were conducted for the Disinfection System (TM-2), Effluent Pump Station (TM-3), Digestion System (TM-4), and for the Standby Dewatering Equipment (TM-5). For these assets, the costs from the pre-design evaluations were incorporated into the budget projections. Furthermore, some of the identified projects included construction of additional major assets not currently in service and so the cost of these additional assets were estimated and added into the CIP budget calculations without a detailed pre-design evaluation. Section 3 of this report and the Project Descriptions section of this report contain descriptions of the components of each CIP project and the scope of each capital improvement project.

### 2.2.3 Risk Management through Maintenance and Repairs

Maintenance risk management strategies were for the most part selected for assets in the medium risk and low risk categories. By identifying individual assets under the various maintenance risk management strategies, it was possible to estimate annual maintenance budgets as a percentage of the replacement cost of these assets. For budgeting purposes, the maintenance and repair budget for each asset with a maintenance risk management strategy was estimated to be a percentage annually of the materials and installation cost of the asset plus contingency and variable engineering fees. Table 6 contains information on how estimated costs were determined and markups applied to the budget calculations for each of the maintenance management strategies.

Table 6: Maintenance and Repairs Budget Calculations

| Maintenance Strategy | Annual Percentage of Materials and Installation | Contingency | Engineering |
|---|---|---|---|
| Predictive Maintenance (Failure Prediction) | 1.5% | 30% | 20% |
| Preventative Maintenance (Maintain Condition) | 2% | 30% | 5% |
| Corrective Maintenance (Fix it When it Breaks) | 2% | 30% | 5% |

## 2.3 Budget Planning by Process Area

Table 7 contains the budgets for the capital improvement and maintenance risk management strategies. Budgets are divided up into 15-year CIP Budgets, 15-year Preventative/Corrective Maintenance Budgets, and 15-year Predictive Maintenance Budgets. Preventative/corrective maintenance would correspond with the "Maintenance and Repairs" line item currently used by CAWD in budget plans. Predictive maintenance could also be included in the "maintenance and Repairs" line item or could be a new line item in CAWD's current yearly budgeting plan reports. The budgets are listed for each process area and compared to the area assets total replacement cost to illustrate the percent investment. Table 8 contains roll-up values for the overall 15-year Secondary Treatment Plant CIP and maintenance budget projections with range of accuracy estimates.

Included in the CIP budget are "Other Projects" such as a project for demolition of major assets after they are replaced, various individual studies, as well as an allowance for projects to be determined (TBD). Each project is described in more detail in Section 3.

Table 7: 15-Year CIP and Maintenance Risk Management Strategies Budget Projection

| Area | Area Assets Replacement Cost | Risk Management Strategies: 15-Year CIP Budget | 15-Year Predictive Maintenance Budget[a] | 15-Year Preventative/ Corrective Maintenance Budget[b] | Total 15-Year Risk Management Budget | Percent of Replacement Cost |
|---|---|---|---|---|---|---|
| **Influent** | | | | | | |
| Influent Building | $6,009,000 | $2,198,000 | $155,000 | $828,000 | $3,181,000 | 53% |
| Influent Manhole | $413,000 | $359,000 | $0 | $0 | $359,000 | 87% |
| ***Influent Totals:*** | ***$6,422,000*** | ***$2,557,000*** | ***$155,000*** | ***$828,000*** | ***$3,540,000*** | **55%** |
| **Primary Treatment** | | | | | | |
| Headworks | $2,800,000 | $675,000 | $144,000 | $410,000 | $1,229,000 | 44% |
| Primary Clarifiers | $3,183,000 | $1,437,000 | $0 | $75,000 | $1,512,000 | 48% |
| ***Primary Treatment Totals:*** | ***$5,983,000*** | ***$2,112,000*** | ***$144,000*** | ***$485,000*** | ***$2,741,000*** | **46%** |
| **Secondary Treatment** | | | | | | |
| EQ/Aeration | $11,190,000 | $408,000 | $117,000 | $2,217,000 | $2,742,000 | 25% |
| Blower Building | $3,885,000 | $695,000 | $168,000 | $513,000 | $1,376,000 | 35% |
| RAS Pump Building | $2,063,000 | $1,470,000 | $10,000 | $80,000 | $1,560,000 | 76% |
| Secondary Clarifiers | $4,671,000 | $1,949,000 | $10,000 | $234,000 | $2,193,000 | 47% |
| ***Secondary Treatment Totals:*** | ***$21,809,000*** | ***$4,522,000*** | ***$305,000*** | ***$3,044,000*** | ***$7,871,000*** | **36%** |
| **Disinfection/Disposal** | | | | | | |
| Chlorine Contact | $4,193,000 | $1,511,000 | $102,000 | $252,000 | $1,865,000 | 44% |
| Chlor/Dechlor Building | $3,687,000 | $1,359,000 | $191,000 | $482,000 | $2,032,000 | 55% |
| Effluent Bldg | $3,083,000 | $1,744,000 | $3,000 | $278,000 | $2,025,000 | 66% |
| Outfall | $2,199,000 | $0 | $266,000 | $464,000 | $730,000 | 33% |
| ***Disinfection/Disposal Totals:*** | ***$13,162,000*** | ***$4,614,000*** | ***$562,000*** | ***$1,476,000*** | ***$6,652,000*** | **51%** |
| **Solids Treatment/Disposal** | | | | | | |
| DAF Thickener | $1,086,000 | $1,000,000 | $0 | $230,000 | $1,230,000 | 113% |
| Digester Control Building | $2,836,000 | $778,000 | $29,000 | $389,000 | $1,196,000 | 42% |
| Digesters | $6,202,000 | $3,940,000 | $0 | $345,000 | $4,285,000 | 69% |
| Belt Press Building | $4,451,000 | $1,581,000 | $41,000 | $459,000 | $2,081,000 | 47% |
| FOG Facility | $376,000 | $0 | $0 | $80,000 | $80,000 | 21% |
| ***Solids Treatment/Disposal Totals:*** | ***$14,951,000*** | ***$7,299,000*** | ***$70,000*** | ***$1,503,000*** | ***$8,872,000*** | **59%** |

| Area | Area Assets Replacement Cost | Risk Management Strategies: 15-Year CIP Budget | Risk Management Strategies: 15-Year Predictive Maintenance Budget[a] | Risk Management Strategies: 15-Year Preventative/ Corrective Maintenance Budget[b] | Total 15-Year Risk Management Budget | Percent of Replacement Cost |
|---|---|---|---|---|---|---|
| ***Site Utilities/Yard Piping*** | | | | | | |
| Yard Piping | $3,856,000 | $2,041,000 | $192,000 | $376,000 | $2,609,000 | 68% |
| 3W System | $444,000 | $406,000 | $0 | $0 | $406,000 | 91% |
| 1W System | $263,000 | $263,000 | $0 | $0 | $263,000 | 100% |
| ***Site Utilities/Yard Piping Totals:*** | ***$4,563,000*** | ***$2,710,000*** | ***$192,000*** | ***$376,000*** | ***$3,278,000*** | **72%** |
| ***Miscellaneous Buildings*** | | | | | | |
| Ops Building | $3,299,000 | $2,044,000 | $0 | $245,000 | $2,289,000 | 69% |
| Miscellaneous Structures | $1,989,000 | $88,000 | $0 | $401,000 | $489,000 | 25% |
| ***Miscellaneous Buildings Totals:*** | ***$5,288,000*** | ***$2,132,000*** | ***$0*** | ***$646,000*** | ***$2,778,000*** | 53% |
| ***Other Projects*** | | | | | | |
| Demolition | | $400,000 | $0 | $0 | $400,000 | |
| To Be Determined | | $3,000,000 | $0 | $0 | $3,000,000 | |
| Studies | | $375,000 | $0 | $0 | $375,000 | |
| ***Other Projects Totals:*** | ***$0*** | ***$3,775,000*** | ***$0*** | ***$0*** | ***$3,775,000*** | |
| **Totals (Rounded Up to Nearest $100K)** | **$72,200,000** | **$29,800,000** | **$1,400,000** | **$8,400,000** | **$39,600,000** | **55%** |

**Notes:**

(a) Predictive maintenance could be tracked as a new separate line item in CAWD budget plan reports.
(b) Preventative/corrective maintenance would correspond to the “Maintenance and Repairs” line item used in current CAWD budget plan reports.

### Table 8: 15-year Estimated Secondary Treatment Plant CIP and Maintenance Projection

| | -15% Estimate[(a)] | Estimated | +25% Estimate[(a)] |
|---|---|---|---|
| 15-Year CIP Budget | $26,000,000 | $29,800,000 | $38,000,000 |
| 15-Year Maintenance and Repairs Budget | $8,400,000 | $9,800,000 | $12,300,000 |
| 15-Year Total CIP and Maintenance | **$33,700,000** | **$39,600,000** | **$49,500,000** |

**Notes:**

(a) -15% to +25% estimate range is based on AACE recommended practice.
(b) Includes Materials and Installation, Construction Markups, Contingency, and Engineering costs.

**Carmel Area Wastewater District Wastewater Treatment**

# Capital Improvement Program 15-year Master Plan

Capital Improvements Projects

Kennedy/Jenks Consultants

# Section 3: Capital Improvement Projects

## 3.1 Introduction

Capital improvement projects were developed based on the risk evaluations and risk graphs developed in *TM-8 WWTP Assets Business Risk Evaluations.* High risk assets were selected to receive capital improvements and are recorded in the asset registry. Each of the assets selected for CIP renewal were grouped into projects according to their particular process area. In this way projects are focused on the process areas and asset renewal is organized such that each process area can be renewed as a comprehensive project. This is a financially efficient approach to organizing projects so that contractor mobilization costs and contingencies are minimized by not having recurring mobilization and rework in each area. In some cases, projects in different process areas were grouped into larger multi-process projects to expedite project delivery of highest risk areas and to take advantage of economies of scale for contractor mobilization costs.

## 3.2 Major CIP projects

Projects were grouped into logical groupings to complete work more efficiently. The projects included in the CIP are summarized in Table 9.

### Table 9: Major CIP Projects

| Project | Brief Description | Pre-Design Report? (*Yes/No*) | CIP Budget[(a)(b)] |
|---|---|---|---|
| **Studies** | Studies Budgeted Include: Flooding/Storm Water Reliability Study, Septic Tank Waste Receiving Study, and Additional Asset Management Re-Evaluations | *N/A* | $375,000 |
| **Misc Yard Piping Rehabilitation** | Allowance for ongoing buried piping rehabilitation work | *No* | $1,341,000 |
| **Multi-Process Area Improvement Project #1:**<br><br>**Power/Blower/ Chlor-Dechlor/ 1 Water System** | Multiple Process Area Improvements Project:<br>• WWTP Electrical Power System - Upgrades to Main Power Feed and Standby Power Systems<br>• Blower System - Blower System Energy Efficiency and Reliability Improvements<br>• Chlor-Dechlor - New Hypochlorite and Sodium Bisulfite Storage and Feed Systems<br>• 1-Water - Rehabilitation of 1 Water System | *Yes – (Hypochlorite System Pre-Design Only)* | $5,278,000 |
| **RAS Portable Pumps and Piping** | Purchase temporary portable pumps and flexible hose for backup RAS/WAS pumping and install quick connect pipe connections for emergency installation of portable backup pump system | *No* | $250,000 |
| **Interim Digester Improvements** | Address immediate digester equipment deficiencies including the sludge heating system and sludge recirculation piping. | *Yes* | $778,000 |

| Project | Brief Description | Pre-Design Report? (*Yes/No*) | CIP Budget[(a)(b)] |
|---|---|---|---|
| **Digester Firm Capacity** | Construct a new digester to provide firm digestion capacity when one digester is out of service and to replace existing Digesters 2 and 3. Includes cleaning and rehabilitation of Digester 1 after new digester is built and in service. | *Yes* | $3,940,000 |
| **Dewatering Improvements** | Install new standby dewatering equipment to allow maintenance of sole operating dewatering press. Upgrades to dewatering building mechanical and electrical systems. | *Yes* | $1,581,000 |
| **Multi-Process Area Improvement Project #2:**<br><br>**Influent/ Effluent/ 3 Water System** | Multiple Process Area Improvements Project:<br>• Influent Building – Construction of a new influent pump screening system, rehabilitation of existing influent pumps, replacement/retrofit of existing influent manhole and main influent process piping.<br>• Effluent – Replacement of existing effluent pumps and electrical system in Effluent Building. Miscellaneous Effluent Building rehabilitation.<br>• 3 Water System - New 3 Water Hydropneumatic Tank, Strainer and Instrumentation. | *Yes – (Effluent Pump Station Only)* | $3,279,000 |
| **Multi-Process Area Improvement Project #3:**<br><br>**RAS/Aeration** | Multiple Process Area Improvements Project:<br>• RAS Pump Building – Electrical, Controls, and Mechanical Improvements<br>• EQ/Aeration Basins - Replacement of existing aeration basin valves, gates and miscellaneous piping and instrumentation. | *No* | $1,628,000 |
| **Multi-Process Area Improvement Project #4:**<br><br>**Primary and Secondary Clarifier Rehabilitation** | Multiple Process Area Improvements Project:<br>• Primary Clarifier – Rehabilitation of clarifier structures and effluent launderer, rehab/replace sludge collector mechanisms.<br>• Secondary Clarifier - Rehabilitation of clarifier structures and effluent launderer, rehab/replace sludge collector mechanisms. | *No* | $3,386,000 |
| **Storm Water Pumping Improvements** | Construct a new Storm Water Pump station to pump storm runoff to head of WWTP. | *No* | $700,000 |
| **Demolition of Abandoned Assets Project** | Demolish Digesters 2 and 3, existing chlorine gas storage/feed building, and other abandoned assets. | *No* | $400,000 |
| **Headworks Rehabilitation** | Rehabilitate miscellaneous equipment, piping and upgrade electrical assets. | *No* | $675,000 |
| **Thickener Replacement** | Replace existing dissolved air flotation thickener with a gravity belt thickener. | *No* | $1,000,000 |
| **Chlorine Contact Rehabilitation** | Rehabilitate underground Chlorine Contact structure concrete, large diameter process piping, and improve access into structure for maintenance. | *No* | $1,511,000 |

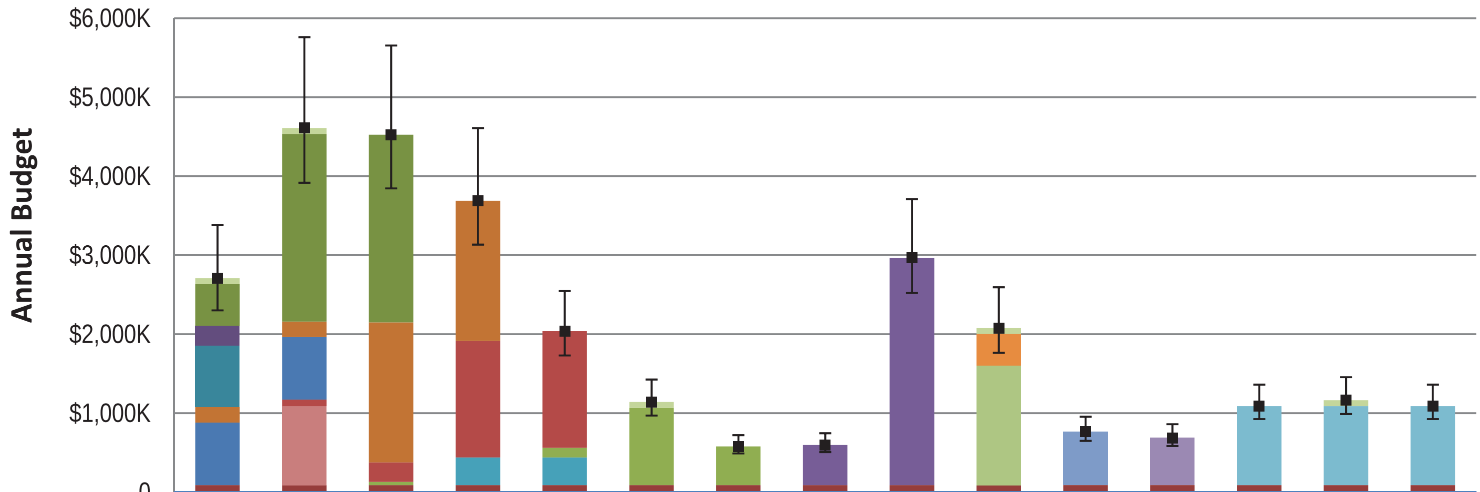
| Project | Brief Description | Pre-Design Report? (*Yes/No*) | CIP Budget[(a)(b)] |
|---|---|---|---|
| **Ops Building Improvements** | Renovate Operations Building interior including restrooms, office spaces, building mechanical and upstairs electrical room. | *No* | $599,000 |
| **TBD** | To be determined project placeholder budget | *No* | $3,000,000 |
| | **Total (Rounded Up to Nearest $100K)** | | **$29,800,000** |

**Notes:**

(a) Assumed -15% to +25% range of accuracy of budgetary estimates.
(b) Includes Materials and Installation, Construction Markups, Contingency, and Engineering costs.

## 3.3 Capital Improvements Yearly Budget Projections and Scheduling

Figure 2 contains a graphical representation of the scheduling and corresponding annual budgets for the projects in Table 9. The approach to project scheduling is to implement renewal projects for high risk assets expeditiously to reduce CAWD's business risk exposure. See *TM-8 WWTP Assets Business Risk Evaluations* for detailed graphs showing assets risk exposures by process area. The approach to expeditiously address major business risks results in a project implementation schedule with several large projects being implemented in the first five years of the fifteen year plan projection. The average annual CIP budget for the first five year period is estimated to be in the range of $3.5 million, the average annual CIP budget for the second five year period is estimated to be in the range of $1.5 million, and the average annual CIP budget for the third five year period is estimated to be in the range of $1.0 million.




| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Studies | $75K | $75K | | | | $75K | | | | $75K | | | | $75K | |
| Power/Blower/Chlor-Dechlor/1 Water | $528K | $2,375K | $2,375K | | | | | | | | | | | | |
| RAS Portable Pump and Piping | $250K | | | | | | | | | | | | | | |
| Interim Digester Improvements | $778K | | | | | | | | | | | | | | |
| Digester Firm Capacity | $197K | $197K | $1,773K | $1,773K | | | | | | | | | | | |
| Dewatering Improvements | $791K | $791K | | | | | | | | | | | | | |
| Influent/Effluent/3W | | $82K | $246K | $1,476K | $1,476K | | | | | | | | | | |
| RAS/Aeration | | | $41K | | $122K | $977K | $488K | | | | | | | | |
| Primary and Secondary Clarifier Rehab | | | | | | | | $508K | $2,878K | | | | | | |
| Storm Water Pumping | | | | $350K | $350K | | | | | | | | | | |
| Demo Abandoned Assets | | | | | | | | | | $400K | | | | | |
| Headworks Rehab | | | | | | | | | | | $675K | | | | |
| Thickener Replacement | | $1,000K | | | | | | | | | | | | | |
| Chlorine Contact Rehab | | | | | | | | | | $1,511K | | | | | |
| Ops Building Improvements | | | | | | | | | | | | $599K | | | |
| TBD | | | | | | | | | | | | | $1,000K | $1,000K | $1,000K |
| Misc Yard Piping Rehab | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K | $89K |
| Total | $2,708K | $4,609K | $4,524K | $3,688K | $2,037K | $1,141K | $578K | $597K | $2,968K | $2,075K | $764K | $688K | $1,089K | $1,164K | $1,089K |

Figure 2: 15-Year Capital Improvement Project Annual Budget Summary

# Carmel Area Wastewater District Wastewater Treatment

# Capital Improvement Program 15-year Master Plan


Kennedy/Jenks Consultants

Project Descriptions

**Carmel Area Wastewater District**
**Major Capital Project Description**

## *Yard Piping – Miscellaneous Yard Piping Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$1,341,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Predictive Maintenance of Yard Piping with a high consequence of failure (COF) |
| **Description:** | After inspections of select buried piping segments that have a high consequence of failure, it may be found that the buried pipeline should be rehabilitated. An allowance is estimated for rehabilitation of buried piping in the WWTP.<br><br>Buried piping with a high COF and selected for possible rehabilitation includes:<br>• 1 Water Distribution Piping<br>• 3 Water Distribution Piping<br>• Natural Gas Piping<br>• Fire Water Piping<br>• Influent Piping<br>• Carmel Meadows Influent Pipeline<br>• Piping Between the Headworks and Primary Clarifiers<br>• Secondary Clarifier #1 Effluent Piping<br>• Digester 1 Sludge Piping<br>• Digester 1 Gas Piping<br>• Digester Gas Piping to Flare<br>• Gas Pit<br>• Digesters Supernatant Piping |
| **Functional Level of Service:** | Piping assets should carry fluids, gas or chemicals without leaks or breaks. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The condition of buried piping is unknown however due to the prevalent corrosion that can occur in wastewater process piping it is likely that condition issues exist in some buried piping. |
| **Business Case Summary:** | The condition of most of the buried piping at the WWTP is unknown therefore inspections as part of predictive maintenance should be done. It is likely that some buried piping is in poor condition and in need of rehabilitation due to the corrosive environments both with wastewater processes and the nearby marine environment. |

**Photos: (None)**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #1
## *Operations Building – Main Power Feed and Switchgear Electrical Upgrades*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,533,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Electrical Systems Integration Study;<br>• Influent Building – Standby Power Upgrades<br>• 1 Water System Rehabilitation |
| **Description:** | Upgrade switchgear and main power feeders. Relocate updated electrical equipment to optimize space in the Operations Building and to make space in the electrical room for a future SCADA control and monitoring station. |
| **Functional Level of Service:** | The main power feed into the plant provides electricity for the WWTP operations. |
| **Current Failure Mode(s) Addressed:** | **Level of Service Failure:** Obsolete electrical equipment is increasingly difficult to maintain. Lack of integration of electrical power systems are impacting the reliability of WWTP operation.<br><br>**Physical Mortality:** The main power feed equipment is approximately 40 years old. |
| **Business Case Summary:** | The main power feed into the Operations Building was built in 1970 when the Operations Building was built. Upgrades are likely necessary due to age alone and at this time when equipment is upgraded it would be beneficial to better integrate the plant electrical to simplify the power feed and distribution in the plant to improve maintainability and reliability. |

**Photos:**

**Main Power Feed Switchgear**

**Conduits in Basement**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# <u>Multi-Process Area Improvement Project #1</u>
## *Influent Building – Standby Power Electrical Upgrades*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$1,428,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Electrical Systems Integration Study;<br>• Operations Building Main Power Feed/Switchboard Electrical Upgrades |
| **Description:** | Upgrade switchgear, electrical equipment, and controls associated with the standby engine generators located in the Influent Building Electrical Room. Upgrades will most likely require replacement of existing electrical equipment.<br><br>Upgrades to miscellaneous Influent Pump System Electrical components should be incorporated with this project as needed to take advantage of mobilization in the Influent Building Electrical Room.<br><br>The Standby Power System and miscellaneous Influent Pump electrical needs to be tested to determine the extent of reliability issues and further Pre-design work will be required to define the details of the project.<br><br>The project could be grouped with improvements to the Operations Building Main Power Feed/Switchboard Electrical Upgrades depending on the recommendations of an Electrical System Integration Study. |
| **Functional Level of Service:** | The Influent Building electrical room houses the backup engine generators for the WWTP, which provide power to all the treatment processes in the event of a power outage to continue to meet NPDES permit requirements.<br><br>The Influent Pumps transfer variable influent flow from the Influent wet well to the Headworks. |
| **Current Failure Mode(s) Addressed:** | **Level of Service Failure:** Lack of reliability of critical electrical systems including the influent pumping system and the standby power system.<br><br>**Physical Mortality:** A significant portion of the existing electrical equipment in the Influent Building Electrical Room has been in service for about 30 years, which is the average useful life for electrical equipment. |
| **Business Case Summary:** | The Standby Power System has a high consequence of failure including a complete shutdown of all systems in the event of a power outage and a failure of the standby power system. The Standby Power System is reliant heavily on electrical systems which are at the end of their useful life, and therefore to improve reliability the system needs to be tested and it is |

| | |
|---|---|
| | likely that upgrades are necessary to address aging equipment. The extent of upgrades is dependent on further testing of the switchgear, wiring, breakers and likely significant code changes since the original design 30 years ago. |

**Photos:**

| | |
|---|---|
|  |   |
| **Generator Switchgear built in 1982** | **Distribution Switchboard “ISD” (Sludge Dewatering, Lab, Influent)** |
|  | |
| **Distribution Switchboard “ISD2” (Blower Building, Main)** | |

**Carmel Area Wastewater District**
**Major Capital Project Description**

## <u>Multi-Process Area Improvement Project #1</u>
## *Blower Building – Blower System Energy Efficiency and Reliability Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$695,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | N/A |
| **Description:** | Replace existing standby blower with a properly sized blower to provide a backup blower for the single reliable blower. Include energy saving modifications to the existing blowers such as inlet throttling or variable speed drives if financially efficient (i.e. acceptable payback on energy savings investment). Other improvements to the air piping and upgrades to blower electrical systems may be included in the project. |
| **Functional Level of Service:** | The blowers provide air to the aeration basins to maintain sufficient dissolved oxygen levels in the aeration basins. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The existing standby blowers have bent drive shafts and vibrate excessively when operated. The standby blowers with bent shafts are the only backups to a single reliable blower.<br>**Level of Service:** Redundancy/Reliability of the blower system. Dissolved oxygen in the aeration basins is critical for reducing BOD in the treatment process. Currently there is only one reliable blower. For a critical system such as the blowers there should be a redundant blower.<br>**Financial Inefficiency:** The blowers use the most energy of any other process in the treatment plant. Investments in more energy efficient controls could reduce the overall life cycle cost of the blower system. |
| **Business Case Summary:** | Reliability and redundancy of critical process equipment has been established as a level of service goal. The blower system currently does not have a reliable redundant blower which increases risk of failure of the aeration process and makes taking down the only reliable blower for regular maintenance more difficult. |

**Photos:**

**Oversized Standby Blower with Bent Shaft**


**Only Reliable Aeration Blower (Turblex)**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #1
## *Chlorination/Dechlorination Building – Hypochlorite and Sodium Bisulfite (SBS) Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,359,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • 3W System |
| **Description:** | Convert the existing chlorine gas disinfection system to a bulk 12.5% liquid sodium hypochlorite disinfection system. A new tank storage double-containment pad would be built with multiple polyethylene storage tanks to store sodium hypochlorite chemical. Chemical feed pumps would be located on the double-containment pad and would pump sodium hypochlorite upstream of the chlorine contact channels for disinfection. A feed would also be provided for disinfection of the recycled water upstream of the recycled water chlorine contact channels. See TM-2 for analysis of disinfection alternatives.<br><br>Construct an additional sodium bisulfite (SBS) storage tank to provide a redundant SBS storage tank to increase reliability of the dechlorination system. |
| **Functional Level of Service:** | The chlorination and dechlorination chemical systems functions to dose and disperse chlorine upstream of the chlorine contact channel for disinfection and dose SBS downstream of the chlorine contact channel to dechlorinate prior to discharge to the ocean. |
| **Current Failure Mode(s) Addressed:** | **Regulatory Level of Service:** The existing chlorine gas cylinder room is used for both storage of standby chlorine gas cylinders and for use of cylinders. Because the chlorine gas cylinder room is used for storage of cylinders, a chlorine scrubber is required per California Fire Code (CFC) Section 3704.2.2.7 Exception 2. The gas storage room is currently not equipped with a scrubber.<br><br>**Physical Mortality:** There have been minor valve failures in the chlorine gas system in the recent past which calls for upgrades and rehabilitation of the existing gas feed system piping. |

| | |
|---|---|
| **Business Case Summary:** | The existing chlorine gas feed system will require upgrades to meet regulatory requirements and address physical mortality issues. There are several disinfection alternatives that could be implemented to address the current failure modes. The alternatives are summarized in TM-2 and the preferred alternative should be based on an organizational decision based on the advantages and disadvantages of the types of systems. For the purposes of the project description it is assumed that 12.5% liquid sodium hypochlorite storage and feed is the preferred alternative.<br><br>The existing sodium bisulfite system is comprised of a single storage tank and multiple feed pumps. If the single storage tank or connected piping fails. the entire sodium bisulfite system could fail which would lead to chlorine being discharged out the outfall (a permit violation). Tank failures are fairly common at WWTP, therefore to increase reliability a redundant storage tank is recommended. |

**Photos:**

**Chlorine Cylinder Storage and Use**

**Chlorine Gas Feed Header with Automatic Shutoff Valves**


**Chlorine Feed Piping**


**Stand Alone SBS Tank**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #1
## *1 Water System – 1 Water System Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$263,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Operations Building Main Power Feed/Switchboard Electrical Upgrades |
| **Description:** | Construction of a new 1 water feed system (storage tank, distribution system pressurization pumps, and hydropneumatic tank). New 1 Water System feed system would be located in a new location not in the operations building electrical room. Replacement of 1 Water distribution piping not included (see Miscellaneous Yard Piping Rehabilitation and Replacement Project). |
| **Functional Level of Service:** | Supply potable water throughout the plant for use in restrooms, sinks, lab, pump seal water, and emergency eyewash showers. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The existing 1W System has reached the end of its useful life and major components such as the storage tank could fail resulting in a loss of service. |
| **Business Case Summary:** | The 1W System is a critical support system and supports many uses around the plant. Regular rehab and replacement of the equipment is necessary to improve condition of assets and extend the useful life of the system. |

**Photos:**


1 Water Hydropneumatic Tank

1 Water Storage Tank and Pressurization Pumps

**Carmel Area Wastewater District**
**Major Capital Project Description**

## *RAS Pump Building – RAS/WAS Portable Pumps and Piping*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$250,000** |
| **Lead Department:** | Operations |
| **Related Projects:** | • EQ/Aeration Pipe, Valve/Gate, and Instrumentation Rehabilitation<br>• RAS Pump Building Electrical, Controls and Mechanical Improvements |
| **Description:** | Purchase portable pumps to provide an independent emergency backup pump system for RAS/WAS pumping. Mechanical improvements include installing permanent connections for portable pumps to the RAS wet well for emergency RAS/WAS pumping in the event of a failure of the RAS pumps, piping or valves. |
| **Functional Level of Service:** | Equipment in the RAS Pump Building functions to: Pump activated sludge collected in the Secondary Clarifiers to the Anoxic Selector (upstream of aeration basins), to pump WAS to the thickener, and to Pump Secondary Clarifier Scum to RAS or WAS stream. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** Existing electrical wiring has been severely compromised due to corrosion. Electrical equipment (wiring, breakers, MCC, etc.) are 40 years old which is beyond the average useful life of electrical equipment.<br><br>**Physical Mortality:** Existing mechanical (valves and piping) equipment is aged and will need to be rehabilitated or replaced. |
| **Business Case Summary:** | The RAS pumping system is critical to the activated sludge treatment process. Electrical systems are approximately 40 years old (beyond average useful life) and have advanced corrosion as a result of flood events flooding the pump room. Mechanical equipment such as valves may be seized up due to lack of use. |

**Photos:**

| | |
|---|---|
|  |  |
| **Corroded Wiring in RAS Pump Building** | **RAS Pumps** |

**Carmel Area Wastewater District**
**Major Capital Project Description**

# *Digestion System – Interim Digester Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$778,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Digester Firm Capacity Improvements<br>• Digester 1 Rehabilitation |
| **Description:** | Equipment replacement inside the Digester Control Building including a new hot water boiler, new sludge spiral heat exchanger, new sludge recirculation pumps. Possible leaks in the natural gas feed line to the boiler needs to be investigated and repaired. New interconnect piping between Digester 2 and Digester 1 to allow heating Digester 2 with new equipment. |
| **Functional Level of Service:** | The Digester Control Building equipment heats the digester sludge to facilitate mesophilic conditions and pathogen removal in the anaerobic treatment process in order to meet Class B biosolids regulations. |
| **Current Failure Mode(s) Addressed:** | **Level of Service Failure:** Lack of Reliability/Redundancy of critical process equipment. Regulatory non-compliance of biosolids could result if there is a failure of the single sludge heater, because currently there is no redundancy of the existing sludge heating system.<br><br>**Physical Mortality:** The existing sludge heater has 70% life consumed. Ferric chloride injected upstream of the Sludge Recirculation Pump and Sludge Heater have corroded the inside of this equipment which could lead to premature physical failures.<br><br>**Physical Mortality:** The piping valves that allow heating of Digester 2 are not functioning due to a long period of downtime.<br><br>**Physical Mortality:** The existing boiler runs on natural gas provided by PG&E. Leaks have been found recently in the existing natural gas feed line.<br><br>**Physical Mortality:** Digester 1 cannot be taken down for cleaning until after Digester Firm Capacity Improvements are completed. Potential increases in ragging of the heating recirculation system could occur as a result of lack of cleaning. |

| | |
|---|---|
| **Business Case Summary:** | Currently, only Digester 1 can be successfully heated making it impossible to take Digester 1 out of service for maintenance. Furthermore, there is inadequate redundancy in the existing sludge heating system for heating sludge in the event of a failure of the existing single hot water boiler/sludge heater. Heating supplied by the cogeneration microturbine heat return unit is not sufficient to heat Digester 1 without additional heating. |

**Photos:**

| | |
|---|---|
|  |  |
| **Existing Sludge Heater (Combined Boiler and Heat Exchanger)** | **Existing Sludge Recirculation Pump – Ferric Chloride Injection Upstream** |

**Carmel Area Wastewater District**
**Major Capital Project Description**

## <u>Digester Firm Capacity Improvements:</u>
## *Digesters – Digester Firm Capacity Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$2,850,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Interim Digester Improvements<br>• Digester 1 Rehabilitation |
| **Description:** | Construct a new approximately 360,000-gallon digester complete with ancillary equipment (mixing system, digester gas equipment, sludge heating equipment, etc.). The new digester would be integrated with Digester 1. New equipment would be placed on an elevated equipment pad adjacent to the new digester and the Digester Control Building. |
| **Functional Level of Service:** | The digesters provide solids retention time of over 15 days for anaerobic digestion. Ancillary equipment heats and mixes the digester sludge to facilitate mesophilic conditions and pathogen removal in order to meet Class B biosolids regulations. Gas equipment handles flammable digester gas produced as a byproduct of digestion. |
| **Current Failure Mode(s) Addressed:** | **Level of Service:** Capacity failure. The existing digestion system does not have adequate capacity to digest sludge with Digester 1 out of service (i.e. firm capacity with largest unit out of service).<br><br>**Physical Mortality:** Digesters 2 and 3 are both in poor condition and exhibit signs of structural degradation.<br><br>**Physical Mortality:** Digesters 2 and 3 gas piping is in poor condition.<br><br>**Physical Mortality:** Digester 2 Mixer is losing a quart of oil every week which may be an indication of a pending failure. |
| **Business Case Summary:** | Digester 1 cannot be taken out of service for routine maintenance work such as cleaning the inside of the digester or for rehabilitation of aging assets. According to current sludge flow estimates, the existing standby digesters (Digesters 2 and 3) do not currently have adequate capacity to operate alone with Digester 1 offline. Furthermore, Digesters 2 and 3 are in poor condition and should not be relied on to operate long term without improvements. TM-4 reviewed alternatives and compared repairing Digesters 2 and 3 vs. building a new digester. The recommended alternative is to build a new digester of adequate size to replace Digesters 2 and 3. After the new digester is built, Digester 1 can be taken offline for service and rehabilitation. |

**Photos:**

**Digester 2**

**Digester 3**

**Cracks in Digester 2**

**Rust staining on Digester 2 (rebar corrosion or ferric)**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# <u>Digester Firm Capacity Improvements:</u>
## *Digesters – Digester 1 Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Lead Department:** | Engineering |
| **<u>Proposed Budget:</u>** | **<u>$1,090,000</u>** |
| **Related Projects:** | • Interim Digester Improvements<br>• Digester Firm Capacity Improvements |
| **Description:** | Rehabilitate Digester 1 by coating the inside of the digester with an elastomeric polyurethane coating, replacing the steel cover and installing the second mixer. |
| **Functional Level of Service:** | The digesters provide solids retention time of over 15 days for anaerobic digestion. Equipment level of service is to heat and mix the digester sludge to facilitate mesophilic conditions and pathogen removal in order to meet Class B biosolids regulations. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** Digester 1 is about 35 years old and has signs of degradation as seen by a horizontal crack around the digester with some leakage and efflorescence.<br><br>**Physical Mortality:** The steel cover on Digester 1 is critical to the operation of the digester as it contains the methane gas produced in the anaerobic digestion process the cover is 35 years old. It is not known when the cover was last rehabilitated but fixed steel covers often need to be recoated after 20 years of use and depending on the interior condition of the cover it may need to be replaced by the time this project is initiated. |
| **Business Case Summary:** | Digester 1 was last taken out of service 15 years ago. By the time this project takes place about 20 years will have passed since the digester was last inspected. The Digester 1 structure is showing signs of degradation and internal coating would extend the useful life of the structure. The steel cover is a critical component to keep methane gas in the digester and rehabilitation or replacement will be necessary so that the physical condition of this critical component is reliable. |

**Photos:**

**Digester 1 Concrete Horizontal Crack**

**Digester 1 Mixer**

|  |  |
|---|---|
| **Steel Cover** | **Rust Stains on Steel Cover** |

**Carmel Area Wastewater District**
**Major Capital Project Description**

## *Belt Press Building – Dewatering Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$1,581,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | N/A |
| **Description:** | Construction of a backup dewatering skid adjacent to the existing belt filter press (BFP). Requires demolition of the current non-operational BFP which is located too close to the current operating BFP such that certain maintenance tasks could not be completed (i.e. removing rollers). Recommended dewatering equipment includes a screw press, or rotary press, which have a smaller footprint than a BFP and will permit future maintenance of the BFP. Construction should be sequenced to allow temporary dewatering activities with the new skid outside of the BFP building while demolition and maintenance activities commence inside the building. Once the non-operational BFP is removed and required maintenance is completed on the existing BFP, the new dewatering equipment can be installed in the BFP building.<br><br>The project would also address miscellaneous mechanical, electrical systems, and controls upgrades to replace assets which are near the end of their useful life. |
| **Functional Level of Service:** | The dewatering equipment dewaters digested sludge to reduce the volume of sludge that needs to be transported for disposal (approximately 85% reduction in sludge volume). |
| **Current Failure Mode(s) Addressed:** | **Level of Service Failure:** Lack of Reliability/Redundancy of existing dewatering equipment. There is currently only one operable BFP therefore if the BFP breaks down there would be no means of dewatering sludge requiring costly liquid hauling and/or emergency dewatering services.<br><br>**Level of Service Failure:** Lack of maintainability of the existing BFP. The existing BFP cannot be rebuilt due to the adjacent non-operational BFP and lack of space adjacent to the unit.<br><br>**Physical Mortality:** The existing operational BFP was installed in 1998 and is in need of repairs for reliable operation.<br><br>**Physical Mortality:** Other miscellaneous assets in the BFP building are at the end of their useful life and should be replaced as part of this project for economies of scale. |
| **Business Case Summary:** | The only operational BFP cannot be taken down for maintenance without removing the existing non-operational BFP. If the only operational BFP |

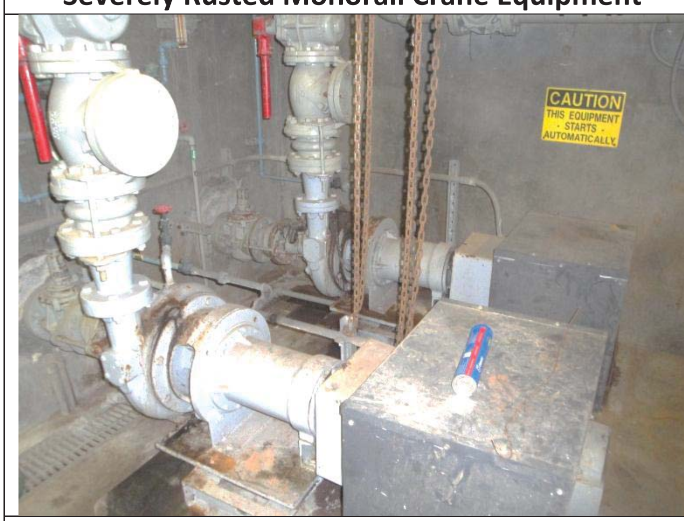
breaks down there is no standby means of providing dewatering which would result in an emergency situation in which an emergency dewatering contractor would need to be brought in. This may take several days or several weeks depending upon the availability of temporary dewatering contractors. Hauling wet sludge to Monterey Regional WWTP would be costly and a major endeavor. Standby dewatering provides dewatering reliability. See TM-5 for analysis of dewatering equipment alternatives.

The BFP building has other assets such as the filtrate return pumps, and electrical and PLC equipment that are nearing physical mortality need to replaced and it would be beneficial to replace this equipment at the same time as other major work in the building.

**Photos:**

**Severely Rusted Monorail Crane Equipment**

**Non Operational BFP (to be demolished)**




**Filtrate Return Pumps**


**Abandoned Polymer System**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# <u>Multi-Process Area Improvement Project #2</u>

## *Influent Building/Influent Manhole – Influent Manhole Replace/Retrofit and Influent Conveyance Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$1,129,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Headworks Equip, Piping and Electrical Rehab |
| **Description:** | Improve Hydraulic Capacity of the Influent Manhole and Improve the Condition of the Influent Manhole Sluice Gates and Inspect/Rehabilitate Buried Influent Piping. The Influent Piping and Valves in the Influent Building may also need to be upgraded at the same time to improve condition upstream of the influent manhole. The Influent Building needs repairs to the roof and the influent wet well equipment and lighting. |
| **Functional Level of Service:** | The Influent Pumps transfer variable influent flow from the Influent wet well to the Influent Manhole which is at a higher elevation to allow gravity flow through the primary and secondary treatment processes. The influent wet well provides removal of grease and settling of heavy objects before the influent pumps and provides storage volume to keep influent pumps from cycling on and off. |
| **Current Failure Mode(s) Addressed:** | **Level of Service Failure:** At higher influent flows, the water level in the Influent Manhole nearly overflows the structure because of backup of gravity flow.<br><br>**Physical Mortality:** The condition inside buried and exposed influent piping is unknown and therefore piping should be inspected and an allowance budgeted for improvements to piping to mitigate against possible corrosion related failure of influent pump piping.<br><br>**Physical Mortality:** The condition inside the Influent Wet Well is unknown and therefore needs to be inspected and an allowance budgeted for rehabilitation of the wet well or slide gates.<br><br>**Physical Mortality:** The condition of the influent manhole sluice gates and walkway is poor and rehabilitation is needed. |

**Business Case Summary:**

The WWTP Influent System conveys instantaneous flows up to 10 MGD during wet weather and would be subject to significant untreated wastewater spills if a failure of the conveyance system was to occur. Hydraulic concerns related to the Influent Manhole capacity coupled with unknown corrosion of influent piping systems makes the Influent Manhole and Influent Piping a high risk group of assets.

Inspection of interior pipe condition and ultrasonic pipe thickness tests may reveal that piping is in good condition and does not need to be rehabilitated. Thus the risk profile for these assets would be reduced.

The influent manhole structure would be improved to better provide the level of service of providing gravity flow into the headworks.

**Photos:**

**Corroded Influent Manhole Sluice Gate**

**Influent Manhole**


**Piping Into Influent Manhole**

**Influent Wet Well**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #2
## *Effluent Building – Effluent Building Pumping and Electrical Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,744,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Outfall (Yard Piping)<br>• 3W System Rehabilitation |
| **Description:** | Rehabilitate the existing effluent pump system with new properly sized effluent pumps and upgrade aging electrical systems in the effluent building. Other miscellaneous building improvements include roof repairs and rehabilitating the existing standby 3W pumps. |
| **Functional Level of Service:** | The effluent pumping system functions to pump treated effluent out the outfall. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The existing high flow pumps are at the end of the average useful life for pumps and there have been vibration issues encountered which could lead to accelerated pump failure.<br><br>**Cost Effectiveness:** The existing low flow pump that is used primarily to pump reverse osmosis concentrate water has a 58% wire to water efficiency as compared to a more efficient pump that could have 76% wire to water efficiency.<br><br>**Physical Mortality:** Roof leaks could lead to water damage and short circuits in the electrical gear, which could lead to a complete failure of the pump station.<br><br>**Physical Mortality:** The electrical gear and PLC have outlived their useful service life, which reduces the effluent pump station reliability.<br><br>**Obsolescence:** Obsolescence of electrical gear reduces the availability of spare parts which makes maintaining the equipment difficult.<br><br>**Safety:** Electrical gear in the effluent building has not been verified to meet arc flash safety requirements. |

| | |
|---|---|
| **Business Case Summary:** | The Effluent Pump System is a critical system and failure of the effluent pumps could result in wastewater overflows in the treatment process. The Effluent Pumps are 40 years old which is a typical average useful life for wastewater pumping equipment. Failures of the Effluent Pump electrical components have occurred in the recent past resulting in a complete shutdown of the Effluent Pump System and almost resulted in wastewater overflows. A pre-design alternatives analysis was conducted to summarize recommended effluent pump station improvements and is presented in TM-3. |

**Photos:**

**Effluent Building Electrical Gear**

**Two High Flow Effluent Pumps**


**Low Flow (RO Concentrate Pump)**


**Standby 3W Pumps**

**Carmel Area Wastewater District**
**Major Capital Project Description**

## Multi-Process Area Improvement Project #2
## *3 Water System – 3 Water System Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$406,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Hypochlorite and SBS Improvements<br>• Effluent Building Pumping and Electrical Improvements |
| **Description:** | Construction of replacement equipment to replace the existing 30-year old 3 Water (3W) System hydropneumatic tank, which is beyond its useful life. Replacement of 3W strainer and replacement of 3W system controls electrical and instrumentation systems. The existing 3W pumps are 30 years old, but may be rebuilt to extend the useful life, or the pumps may be replaced. |
| **Functional Level of Service:** | Supply reclaimed water throughout the WWTP for pump seal water, spray-water for secondary clarifier scum collection, belt filter press spray water, and various washdown and flushing uses. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The existing 3W System has reached the end of its useful life and major components such as the hydropneumatic tank could fail resulting in a loss of service, the highest consequences of failure could be related to loss of process pump seal water. |
| **Business Case Summary:** | The 3W System is a critical support system and supports many uses around the plant. Regular rehab and replacement of the equipment is necessary to improve condition of assets and extend the useful life of the system. |

**Photos:**

|  |  |
|---|---|
| **3 Water Hydropneumatic Tank** | **3 Water Strainer** |

**3 Water Supply Pumps**

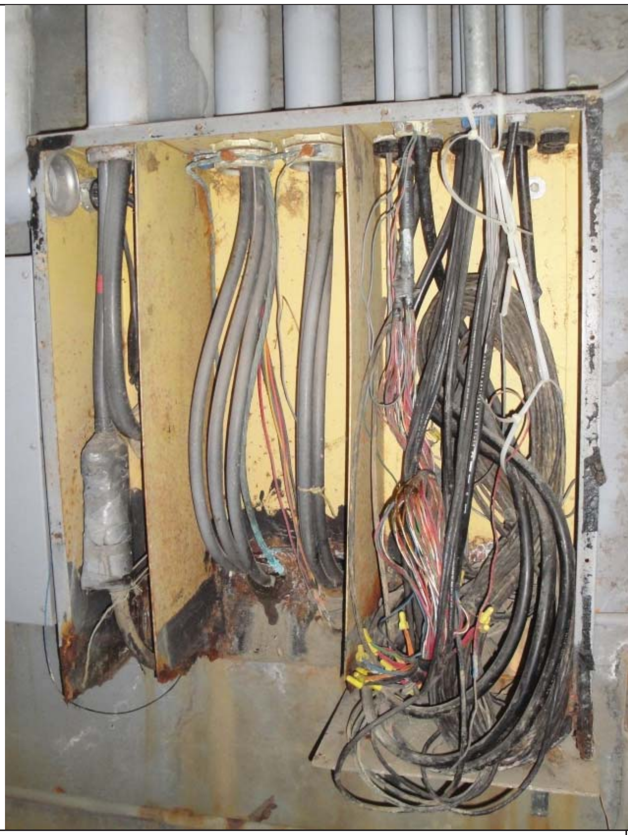
**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #3:

## *RAS Pump Building – Electrical, Controls, and Mechanical Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,220,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • EQ/Aeration Pipe, Valve/Gate, and Instrumentation Rehabilitation<br>• Portable Pumping Equipment Purchase |
| **Description:** | Inspect and repair or replace electrical equipment (wiring, breakers and MCC) in the RAS Pump Building. Install new dedicated sludge wasting pumps and an ultrasonic level sensor in the RAS wet well. Rehabilitation / Replacement of existing pump valves. |
| **Functional Level of Service:** | Equipment in the RAS Pump Building functions to: Pump activated sludge collected in the Secondary Clarifiers to the Anoxic Selector (upstream of aeration basins), to pump WAS to the thickener, and to Pump Secondary Clarifier Scum to RAS or WAS stream. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** Existing electrical wiring has been severely compromised due to corrosion. Electrical equipment (wiring, breakers, MCC, etc.) are 40 years, which is beyond the average useful life of electrical equipment.<br><br>**Physical Mortality:** Existing mechanical (valves and piping) equipment is aged and will need to be rehabilitated or replaced.<br><br>**Level of Service:** Safety. In addition to the condition and age of electrical equipment, electrical equipment in the RAS Pump Building is in close quarters to working areas which increases hazards if work needs to be done to repair electrical equipment in the event of an electrical failure.<br><br>**Financial Inefficiency:** Sludge wasting pumps to replace the current practice of flow control valves may improve efficiency of the sludge process by reducing loading on solids treatment equipment. |
| **Business Case Summary:** | The RAS pumping system is critical to the activated sludge treatment process. Electrical systems are approximately 40 years old (beyond average useful life) and have advanced corrosion as a result of flood events flooding the pump room. Mechanical equipment such as valves may be seized up due to lack of use. Improvements to WAS metering could result in greater financial efficiency of the solids treatment process. |

**Photos:**



| Corroded Wiring in RAS Pump Building | RAS Pumps |
|---|---|

**Electrical/MCC Room (Notice Desk in front of MCC)**

**Carmel Area Wastewater District**
**Major Capital Project Description**

## Multi-Process Area Improvement Project #3:
## *EQ/Aeration – Pipe, Valve/Gate and Instrumentation Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$408,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • RAS Pump Building Electrical Controls and Portable Pumping |
| **Description:** | Rehabilitate exposed process piping and valves in the area of the Aeration Basins. Replace failed Aeration Basin effluent sluice gates. Also, conduits and wiring and miscellaneous instrumentation will need to be rehabilitated. |
| **Functional Level of Service:** | The Aeration Basin converts BOD to biomass. Piping conveys return activated sludge and mixed liquor to support the process and instrumentation provides monitoring for reporting and control of the process. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** Exposed piping and valves in and around the aeration basins are in a corrosive environment and will need to be rehabilitated or replaced. PVC piping will need to be replaced due to exposure to UV light.<br><br>**Physical Mortality:** Sluice gates for the aeration basins effluent are corroded and are no longer operable. Sluice gates will need to be rehabilitated or replaced due to corrosion.<br><br>**Physical Mortality:** Instrumentation and associated electrical and controls will need to be replaced at the end of their useful life as part of other rehab work in this project. Instrumentation is exposed to sunlight which reduces the life of panels and gauges |
| **Business Case Summary:** | To keep the aeration basin mechanical, instrumentation, and electrical systems in acceptable condition, rehabilitation of aging assets should be planned. |

**Photos:**

**PVC Mixed Liquor Return Piping and Flowmeter**

**Corroded Sluice Gate Stem Operator Guide**


**Corroded RAS Piping**

**Aeration Basin Instrumentation**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Multi-Process Area Improvement Project #4:
## *Primary Clarifiers – Primary Clarifiers Sludge Collectors and Structural Repairs*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,437,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Secondary Clarifiers Sludge Collectors and Structural Repairs |
| **Description:** | Rehabilitate the Primary Clarifier structures (by internal lining or concrete repair). Rehabilitate effluent launders (coating). Replace sludge collector mechanisms. |
| **Functional Level of Service:** | The Primary Clarifiers remove settleable solids from the liquid treatment process. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The Primary Clarifier Structures are over 40 years old, which is the average useful life for this type of structure. There are signs of degradation of the concrete structure both on the exterior of the tanks (cracks with efflorescence) and inside the effluent and scum boxes (concrete biogenic sulfide corrosion).<br><br>**Physical Mortality:** The Primary Clarifier Sludge Collectors are beyond their useful life and will need to be repaired or replaced. |
| **Business Case Summary:** | By repairing the Primary Clarifier structures, the useful life of the structures can be greatly extended. Addressing structural degradation proactively would allow simpler less costly repair methods to be instigated as opposed to letting the degradation continue until the structure is in major disrepair which would be more costly to repair. |

**Photos:**

|  |  |
|---|---|
| **Primary Clarifier Sludge Collector Drive** | **Primary Clarifier Effluent Launderer** |

**Primary Clarifier Structure with Vertical Cracks**

**Carmel Area Wastewater District**
**Major Capital Project Description**

## Multi-Process Area Improvement Project #4:
## *Secondary Clarifiers – Secondary Clarifiers Sludge Collectors and Structural Repairs*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,949,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Primary Clarifiers Sludge Collectors and Structural Repairs |
| **Description:** | Rehabilitate Secondary Clarifier structures after detailed seismic review and materials testing of the structure. Rehabilitate effluent launders (coating). Replace sludge collector mechanisms. |
| **Functional Level of Service:** | The Secondary Clarifiers remove suspended and floatable biomass from the mixed liquor coming from the Aeration Basins. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The Secondary Clarifier Structures are 40 years old (Clarifier 1) and 30 years old (Clarifier 2), which is about the average useful life for this type of structure. Because they are nearing the end of their useful life the structures should be evaluated and repaired to extend the useful life.<br><br>**Physical Mortality:** The Secondary Clarifier Sludge Collectors are beyond their useful life and will need to be repaired or replaced. |
| **Business Case Summary:** | By repairing the Secondary Clarifier structures the useful life of the structures can be greatly extended. Addressing structural degradation proactively would allow simpler less costly repair methods to be instigated as opposed to letting the degradation continue until the structure is in major disrepair which would be more costly to repair. |

**Photos:**

| Wooden Bridge | Secondary Clarifier Effluent Launderer |
|---|---|

**Secondary Clarifier Center Structure**

**Carmel Area Wastewater District**
**Major Capital Project Description**

## Storm Water Pumping Improvements

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$700,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | N/A |
| **Description:** | Construct a storm water pump station to improve control of storm water onsite. The storm water pump station would pump any contaminated storm water runoff collected on site to the equalization basin or headworks. |
| **Functional Level of Service:** | Compliance with State Water Board General Permit No. CAS000001 (General Permit) Waste Discharge Requirements (WDRS) for discharges of storm water associated with industrial activities excluding construction activities |
| **Current Failure Mode(s) Addressed:** | **Level of Service:** The WWTP currently has the ability to contain storm water onsite; however, no permanent pumping system is in place to pump contaminated storm water to the head of the WWTP. Portable pumps must currently be used to pump contained storm water to the head of the WWTP. |
| **Business Case Summary:** | This project would enhance the control of storm water onsite. However, major flooding events from the Carmel River would not be managed by this pump station. |

**Photos: (None)**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# Demolition of Abandoned Assets

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$400,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Digester Firm Capacity Improvements<br>• Chlor-Dechlor Improvements |
| **Description:** | Demolish major structures which have been replaced with new infrastructure. Major structures could include Digester 2, Digester 3, and the Chlor-Dechlor Building. |
| **Functional Level of Service:** | N/A |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** Existing structures that are abandoned should be demolished to avoid ongoing issues with structural degradation and seismic damage. |
| **Business Case Summary:** | Abandoned structures should be demolished as they could be a safety concern if not maintained. Demolishing these structures would create space at the site for better access to operate and maintain processes that are in service. For example, demolition of the Chlor-Dechlor Building will improve access for maintenance of the Chlorine Contact Channels. |

**Photos:**

| Digester 2 | Digester 3 |
|---|---|

Chlor-Dechlor Building

**Carmel Area Wastewater District**
**Major Capital Project Description**

## *Headworks – Equipment, Piping and Electrical Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **<u>Proposed Budget:</u>** | **<u>$675,000</u>** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Influent Manhole Replace/Retrofit and Influent Conveyance Improvements |
| **Description:** | Rehabilitate equipment, piping and electrical assets in the headworks area. The assets that should be rehabilitated range from channel grinder equipment, sludge piping, and electrical system to meet arc flash requirements. |
| **Functional Level of Service:** | The Headworks process removes rags and grit from the liquid treatment process. Also in the Headworks structure is primary clarifier sludge and scum pumps which convey sludge and scum to the digesters. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The Headworks was originally built about 40 years ago. Improvements in 2001 addressed repairs to some equipment but other equipment has not been rehabilitated and is beyond the average useful life.<br><br>**Obsolescence:** Existing electrical equipment is obsolete and therefore difficult to maintain. |
| **Business Case Summary:** | To maintain the functionality of the equipment in the Headworks area, it is necessary to plan a rehabilitation project to occur in about 10 years. Headworks equipment has an average useful life of about 15 years due to the harsh duty environment. Electrical assets will need to be updated to current plant standards. |

**Photos:**

Headworks Effluent Valves

MCC HM

Grit Classifier

**Carmel Area Wastewater District**
**Major Capital Project Description**

## Thickener Replacement

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,000,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | N/A |
| **Description:** | Replace the existing Dissolved Air Flotation (DAF) Thickener with a more efficient Gravity Belt Thickener (GBT). In addition to thickening WAS the gravity belt thickener would also handle washwater which comes from the membrane microfiltration (MF) filters in the recycled water process. |
| **Functional Level of Service:** | The DAF Thickener thickens WAS and MF washwater to reduce the volume of sludge sent to digesters. The thickener increases sludge concentration and returns liquid removed from sludge to the head of the WWTP. |
| **Current Failure Mode(s) Addressed:** | **Financial Inefficiency:** The existing DAF thickener is not as efficient in separating suspended solids from WAS and MF washwater as would be a GBT. A more efficient thickener would reduce the TSS load recycled to the head of the plant and increase the TSS sent to the digesters. This would likely reduce the operations and energy cost of the secondary treatment process and improve the efficiency of the digestion and dewatering systems. |
| **Business Case Summary:** | A pre-design report will be needed to define the payback in reduction of power use in the secondary process that could be realized by replacing the existing DAF thickener with a GBT. In addition to improved power costs the GBT would help resolve current operational issues with the existing MF washwater thickener which is used solely for the tertiary plant. It may be possible to eliminate the MF washwater thickener and send MF washwater directly to the GBT. |

**Photos:**

|  |  |
|---|---|
| **DAF Equipment** | **DAF Thickener** |

**DAF Thickener**

**Carmel Area Wastewater District**
**Major Capital Project Description**

# *Chlorine Contact – Chlorine Contact Structure Repairs and Misc Piping Rehabilitation*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$1,511,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Demolition of Abandoned Assets Project |
| **Description:** | Rehabilitate the Chlorine Contact structures after detailed seismic review and materials testing of the structure. Rehabilitate large diameter piping. Replace steel covers on top of the Chlorine Contact Pipe Gallery which leak and allow rainwater into the pipe gallery. |
| **Functional Level of Service:** | The Chlorine Contact Channels provide contact time for chlorine to sufficiently remove or inactivate pathogens. |
| **Current Failure Mode(s) Addressed:** | **Physical Mortality:** The Chlorine Contact structure will be 40 years old at the time of this project and assessing the need for repairs will extend the useful life of this structure.<br><br>**Physical Mortality:** Piping in the pipe gallery should be recoated to avoid further corrosion of the pipes occurring where the coating has failed. |
| **Business Case Summary:** | A budget allowance is estimated for this project to evaluate the chlorine contact structure to determine if there are condition issues. Other miscellaneous piping, mechanical and instrumentation work will be necessary to rehabilitate assets associated with the chlorine contact channels. |

**Photos:**

**Piping in Chlorine Contact Pipe Gallery Coating Failure**

**Rusted Piping and Equipment in Skimmer Pump Wet Well**

**Cracks on Concrete Deck Above Chlorine Contact Channels**

**Carmel Area Wastewater District**
**Major Capital Project Description**

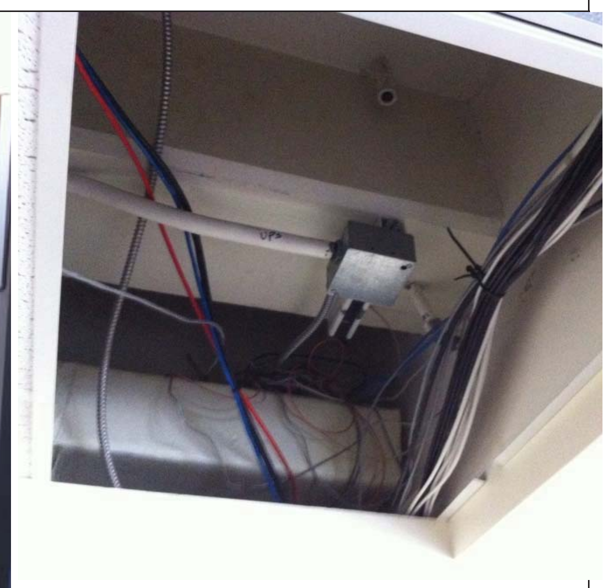
## *Operations Building – Ops Building Improvements*

| | |
|---|---|
| **Project Number:** | To Be Assigned |
| **Funding:** | Reserve |
| **Proposed Budget:** | **$599,000** |
| **Lead Department:** | Engineering |
| **Related Projects:** | • Ops Building - Main Power Feed and Switchboard Electrical Upgrades |
| **Description:** | Renovate the Ops Building ncluding restrooms, office spaces, building mechanical, roofing, SCADA system wiring and repurposing the upstairs electrical room to facilitate added useable space for central SCADA monitoring and control or for other uses such as library storage. |
| **Functional Level of Service:** | The Operations Building is the center of operations and control of the WWTP. Currently the Operations Building is a multi-purpose building with office space, restrooms/locker rooms, library storage, and also houses critical plant infrastructure including the main electrical power feed equipment for the WWTP. |
| **Current Failure Mode(s) Addressed:** | **Level of Service:** To meet the strategic WWTP levels of service of Reliability and Regulatory Compliance, the Operations Building should serve as the central Supervisory Control and Data Acquisition (SCADA) interface location where the plant processes can be effectively monitored and controlled. The Ops building SCADA control and monitoring system will need improvements to continue to effectively monitor and control the WWTP process. Furthermore, currently during maintenance of SCADA, operations has difficulty maintaining interface with SCADA.<br><br>**Physical Mortality:** The restrooms and locker rooms in the Operations Building have not been renovated since original construction in 1970 and are in poor condition.<br><br>**Physical Mortality:** Building mechanical systems are in poor condition and need to be replaced with newer and more efficient systems. |
| **Business Case Summary:** | The Operations Building has been in service since 1970 without any major improvements. Electrical improvements are planned for the plant's main power feed which terminates in the Ops Building as part of a separate project. This project would follow those electrical improvements to improve the functionality of the space and SCADA accessibility. Other improvements should be made to the restrooms and locker rooms to improve the condition of the facilities. Building mechanical systems should also be replaced with more efficient equipment to improve energy efficiency. The roof should also be repaired to prevent leaks. |

**Photos:**


**Operations Building Locker Room/Restroom**

**Operations Building Locker Room/Restroom**



**SCADA Wiring in Operations Building**

# Carmel Area Wastewater District Wastewater Treatment

# Capital Improvement Program 15-year Master Plan

Kennedy/Jenks Consultants

Pre-Design
Technical Memoranda

29 June 2012

# Technical Memorandum No. 2

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Review: Mr. Bob Ryder, P.E., Kennedy/Jenks Consultants

Subject: Evaluation of Alternatives for Disinfection System
K/J 1268007*01

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This memorandum presents an evaluation of disinfection system alternatives for the Carmel Area Wastewater District (CAWD) wastewater treatment plant (WWTP). The alternatives that are evaluated in detail in this evaluation are:

1. **Alternative 1:** Maintain and improve existing gaseous chlorine disinfection system.

2. **Alternative 2:** Construct a new bulk storage and feed system for 12.5% liquid sodium hypochlorite.

3. **Alternative 3:** Generate 0.8% liquid sodium hypochlorite onsite using direct electrolysis hypochlorite generators.

Other disinfection technologies which are discussed, but not evaluated in detail, in this memorandum include ultraviolet disinfection, ozone, and pasteurization. These non-chlorine disinfection alternatives do not appear to be more favorable than liquid and gaseous chlorine for the CAWD WWTP at this time. One reason that these non-chlorine disinfection alternatives are not well suited for the existing CAWD WWTP is that a residual of mono-chloramines is currently required through the tertiary membrane treatment process to control bio-fouling as well as for disinfection residual of the recycled water. Furthermore, moving away from chlorine disinfection would either require changing the operation of the tertiary process, or having chlorine feed in addition to a non-chlorine disinfection system. Further discussion of pros and cons of these non-chlorine disinfection systems are discussed herein.

## Previous Studies

Previous studies regarding the chlorination system at CAWD include a “Disinfection Options Study” by HDR written in 1998, and an “Offsite Consequence Analysis” by Montgomery Watson written in 1993. The 1998 report by HDR reviewed alternatives for disinfection including: options to maintain the current chlorine gas system, options for a 12.5% liquid sodium hypochlorite system, and options for ultraviolet (UV) disinfection. The HDR report concluded that continued use of chlorine gas would be an acceptable alternative with continued upgrades for safety and reliability. For future long-term implementation the HDR report recommended 12.5% liquid sodium hypochlorite. 14 years have passed since the HDR report and CAWD is re-evaluating these conclusions. The 1993 Montgomery Watson study identified several chlorine gas leak scenarios that could have significant offsite impacts.

## Evaluation Criteria

### Level of Service Goals

A disinfection system pre-design meeting was conducted with the CAWD WWTP operations staff including the plant superintendent, lead operators, staff operators, laboratory technicians, and maintenance staff. The meeting included a discussion of the level of service goals for the disinfection system as envisioned by each attendee at the meeting. The level of service goals for the disinfection system compiled by the CAWD staff are shown in Table 1.

Table 1: CAWD Level of Service Goals

| | |
|---|---|
| *Improved Safety for Staff* | *Reliability of the System* |
| *Improved Safety for the Public* | *Economical Life Cycle* |
| *Simplicity of Operations* | *Compatibility with Existing Systems (i.e. bio-fouling control in MF/RO)* |

These levels of service goals, developed by CAWD staff, are well aligned with the standard of care for the design of this type of system in the municipal sector and therefore will serve as criteria by which the alternatives will be compared in this evaluation.

### Risk Profile

At certain concentrations, chlorine is a toxic chemical. Therefore, maintaining and operating chlorine storage and delivery systems can carry risk to operations staff of exposure to chemical above safe levels; and in the case of chlorine gas there is also risk of offsite public exposure. Furthermore, disinfection systems for WWTP effluent and recycled water are vulnerable to failure, resulting in permit violations. Table 2 identifies four major risk categories to be assessed relatively for the future disinfection system improvement alternatives.

Table 2: Risks Associated with Chlorine Disinfection at CAWD

| | |
|---|---|
| *Chemical Exposure above Safe Levels (onsite and offsite)* | *Free Chlorine Damage to Micro-Filtration Membranes* |
| *NPDES Permit Violations* | *California Department of Public Health Recycled Water Permit Violations* |

## Disinfection Requirements

The CAWD WWTP currently utilizes chlorine for three principal functions:

1. Disinfect the secondary effluent to meet National Pollutant Discharge Elimination System (NPDES) requirements.

2. Maintain a mono-chloramines residual in the MF/RO recycled water process to reduce bio-fouling.

3. Disinfect the tertiary treated recycled water to meet California Department of Public Health (DPH) recycled water permit requirements.

The design criteria for the quantity of chlorine being used at the CAWD wastewater treatment plant (WWTP) for different influent flow rates are described in Table 3.

Table 3: Design Criteria: Chemical Usage

| | Maximum Instantaneous Effluent | Winter Avg. Effluent | Summer Avg. Effluent | Recycled Water |
|---|---|---|---|---|
| **Plant Flow (MGD)** | 9 | 4 | 1.5 | 1.0 |
| **Minimum Chlorine Dose (mg/l as $Cl_2$)** | 10 | 10 | 10 | 10 |
| **Maximum Chlorine Dose (mg/l as $Cl_2$)** | 20 | 20 | 20 | 20 |
| **Required Capacity Range of System (lb/day as $Cl_2$)** | 750 to 1,500 | 330 to 660 | 125 to 250 | 80 to 160 |

Actual historical chemical usages of gaseous chlorine in pounds per day (ppd) from 2008 to 2012 are shown in Figure 1.

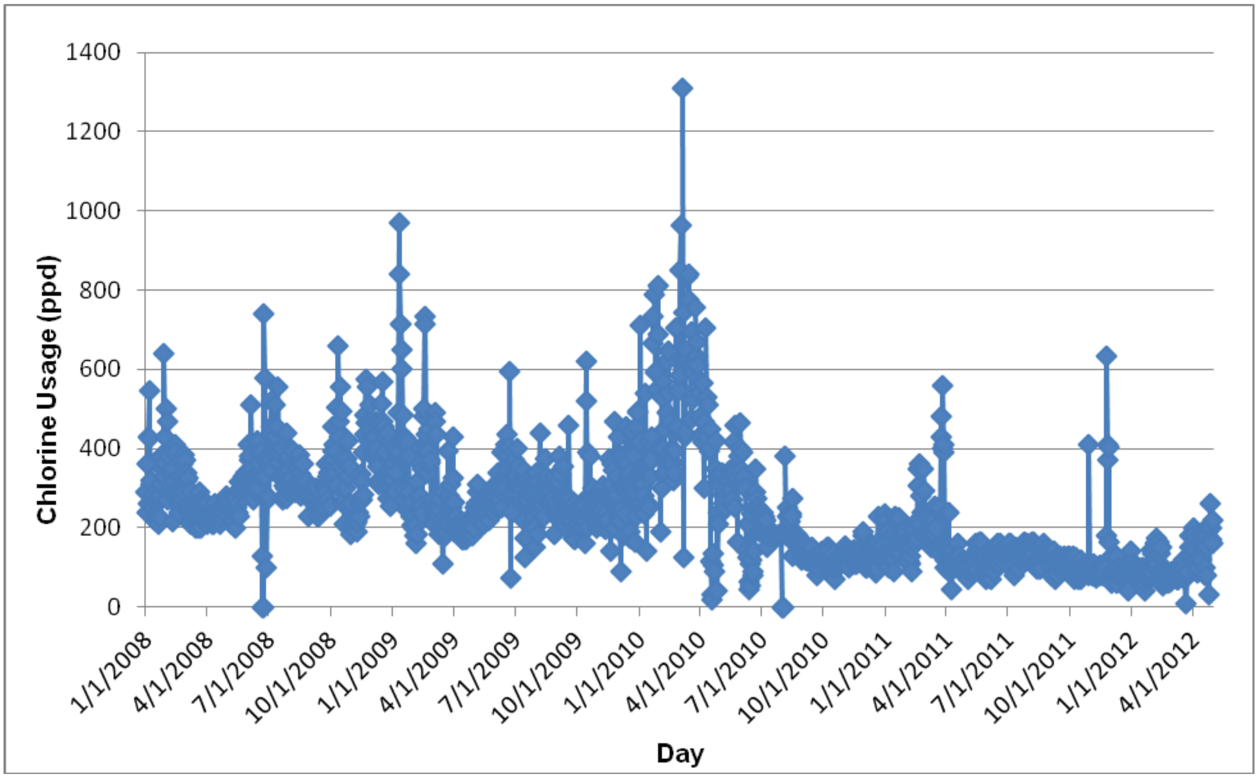



Figure 1: Historic Effluent Chlorine Usage Data (2008 – 2012)

The daily chemical usage for 2008 to 2012 indicates that chlorine usage ranged from about 1,300 ppd to less than 100 ppd.

## Alternative 1: Maintain and Improve Existing Gaseous Chlorine System

The existing chlorine gas storage and feed system is comprised of one ton chlorine gas containers, chlorinator equipment, a water champ educator mixer diffuser system, backup eductors and diffusers for chlorine solution, chlorine gas detection and ventilation in the cylinder storage room, and various piping and appurtenances.

The existing gas storage and feed does not currently meet the desired levels of safety for the CAWD treatment plant staff. Recent pipe leaks have highlighted the vulnerabilities of the existing system. Recently an automatic switchover valve on the tertiary manifold in the chlorine ton container storage room failed from internal corrosion and leaked chlorine gas into the storage room. Other vulnerabilities in the chlorine gas distribution piping have been identified as potential points of failure for chlorine gas leaks outside of the chlorine storage room and outside of the limits of the chlorine gas detection system.

## Improvements to Existing Gaseous Chlorine System to Meet Level of Service

System rehabilitation upgrades will be required to maintain safety and reliability of the existing gas chlorine system. The existing system was originally constructed in the early 1980’s prior to many of the toxic/hazardous chemical regulations and requirements. The system has been retrofit within the last 10 years with new effluent chlorinators and a new chlorine detection system for the Cylinder Storage Room. Furthermore, a new water champ was installed in the last 10 years.

Elements of the existing system which have been identified as needing improvement to maintain the desired levels of service include:

- Chlorine gas piping and appurtenances
- Tertiary chlorinators
- Containment, scrubber and ventilation improvements in the Chlorine Storage Building

**Chlorine Gas Distribution Piping and Appurtenances:** The existing chlorine gas system includes a network of Schedule 80 PVC chlorine gas piping in the Chlorine Building area, and in the Tertiary Building area. Furthermore, there is a transfer pipe which transfers chlorine gas from the Chlorine Building to the Tertiary Building; a distance of about 300 feet.. The network of piping includes manual valves, and solenoid valves. Much of the piping and valves are near the end of their typical 25-year useful life and need to be replaced to improve safety for plant staff and the community. Furthermore, to decrease the potential for chlorine leaks, exterior piping should be reconstructed to include double containment to contain possible leaks. The double containment should terminate into areas containing gas detection and gas containment.

**Tertiary Chlorinators:** The effluent chlorinators located in the chlorine building were replaced with new chlorinators within the last 10 years; however the tertiary chlorinators were not replaced during that time and will need to be replaced in the near future to maintain reliability of the recycled water chlorination process. Chlorinator equipment typical useful life is in the range of 15 years.

**Scrubber/Ventilation Improvements:** The existing one-ton container storage room is not equipped with a chlorine scrubber which would treat exhaust fumes from the building containing chlorine gas in the event of a major chlorine leak in the building. The storage room typically contains eight one-ton containers in use (four for the effluent disinfection system and four for the recycled water disinfection system). There are also typically five additional standby one-ton containers stored in the Chlorine Storage Room. A chlorine ton container can deliver a maximum of 450 ppd of chlorine. Chlorine ton containers are typically delivered at 5 to 11 containers per truck. There is sufficient existing storage of chlorine at the WWTP for about a month of normal winter use.

CAWD has been advised by others that a chlorine scrubber system may not be required by the California Fire Code (CFC) for this system. The CFC has two separate requirements for buildings containing chlorine gas containers for: 1) storage of containers, and 2) use of containers. The Chlorine Storage Room at the CAWD WWTP serves both functions, that of a storage room, and for use of chlorine containers. The following summarizes the requirements for each function (use and storage). These referenced sections of the CFC are attached to this technical memorandum for information.

1. Use of Chlorine Gas (CFC Section 3704.2.2.7 Exception 1): A chlorine scrubber is not required by the 2010 CFC for use of one-ton chlorine gas containers as long as automatic closing fail-safe valves are installed on the containers that are controlled by a gas detection system. The CAWD system is equipped with a gas detection system and fail-safe valves on the containers in use and therefore the use of toxic gas in the storage room does not require a scrubber.

2. Storage of Chlorine Gas (CFC Section 3704.2.2.7 Exception 2): Storage of one-ton chlorine gas containers has separate requirements in the 2010 CFC. Per the CFC, scrubbers are required for storage rooms unless the containers are located within gas cabinets, exhausted enclosures (ventilated structures do not qualify), containment vessels, or containment systems. To meet the intent of the CFC for storage of the five standby containers, which are not in use in the chlorine storage room, it is recommended that the building be exhausted to a scrubber or the stored vessels be located within an exhausted enclosure. An exhausted enclosure is defined as “an appliance or piece of equipment which consist of a top, a back and two sides providing a means of local exhaust for capturing gasses. Rooms or areas provided with general ventilation, in themselves are not exhausted enclosures” (see attached CFC excerpts for full definition of an exhausted enclosure).

**Miscellaneous Upgrades:** During the asset survey conducted by Kennedy/Jenks in March 2012, several building upgrades were identified for the existing building that houses the chlorination equipment which included installing a permanent stair at the back of the building to replace the existing metal stair which is corroded, and rehabilitate aged electrical equipment. Furthermore, critical system components such as the ton cylinder delivery crane may need to be retrofit to improve the safety of this critical piece of equipment.

## Alternative 1 Level of Service

Table 4 shows a comparison of the levels of service provided by the current chlorine gas system side by side with the levels of service that would be provided with improvements to the existing system to improve safety.

Table 4: Current System and Alternative 1 - Levels of Service

| Level of Service Goal | Current System | Alternative 1 |
|---|---|---|
| Improved Safety for Staff | Recent failure of automatic switchover valve and condition of manual shutoff valves and piping is a safety concern. | Improvements to piping would increase the safety of the system. |
| Improved Safety for the Public | The chlorine storage room is not equipped with a scrubber. | Improvements to piping would increase the safety of the system. Including a scrubber on the building would limit the potential of leaks inside the chlorine storage room from escaping offsite. |
| Simplicity of Operations | Operations work during container unloading and connecting containers to system requires specialized safety training. Otherwise operations are fairly simple. | No change. |
| Reliability of the System | System has proven reliable over the approximately 30 years of operation. | Reduction in piping vulnerabilities would increase reliability. |
| Economical Life Cycle | The current system has the lowest consumables cost of any other disinfection system on the market. | No change. |
| Compatibility with Existing System | Compatible with existing system. | No change. |

## Alternative 1 Estimated Cost

**Capital Cost:** Table 5 shows the estimated probable construction cost for improvements to the existing gaseous chlorine system to meet level of service goals.

Table 5: Alternative 1: Maintain and Improve Existing Gas Chlorine System Estimated Probable Construction Cost Estimate

| Item | Description | Cost |
|---|---|---|
| | **Chlorine Building Modifications** | |
| 1 | Chlorine Gas Treatment System (Scrubber) | $200,000 |
| 2 | Scrubber Concrete Pad | $25,000 |
| 3 | PVC Piping Replacement | $40,000 |
| 4 | Miscellaneous Upgrades | $20,000 |
| | *Chlorine Building Subtotal* | *$260,000* |
| | **Tertiary Building Modifications** | |
| 5 | Replace Old Chlorinators (3) | $50,000 |
| 6 | PVC Piping Replacement | $20,000 |
| | *Tertiary Building Subtotal* | *$70,000* |
| | **Yard Piping Replacement** | |
| 7 | PVC Piping Replacement and Double Contained Pipe | $25,000 |
| | *Yard Piping Subtotal* | *$25,000* |
| | **Electrical** | |
| 8 | Miscellaneous Electrical Improvements | $70,000 |
| | *Electrical Subtotal* | *$70,000* |
| | Project Subtotal: | $450,000 |
| | Mobilization/Demobilization: | $45,000 |
| | Contractor Overhead and Profit: | $90,000 |
| | **Project Total:** | **$585,000** |
| | Pre Design Contingency @ 30%: | $175,000 |
| | **Total with Contingency:** | **$760,000** |

Typically, engineering and construction management are about 20% of construction cost and therefore the projected budget for capital expenditures for Alternative 1 would be $910,000. The total replacement capital cost of the entire chlorine gas disinfection system including the Chlorine Storage Building chlorinator equipment, gas detection equipment, electrical, instrumentation, etc. is estimated to be in the range of $2,500,000 (including engineering and construction management). Therefore, the capital cost for near term upgrades does not account for future rehabilitation and replacement to maintain approximately $2,500,000 worth of assets. Current estimates being developed for the CAWD assets predict that additional improvements will be required in the chlorine storage building in the next 10 to 20 years to continue to maintain the existing gas chlorine system. These estimates are projected based on estimated residual life estimates and are currently at a preliminary level of accuracy. However, given the age of the assets associated with the gas chlorine system it is currently estimated that additional improvements in the range of $500,000 will be required in the next 10 to 20 years to continue to rehabilitate or replace existing gas chlorine system assets not included in the initial near term upgrades. Assets not included in the initial rehabilitation that may need to be rehabilitated or replaced in the next 10 to 20 years include the effluent water champ eductors, effluent chlorinators, Chlorine Building mechanical components, chlorine gas disinfection control systems, and Chlorine Building structural assets.

**Consumables Cost:** The cost of gaseous chlorine is the lowest cost consumables alternative for disinfection. Although there is high volatility in the cost of chlorine that has raised prices as much as 4 to 1, the typical gaseous chlorine cost per pound is about $0.30 per pound of chlorine. Therefore, for the CAWD usage the annual cost for chlorine should be approximately $30,000 per year.

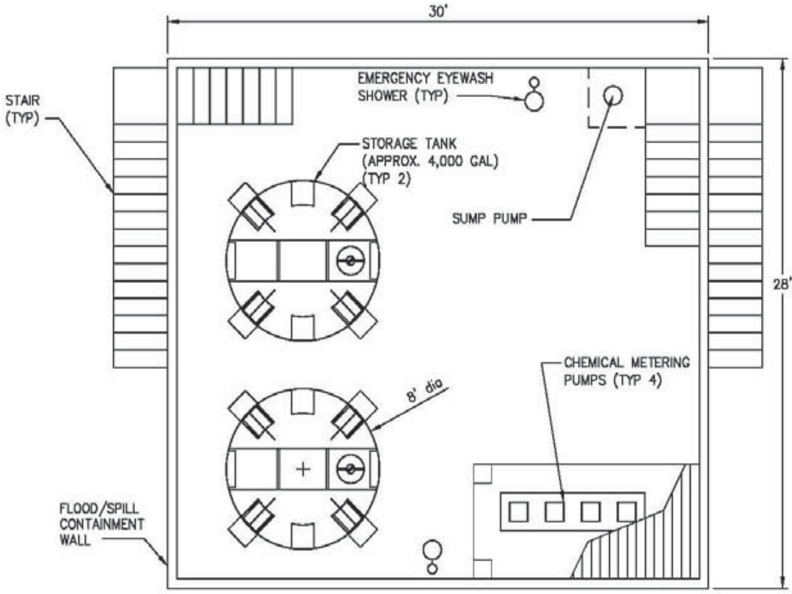
## Alternative 2: 12.5% Concentration Liquid Sodium Hypochlorite Bulk Storage and Feed

Storage and feed of 12.5% liquid sodium hypochlorite (hypo) is a common disinfection approach for municipal applications. The equipment can be simple to operate and can be built with full redundancy to create a reliable system. This type of system would consist of: hypo storage tanks, chemical metering pumps, chemical containment curbs, chemical feed piping, carrier water systems (optional), emergency eyewash/showers, and electrical and instrumentation.

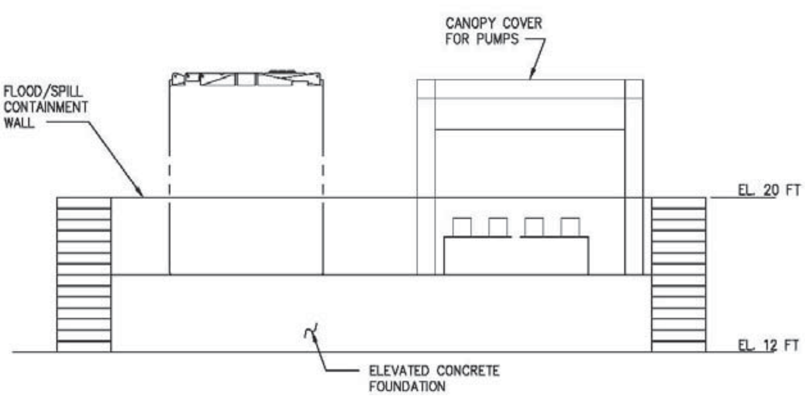
12.5% hypo is a toxic chemical and therefore safety measures should be taken to mitigate exposure. Direct exposure to the eyes can cause serious damage. Liquid sodium hypochlorite naturally off-gasses a little chlorine gas at well below safety thresholds, but can cause corrosion in enclosed areas. Accidental contact between hypo and acids causes an exothermic reaction which can liberate toxic levels of chlorine gas from solution. This sort of accidental off-gas resulting from acid coming into contact with 12.5% sodium hypochlorite has occurred more frequently than chlorine gas releases from chlorine gas systems. However, these occurrences are from operator error as opposed to the failure of equipment or safety systems. Acids should not be stored inside the hypo containment area per code requirements and acid based cleaners should not be used on hypo spills.

**Chemical Storage Tanks and Containment Area:** For this Alternative 2 at CAWD, it is assumed that two hypo storage tanks would be located outdoors on a new concrete chemical containment pad. The new chemical spill containment pad could be located in the existing green space west of the Tertiary Building. Figure 2 shows a preliminary layout for the concrete containment pad for Alternative 2. An alternative location for the storage tanks could be on top of the existing Tertiary Chlorine Contact Channels. Constructing the tanks in this location would reduce the capital cost by eliminating a new elevated concrete foundation designed for flood conditions. Furthermore, with this location the chemical metering pumps could be located inside the existing tertiary building. For cost purposes, an entirely new chemical storage pad is assumed to be conservative.

Sodium hypochlorite is typically delivered in 3,000 to 3,500-gallon tank trucks which are then offloaded into polyethylene (PE) or fiberglass storage tanks. Two 4,000-gallon storage tanks are proposed to provide redundancy. Typically, during summer there would be more than 30 days of chemical storage onsite, and during the winter about 20 days, which would be adequate for a truck delivery every week or two. Also, storage time will not be prolonged so that the hypo solution strength will not seriously diminish in summer heat, which would require a shade cover over the tanks.




12.5% SODIUM HYPOCHLORITE STORAGE AREA PLAN




12.5% SODIUM HYPOCHLORITE STORAGE AREA ELEVATION

**Kennedy/Jenks Consultants**

CARMEL AREA
WASTEWATER DISTRICT

**12.5% SODIUM HYPOCHLORITE**
**STORAGE & FEED AREA**

K/J 1268007*01
JUNE 2012

**FIGURE 2**

**Chemical Metering Pumps:** Chemical metering pumps will be required to feed hypo to the Effluent Chlorine Contact Channel as well as for the Tertiary Chlorine Contact Channel. Full redundancy for the two chlorine contact channels would require four pumps. Positive displacement gear pumps provide accurate, durable and reliable service over a wide metering range and are recommended for the hypo metering pumps. The gear pumps may be sized to handle the entire flow range with each pump and the pumps for the effluent can be interchangeable with the pumps for the recycled water. Each gear pump would be sized to pump the range between 1,500 ppd and 80 ppd by a variable speed motor drive.

### Table 6: 12.5% Liquid Sodium Hypochlorite Design Summary

| Parameter | Unit | Maximum Instantaneous | Winter Avg. | Summer Avg. | Recycled Water |
|---|---|---|---|---|---|
| Plant Flow | MGD | 9 | 4 | 1.5 | 1 |
| Min $Cl_2$ Dosage | mg/l | 10 | 10 | 10 | 10 |
| Average $Cl_2$ Dosage | mg/l | 12 | 12 | 12 | 12 |
| Max $Cl_2$ Dosage | mg/l | 20 | 20 | 20 | 20 |
| Min Dose $Cl_2$ Usage | lb/day | 750 | 330 | 130 | 83 |
| Average Dose $Cl_2$ Usage | lb/day | 900 | 400 | 150 | 100 |
| Max Dose $Cl_2$ Usage | lb/day | 1,500 | 670 | 250 | 170 |
| Sodium Hypo Solution Concentration | Trade Percent | 12.5% | 12.5% | 12.5% | 12.5% |
| Available $Cl_2$ per Gallon | lb/gal | 1.04 | 1.04 | 1.04 | 1.04 |
| 12.5% Hypo Required per Day | gal/day | 1,400 (max dose) | 380 (avg dose) | 140 (avg dose) | 96 (avg dose) |
| Useable 12.5% Hypo Storage Volume | gal | 8,000 | 8,000 | 8,000 | 8,000 |
| Days of Reserve Chemical Storage (Effluent Usage + Recycled Water Usage) | days | 5 (max dose) | 15 (avg dose) | 30 (avg dose) | Included |

## Alternative 2 Level of Service

Table 7 describes the levels of service that would be provided by a new hypo storage and feed system.

### Table 7: Alternative 2: Levels of Service

| Level of Service Goal | Alternative 2 |
|---|---|
| Improved Safety for Staff | A liquid sodium hypochlorite system should be generally considered to carry less risk than a chlorine gas system. There would be some safety concerns associated with a 12.5% liquid hypochlorite disinfection system. For instance, acids should never come into contact with sodium hypochlorite as this can cause an exothermic reaction which can produce heat and off gas of chlorine gas at toxic levels. Therefore, acids and acid based cleaners should be kept away from the hypo containment area. |
| Improved Safety for the Public | As long as acids are kept away from the liquid hypochlorite storage area there would be little risk of offsite public exposure to chlorine gas. |
| Simplicity of Operations | A hypo storage and feed system would be similar to the existing liquid sodium bisulfite storage and feed system and therefore operations staff would already have the knowledge necessary to successfully operate the system. |
| Reliability of the System | Hypo storage and feed systems should be built with fully redundant equipment to maintain continuous service of the disinfection system even during potential equipment failures. |
| Economical Life Cycle | Hypo would cost approximately $70,000 more annually in chemical cost than is currently spent on chlorine gas. Near term capital improvements costs are similar to improving the existing gaseous chlorine system. |
| Compatibility with Existing System | Hypo can be accurately dosed at equivalent rates as the existing chlorine gas system. Modifications to the existing system could include installing new chlorine injection equipment (water champ). |

## Alternative 2 Estimated Cost

**Capital Cost:** Table 8 shows the estimated probable construction cost for a new bulk hypo storage and feed system.

Table 8: Alternative 2: New 12.5% Sodium Hypochlorite Storage and Feed Estimated Probable Construction Cost Estimate

| Item | Description | Cost |
|---|---|---|
| | **New Sodium Hypochlorite System** | |
| 1 | Site Work | $15,000 |
| 2 | Containment Area Elevated Foundation | $35,000 |
| 3 | Containment Area Concrete Equipment Pads | $5,000 |
| 4 | Flood and Spill Concrete Containment Walls | $20,000 |
| 5 | Stairs | $20,000 |
| 6 | Chemical Piping and Appurtenances | $50,000 |
| 7 | Chemical Metering Pumps | $50,000 |
| 8 | Two New Water Champs | $70,000 |
| 9 | Tanks | $60,000 |
| 10 | Emergency Eyewash Showers | $10,000 |
| 11 | Concrete Coatings | $20,000 |
| 12 | Electrical | $70,000 |
| 13 | Instrumentation and Programming | $50,000 |
| | Project Subtotal: | $475,000 |
| | Mobilization/Demobilization: | $45,000 |
| | Contractor Overhead and Profit: | $95,000 |
| | **Project Total:** | **$615,000** |
| | Pre Design Contingency @ 30%: | $185,000 |
| | **Total w/Contingency:** | **$800,000** |

Typically, engineering and construction management are about 20% of construction cost and therefore the projected budget for capital expenditures for Alternative 2 would be $960,000.

**Consumables Cost:** The typical cost of 12.5% sodium hypochlorite is about $0.60 to $1.00 per pound of chlorine. The price of liquid sodium hypochlorite fluctuates as the market is dependent on manufacturing output which historically has varied. For the CAWD usage of approximately 100,000 lbs of chlorine used per year, the annual cost for chlorine would be in the range of $60,000 to $100,000 annually. Historically the price of 12.5% sodium hypochlorite has reached as high as $2.50 per pound and as low as $0.40 per pound of chlorine, which demonstrates the volatility. Most of the chlorine production facilities in the U.S. are located in the Gulf Coast region and are therefore subject to production outages caused by hurricanes. Furthermore, municipal chlorine usage comprises only 5% of the market with the other 95% being consumed by the plastics and pesticides market, which means municipalities have less control over price increases.

### Alternative 3: Low Concentration (0.8%) Onsite Hypochlorite Generation by Direct Electrolysis

Onsite sodium hypochlorite generators (OSHG) generate low concentration (0.8%) sodium hypochlorite through the electrolysis of a saturated sodium chloride solution brine. OSHG is the safest method to deliver chlorine and is increasingly being used throughout North America. The process consumes water, salt, and power. Generation of 1 pound of chlorine (as $Cl_2$) requires approximately 3 to 3.5 pounds of salt, 15 gallons of water (treated by a water softener to remove hardness), and 2 to 2.5 kilowatt-hours (kWh) of electrical energy. Brine enters the electrolytic cell, which forms a sodium hypochlorite solution and hydrogen gas through a series of chemical reactions that produces a net reaction of:

$$NaCl + H_2O = NaOCl + H_2$$

The hydrogen is vented to the atmosphere where it becomes diluted and is not an explosive hazard. A feed water softening system is required to minimize calcium carbonate scaling of the OSHG electrodes. The water softener would be a typical dual self regenerating sodium zeolite commercial water softener.

The 0.8% hypochlorite solution produced onsite is a non-hazardous solution concentration, significantly reducing the requirement for special handling and containment procedures, including a Risk Management Plan (RMP). There are a number of manufacturers of similar OSHG systems including: Severn Trent's ClorTec, Process Solutions, Inc's MICROclor, MIOX systems, and Siemens' Wallace & Tiernan OSEC Systems. This Pre-Design Memorandum utilizes data from the ClorTec system.

**Redundant Supply:** To insure the continuous operation of the chlorination system in case of equipment shutdowns, the system is proposed for redundancy as well as with backup chemical storage in case both the OSHG units fail. Two 600-lb/day OSHG units are recommended at a minimum for the CAWD WWTP. Typically, one unit would be sufficient for winter average conditions. Two units would need to be on line during peak storm influent conditions or chemical would be supplied from the reserves in the storage tanks.

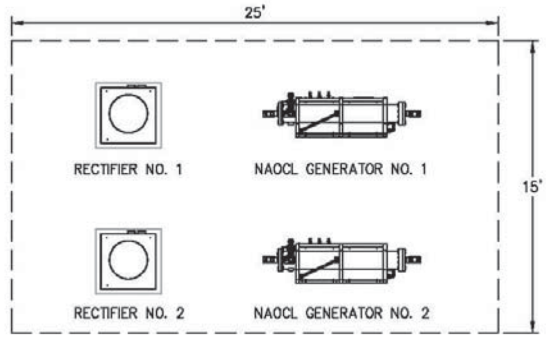
Typically, the OSHG units discharge to a storage tank containing about one day of solution at maximum production from which chemical metering pumps paced by flow and residual discharge to the chlorine contact chamber. Reserve chemical storage would be included to provide an emergency supply in the event that both generators fail, providing time for obtaining emergency chemical delivery and/or for repairing the hypochlorite generator equipment. Storing concentrated 6% hypochlorite as an emergency backup to the low concentration chemical storage is typical and is recommended for high dosage requirements and when there is repair or maintenance of an OSHG unit. It is more concentrated than 0.8% and therefore requires less space. A 6% concentration hypochlorite solution will not degrade rapidly like 12.5% hypochlorite. Table 9 shows the days of backup chemical that would be available for the different wastewater flows under the worst case condition of both hypochlorite generators going offline. Figure 3 shows a general equipment layout including the reserve chemical storage tanks.

**Feed Water Requirements:** The electrolytic cells require hardness below 10 mg/L to prevent electrode scaling and therefore a water softening system should be included. The most efficient operation of the OSHG units is when the temperature of the feed water is above 60$^{o}$ F. The temperature should be confirmed during winter conditions of high chlorine demand. A water heater may be required during winter.

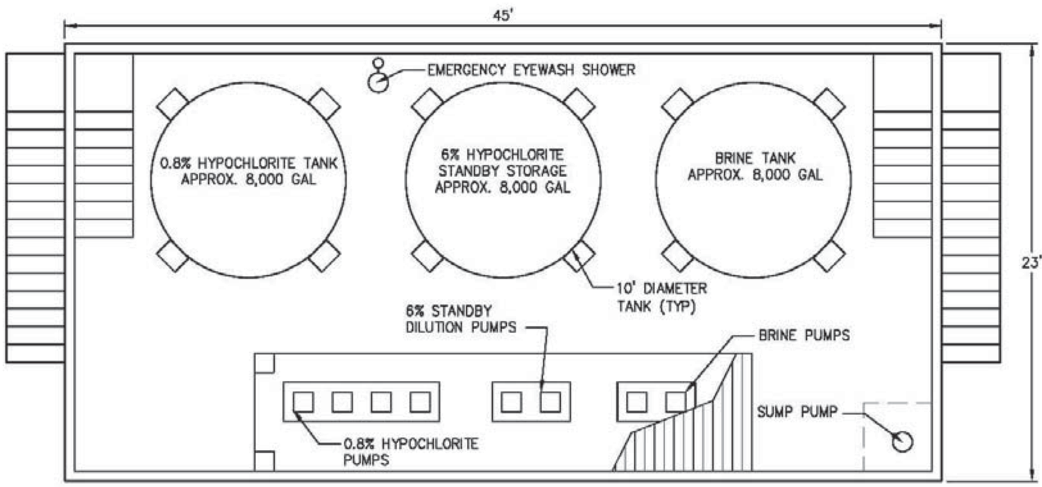
The existing #1 water system has noticeable red discoloration due to iron corrosion in the onsite #1 water piping. This corrosion issue should be addressed by CAWD to utilize OSHG. The reject from the RO membranes could be used as a feed water supply for the OSHG; however, the supply is not continuous and therefore a storage tank would be required to provide a continuous supply of RO reject for the generation of 0.8% hypo.

**Power Requirements:** The power requirements for an OSHG system at CAWD are summarized in Table 9 for the various flow conditions.

**Salt Handling and Brine Storage:** High purity salt is required for OSHG and is locally available from Morton Salt in Newark, Ca. The salt can be delivered in tanker trucks in quantities up to 50,000 lbs (5,000 gallons). The equipment layout for OSHG in Figure 3 shows that the brine would be stored in an 8,000-gallon tank. The brine storage tank is sized so that a full truck load of salt can be delivered. This reduces the frequency of salt deliveries to about seven times a year on average and reduces higher costs associated with purchasing partial truck loads. The bulk salt deliveries would be transferred to the tank from the delivery truck by using a blower. As the salt is blown into the storage tank the displaced air would escape through a filtered vent on top of the vault.




HYPO GENERATOR EQUIPMENT (INSIDE (E) TERTIARY BUILDING) PLAN




STORAGE TANK AND PUMP AREA (OUTSIDE (E) TERTIARY BUILDING)

**Kennedy/Jenks Consultants**

CARMEL AREA
WASTEWATER DISTRICT

**ONSITE SODIUM HYPOCHLORITE GENERATION EQUIPMENT LAYOUTS**

K/J 1268007*01
JUNE 2012

**FIGURE 3**

## Table 9: Low Concentration Onsite Generation System Design Summary

| Parameter | Unit | Maximum Instantaneous | Winter Avg. | Summer Avg. | Recycled Water |
|---|---|---|---|---|---|
| Plant Flow | MGD | 9 | 4 | 1.5 | 1 |
| Min $Cl_2$ Dosage | mg/l | 10 | 10 | 10 | 10 |
| Average $Cl_2$ Dosage | mg/l | 12 | 12 | 12 | 12 |
| Max $Cl_2$ Dosage | mg/l | 20 | 20 | 20 | 20 |
| Min Dose $Cl_2$ Usage | lb/day | 750 | 330 | 130 | 83 |
| Average Dose $Cl_2$ Usage | lb/day | 900 | 400 | 150 | 100 |
| Max Dose $Cl_2$ Usage | lb/day | 1,500 | 670 | 250 | 170 |
| Sodium Hypo Solution Concentration | Trade Percent | 0.8% | 0.8% | 0.8% | 0.8% |
| Available $Cl_2$ per Gallon | lb/gal | 0.067 | 0.067 | 0.067 | 0.067 |
| 0.8% Hypo Required per Day | gal/day | 22,500 (max dose) | 6,000 (avg dose) | 2,250 (avg dose) | 1,500 (avg dose) |
| ***0.8% Hypo Generators:*** | | | | | |
| 0.8% OSHG Units | number | 2 | 2 | 2 | 2 |
| $Cl_2$ Generated by one OSHG Unit | lb/day | 600 | 600 | 600 | 600 |
| 0.8% Sodium Hypo Generated by one Unit | gal/day | 9,000 | 9,000 | 9,000 | 9,000 |
| ***Standby Chemical Storage:*** | | | | | |
| 6% Hypo Standby Storage Volume | gal | 8,000 | 8,000 | 8,000 | 8,000 |
| 6% Storage Available $Cl_2$ | lb | 4,000 | 4,000 | 4,000 | 4,000 |
| 0.8% Solution Storage Volume | gal | 8,000 | 8,000 | 8,000 | 8,000 |
| 0.8% Storage Available $Cl_2$ | lb | 500 | 500 | 500 | 500 |
| Chemical Reserve Days w/Generators Offline (Effluent + RW Usage) | day | 2.8 (max dose) | 8.8 (avg dose) | 18 (avg dose) | Included |
| ***Brine System:*** | | | | | |
| Salt Required | lb/day | 4,500 (max dose) | 1,200 (avg dose) | 450 (avg dose) | 300 (avg dose) |
| Salt Delivery | lb | 50,000 | 50,000 | 50,000 | 50,000 |
| Brine Tank Size | gal | 8,000 | 8,000 | 8,000 | 8,000 |
| Days of Reserve Brine (Effluent + RW Usage) | day | 10 | 30 | 70 | Included |
| ***Power Requirements:*** | | | | | |
| Daily Power Required (Effluent + RW Usage) | kWh/day | 3,200 | 1,000 | 500 | Included |
| ***Water Requirements:*** | | | | | |
| Daily Water Required (Effluent + RW Usage) | gal/day | 22,500 (max dose) | 7,500 (avg dose) | 3,750 (avg dose) | Included |

**Operations and Maintenance:** Standard system operating procedures are described as follows. When the OSHG system is energized either locally or remotely from the storage tank level, a solenoid valve opens on the potable water feed pipe, and water flows through the water softener. Softened water is then fed into the brine tank, where salt dissolves to form a 30% brine solution, which is further diluted to a 12:1 water-to-brine ratio solution before the electrode electrolyzer. This solution is pumped through the electrolytic cells, where a low-voltage direct current is applied to the brine to produce a typical 0.8% hypochlorite solution. The solution is then fed into the storage tank; from there the metering pumps inject the solution as needed. When the hypochlorite tank levels reach a low-level set point, the onsite generation system automatically starts and fills the tank and is turned off on high tank level.

Periodic electrode cell cleaning is required to keep the electrolyzer working efficiently. Typically one or two mild acid washes a year should keep the electrolyzer clean of calcium carbonate build up. Pumps are a main part of the system. For reliability the pumps should be kept on a regular maintenance interval. Daily analytical measurements of chlorine concentration, hypochlorite and brine volumes, and electrode cell power demand should be taken to confirm the system is operating effectively.

## Alternative 3 Level of Service

Table 10 describes the levels of service that would be provided by a new 0.8% sodium hypochlorite onsite generation, storage and feed system.

Table 10: Alternative 3: Levels of Service

| Level of Service Goal | Alternative 3 |
|---|---|
| Improved Safety for Staff | 0.8% liquid sodium hypochlorite is a non-hazardous solution due to the low concentration of $Cl_2$. The 6% liquid hypochlorite used for standby chemical storage is still a hazardous concentration and therefore similar safety procedures should be followed for 6% hypo as 12.5% hypo. |
| Improved Safety for the Public | As long as acids are kept away from the 6% liquid hypochlorite storage area there would be little risk of offsite public exposure to chlorine gas. |
| Simplicity of Operations | The onsite sodium hypochlorite generator equipment is more complex and has a greater number of critical components than the 12.5% hypo storage and feed system (Alternative 2). |
| Reliability of the System | The system would be designed with redundant generators and standby chemical storage. |
| Economical Life Cycle | Consumables costs associated with OSHG can be lower than the cost of bulk 12.5% sodium hypochlorite. However at times when 12.5% hypo bulk costs are less than $0.60 per pound, the cost to generate sodium hypochlorite onsite can be higher. |
| Compatibility with Existing System | 0.8% Liquid sodium hypochlorite can be accurately dosed at equivalent rates as the existing chlorine gas system. Modifications to the existing system could include installing new chlorine injection equipment (water champ). |

### Alternative 3 Estimated Cost

**Capital Cost:** Table 11 shows the estimated capital cost for a new onsite 0.8% sodium hypochlorite generation storage and feed system.

Table 11: Low Concentration (0.8%) Onsite Hypo Generation System Probable Construction Cost Summary

| Item | Description | Cost |
|---|---|---|
| **Sodium Hypochlorite Generation Equipment (Housed in Tertiary Building)** | | |
| 1 | OSHG System (2 x 600 lb/day Capacity) | $450,000 |
| 2 | Equipment Installation & Startup | $30,000 |
| **Storage Tank Area** | | |
| 3 | Site Work | $15,000 |
| 4 | Tank Area Elevated Foundation | $40,000 |
| 5 | Tank Area Concrete Equipment Pads | $10,000 |
| 6 | Flood and Spill Concrete Containment Walls | $25,000 |
| 7 | Stairs | $20,000 |
| 8 | Brine Piping | $5,000 |
| 9 | Brine Pumps | $10,000 |
| 10 | Brine Tank | $30,000 |
| 11 | Chemical Piping and Appurtenances | $50,000 |
| 12 | Chemical Metering Pumps | $65,000 |
| 13 | Two New Water Champs | $70,000 |
| 14 | Tanks | $60,000 |
| 15 | Emergency Eyewash Showers | $10,000 |
| 16 | Concrete Coatings | $20,000 |
| 17 | Electrical | $100,000 |
| 18 | Instrumentation and Programming | $70,000 |
| | Project Subtotal: | $1,080,000 |
| | Mobilization/Demobilization: | $100,000 |
| | Contractor Overhead and Profit: | $200,000 |
| | **Project Total:** | **$1,380,000** |
| | Pre Design Contingency @ 30%: | $400,000 |
| | **Total w/Contingency:** | **$1,780,000** |

Typically, engineering and construction management are about 20% of construction cost and therefore the projected budget for capital expenditures for Alternative 3 would be $2,140,000.

**Consumables Cost:** The consumables cost for OSHG is summarized in Table 12.

Table 12: Low Concentration (0.8%) Onsite Generation System Consumables Cost Summary

| | | |
|---|---|---|
| Estimated lbs of Chlorine Used per Year | 100,000 lbs | |
| | *Unit Cost per lb* | *Annual Cost* |
| Salt Cost | $0.25 | $25,000 |
| Electricity Cost | $0.24 | $24,000 |
| Potable Water Cost | $0.05 | $5,000 |
| Electrolytic Cell Replacement | - | $6,000 |
| Total Yearly Consumables Costs | $0.66 | *$60,000* |

## Discussion of Non-Chlorine Disinfection Systems

Non-chlorine disinfection systems are not recommended for CAWD to implement at this time. The two primary reasons why these are not recommended have to do with the capital cost investment, questionable reduced O&M payback, and in the cases of UV and pasteurization chlorine would still be required on-site for micro-filtration membrane bio-fouling control with chloramines and for recycled water disinfection residual. The following provides a brief synopsis of non-chlorine disinfection technologies.

**Ultraviolet Light (UV) Disinfection:** This disinfection technology utilizes UV wavelength light to kill microorganisms and viruses. The 1998 HDR disinfection options study evaluated UV as a disinfection alternative for disinfection at CAWD. UV disinfection was not recommended due to cost and other factors including changes to the NPDES coliform limits. The HDR UV alternative developed also assumed that liquid sodium hypochlorite would be required to be used during wet weather to reduce the size of the UV disinfection system. Furthermore, the O&M costs cited for UV were higher than for liquid hypochlorite in the HDR study.

**Pasteurization:** Pasteurization can be used to disinfect wastewater by heating the wastewater to a temperature which kills microorganisms and viruses. The heating can be achieved via heat exchangers which can utilize waste heat from various sources such as engine generators powered by digester gas. This approach is currently being tested at full scale wastewater treatment plants and there are promising advantages to this technology at WWTP which have significant amounts of excess waste heat. However, CAWD does not currently have a source of excess waste heat, as the waste heat which does exist should be used to heat the digesters. Therefore, the capital costs associated with pasteurization at CAWD do not appear to be justified without a significant source of onsite waste heat.

**Ozone:** Ozone is a strong oxidant and virucide which is effective in disinfecting wastewater. Ozone is generated onsite because it is unstable and quickly decomposes to elemental oxygen. Ozone generator equipment and ancillary equipment is complex and requires specialized training. The capital cost for an ozone system would include construction of: ozone generation equipment, ozone contact vessel (or contact pipeline), and ozone destruct equipment for off-gasses from the ozone contactor. Generation of ozone onsite is power intensive. The EPA estimates that 90 kW of continuous load is required to disinfect 1 MGD of wastewater and therefore the cost of power for ozone disinfection would be greater than $100,000 a year for CAWD. The annual power costs would therefore exceed the average annual cost of 12.5% liquid sodium hypochlorite. Due to the complexity of the operations, high capital costs and high power costs, ozone is not recommended for further evaluation for the CAWD WWTP at this time.

## Costs Comparison

The estimated capital cost, yearly consumables, risk management planning and liability insurance costs for the three chlorine alternatives presented are summarized in Table 13.

Table 13: Estimated Costs Comparison

| | Alternative 1 $Cl_2$ Gas w/ Scrubber | Alternative 2 12.5% Hypo | Alternative 3 OSHG |
|---|---|---|---|
| Initial Estimated Capital Cost | $910,000 | $960,000 | $2,140,000 |
| 10-year Projected Capital Improvements | $500,000 | $0 | $0 |
| Consumables Cost per year | $30,000[(a)] | $100,000[(b)] | $60,000[(c)] |
| Estimated Total Capital Replacement Value[(d)] | ≈$2,500,000 | ≈$1,000,000 | ≈$2,200,000 |
| 20-Year Present Worth of Costs[(e)] | $2,010,000 | $2,960,000 | $3,340,000 |
| 20-year Annual Cost[(f)(g)] | $100,000 | $148,000 | $167,000 |

**Notes:**

(a) Based upon gas chlorine cost of $0.30/lb. and 100,000 lb $Cl_2$ per year usage.
(b) Based upon bulk sodium hypochlorite cost of $1.00/lb. and 100,000 lb $Cl_2$ per year usage (Historical variations in hypochlorite cost range from $0.40/lb to $2.50/lb).
(c) See Table 12 for OSHG Consumables Cost Summary.
(d) Capital replacement value estimates the total cost of assets if they were completely replaced in 2012 dollars.
(e) 20-year present worth includes capital and consumable cost, and assumes no inflation.
(f) Assumes consumables cost plus straight line amortization of capital cost.
(g) Labor is not included as alternatives can be operated by existing plant staff.

The economic comparison in Table 13 shows that the lowest overall cost option is Alternative 1, maintaining the existing gas chlorine feed system. The significant cost advantage of the gas chlorine system is that it utilizes existing structures and existing equipment. If chlorine gas was being evaluated as a completely new storage and feed system, it would most likely have a 20-year present worth of about $3,000,000.

The market price of 12.5% bulk hypochlorite used in Alternative 2 can change significantly from year to year, as it has for periods in the past. 12.5% sodium hypochlorite volatility could either decrease or increase the total cost of Alternative 2 on an annual basis. The use of $1.00 per pound of chlorine for hypo is conservative.

Alternative 3 costs are slightly higher than Alternative 2 and there does not appear to major economic driver toward Alternative 3 and an OSHG disinfection system except if the price of 12.5% sodium hypochlorite increased significantly for an extended period of time. As discussed below the decision to use OSHG would likely need to be a public policy decision based on reducing transportation of hazardous chemicals on local highways.

## Level of Service Comparison

The desired levels of service for each alternative are compared side by side in Table 14.

### Table 14: Do Alternatives Meet Level of Service Goals?

| Level of Service Goal | Alternative 1 $Cl_2$ Gas w/ Scrubber | Alternative 2 12.5% Hypo | Alternative 3 OSHG |
|---|---|---|---|
| Improved Safety for Staff | Partial Improvement | Yes | Yes |
| Improved Safety for the Public | Partial Improvement | Yes | Yes |
| Simplicity of Operations | Yes | Yes | No |
| Reliability of the System | Yes | Yes | Yes |
| Economical Annual Cost | Yes | No | No |
| Compatibility with Existing System | Yes | Yes | Yes |

## Risk Comparison

Table 15 compares the risks associated with each alternative relatively, therefore the comparison is not meant to assign how likely the risk could occur, but is based on the likelihood compared relatively with the other alternatives.

### Table 15: Relative Risk Comparison

| Risk | Alternative 1 $Cl_2$ Gas w/ Scrubber | Alternative 2 12.5% Hypo | Alternative 3 OSHG |
|---|---|---|---|
| Chemical Exposure above Safe Levels (onsite and offsite) | Higher Risk | Moderate Risk | Lower Risk |
| Free Chlorine Damage to Micro-Filtration Membranes | Equal Risk | Equal Risk | Equal Risk |
| NPDES Permit Violations | Lower Risk | Lower Risk | Moderate Risk |
| Recycled Water Permit Violations | Equal Risk | Equal Risk | Equal Risk |

## Apparent Best Alternative

The cost savings associated with continuing to use chlorine gas for disinfection at CAWD would be about $1 million over the next 20 years when compared to 12.5% sodium hypochlorite. However, the level of service desired by CAWD plant staff in terms of safety would not be completely met by continued use of chlorine gas, though the current level of safety would be improved by upgrading piping systems and adding a scrubber to treat leaks originating in the one-ton storage room. Kennedy/Jenks has not conducted a detailed probability based risk analysis for harmful exposures offsite or onsite resulting from chlorine gas leaks for the CAWD system and cannot verify the risk analyses conducted by Montgomery Watson in their 1993 Offsite Consequence Analysis. Therefore, it is difficult to quantify a dollar amount to place on the potential damage to human health that would be added to the cost of Alternative 1 to account for possible future exposure to chlorine gas. It is conceivable that $1 million in costs could be incurred by CAWD in a law suit if a person or persons were affected by a chlorine gas release in the next 20 years.

The 20-year present worth for OSHG shows that this is the highest cost alternative. The decision to choose OSHG as the disinfection alternative would be a public policy decision as there has been increasing public pressure to discontinue the transport of hazardous chemicals on public highways and in residential areas. OSHG eliminates most of this public concern and is therefore increasing in prominence for public water and wastewater utilities.

Based on the desires of CAWD staff for improved safety and operational simplicity, it appears that Alternative 2, disinfection with 12.5% liquid sodium hypochlorite, is the best apparent alternative for improvements at this time. The total replacement cost for hypo assets is lower than any other alternative. 12.5% liquid sodium hypochlorite is the most frequent chlorine gas conversion in the industry with the majority of municipal WWTP using this disinfection approach. However, CAWD should consider possible future public pressures associated with increased trucking of hazardous chemicals to the WWTP. If public policy associated with hazardous chemicals transport dictates over the life-cycle cost than OSHG may be a more preferable alternative for CAWD to consider.

If CAWD decides to move forward with implementing a 12.5% liquid sodium hypochlorite disinfection system, Kennedy/Jenks recommends that this be built to replace the current chlorine gas system within the next 5 years. The estimated schedule from start of design to completion of construction of a new 12.5% liquid sodium hypochlorite would be in the range of 52 weeks.

## References

White, G.C. 1999. “Handbook of Chlorination and Alternative Disinfectants,” 4th Edition, Witey, New York.

HDR. 1998. “Carmel Area Wastewater District, Disinfection Options Study.”

Montgomery Watson. 1993. “Carmel Area Wastewater District - Offsite Consequence Analysis.”

Enclosure: Applicable Sections of California Fire Code toxic liquids or solids, and the weather protection is attached to a building, the storage or use area shall either be equipped throughout with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1, or storage or use vessels shall be fire resistive. Weather protection shall be provided in accordance with Section 2704.13 for storage and Section 2705.3.9 for use.

**3703.2.6 Outdoor liquid transfer.** Highly toxic and toxic liquids shall be transferred in accordance with Section 2705.1.10.

## SECTION 3704
## HIGHLY TOXIC AND TOXIC COMPRESSED GASES

**3704.1 General.** The storage and use of highly toxic and toxic *compressed gases* shall comply with this section.

**3704.1.1 Special limitations for indoor storage and use by occupancy.** The indoor storage and use of highly toxic and toxic *compressed gases* in certain occupancies shall be subject to the limitations contained in Sections 3704.1.1.1 through 3704.1.1.3.

**3704.1.1.1 Group A, E, I or U occupancies.** Toxic and highly toxic *compressed gases* shall not be stored or used within Group A, E, I or U occupancies.

**Exception:** Cylinders not exceeding 20 cubic feet (0.566 $m^3$) at *normal temperature and pressure (NTP)* are allowed within gas cabinets or fume hoods.

**3704.1.1.2 Group R occupancies.** Toxic and highly toxic *compressed gases* shall not be stored or used in Group R occupancies.

**3704.1.1.3 Offices, retail sales and classrooms.** Toxic and highly toxic *compressed gases* shall not be stored or used in offices, retail sales or classroom portions of Group B, F, M or S occupancies.

**Exception:** In classrooms of Group B occupancies, cylinders with a capacity not exceeding 20 cubic feet (0.566 $m^3$) at *NTP* are allowed in gas cabinets or fume hoods.

**3704.1.2 Gas cabinets.** Gas cabinets containing highly toxic or toxic *compressed gases* shall comply with Section 2703.8.6 and the following requirements:

1. The average ventilation velocity at the face of gas cabinet access ports or windows shall not be less than 200 feet per minute (1.02 m/s) with a minimum of 150 feet per minute (0.76 m/s) at any point of the access port or window.
2. Gas cabinets shall be connected to an exhaust system.
3. Gas cabinets shall not be used as the sole means of exhaust for any room or area.
4. The maximum number of cylinders located in a single gas cabinet shall not exceed three, except that cabinets containing cylinders not over 1 pound (0.454 kg) net contents are allowed to contain up to 100 cylinders.
5. Gas cabinets required by Section 3704.2 or 3704.3 shall be equipped with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1. Alternative fire-extinguishing systems shall not be used.

**3704.1.3 Exhausted enclosures.** Exhausted enclosures containing highly toxic or toxic *compressed gases* shall comply with Section 2703.8.5 and the following requirements:

1. The average ventilation velocity at the face of the enclosure shall not be less than 200 feet per minute (1.02 m/s) with a minimum of 150 feet per minute (0.76 m/s).
2. Exhausted enclosures shall be connected to an exhaust system.
3. Exhausted enclosures shall not be used as the sole means of exhaust for any room or area.
4. Exhausted enclosures required by Section 3704.2 or 3704.3 shall be equipped with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1. Alternative fire-extinguishing systems shall not be used.

**3704.2 Indoor storage and use.** The indoor storage and use of highly toxic or toxic *compressed gases* shall be in accordance with Sections 3704.2.1 through 3704.2.2.10.3.

**3704.2.1 Applicability.** The applicability of regulations governing the indoor storage and use of highly toxic and toxic *compressed gases* shall be as set forth in Sections 3704.2.1.1 through 3704.2.1.3.

**3704.2.1.1 Quantities not exceeding the maximum allowable quantity per control area.** The indoor storage or use of highly toxic and toxic gases in amounts not exceeding the *maximum allowable quantity per control area* set forth in Table 2703.1.1(2) shall be in accordance with Sections 2701, 2703, 3701 and 3704.1.

**3704.2.1.2 Quantities exceeding the maximum allowable quantity per control area.** The indoor storage or use of highly toxic and toxic gases in amounts exceeding the *maximum allowable quantity per control area* set forth in Table 2703.1.1(2) shall be in accordance with Sections 3701, 3704.1, 3704.2 and Chapter 27.

**3704.2.1.3 Ozone gas generators.** The indoor use of ozone gas-generating equipment shall be in accordance with Section 3705.

**3704.2.2 General indoor requirements.** The general requirements applicable to the indoor storage and use of highly toxic and toxic *compressed gases* shall be in accordance with Sections 3704.2.2.1 through 3704.2.2.10.3.

**3704.2.2.1 Cylinder and tank location.** Cylinders shall be located within gas cabinets, exhausted enclosures or gas rooms. Portable and stationary tanks shall be located within gas rooms or exhausted enclosures.

**3704.2.2.2 Ventilated areas.** The room or area in which gas cabinets or exhausted enclosures are located shall be provided with exhaust ventilation. Gas cabinets or exhausted enclosures shall not be used as the sole means of exhaust for any room or area.

**3704.2.2.3 Leaking cylinders and tanks.** One or more gas cabinets or exhausted enclosures shall be provided to handle leaking cylinders, containers or tanks.

**Exceptions:**

1. Where cylinders, containers or tanks are located within gas cabinets or exhausted enclosures.
2. Where *approved* containment vessels or containment systems are provided in accordance with all of the following:
   - 2.1. Containment vessels or containment systems shall be capable of fully containing or terminating a release.
   - 2.2. Trained personnel shall be available at an *approved* location.
   - 2.3. Containment vessels or containment systems shall be capable of being transported to the leaking cylinder, container or tank.

**3704.2.2.3.1 Location.** Gas cabinets and exhausted enclosures shall be located in gas rooms and connected to an exhaust system.

**3704.2.2.4 Local exhaust for portable tanks.** A means of local exhaust shall be provided to capture leaks from portable tanks. The local exhaust shall consist of portable ducts or collection systems designed to be applied to the site of a leak in a valve or fitting on the tank. The local exhaust system shall be located in a gas room. Exhaust shall be directed to a treatment system in accordance with Section 3704.2.2.7.

**3704.2.2.5 Piping and controls—stationary tanks.** In addition to the requirements of Section 2703.2.2, piping and controls on stationary tanks shall comply with the following requirements:

1. Pressure relief devices shall be vented to a treatment system designed in accordance with Section 3704.2.2.7.

   **Exception:** Pressure relief devices on outdoor tanks provided exclusively for relieving pressure due to fire exposure are not required to be vented to a treatment system provided that:

   1. The material in the tank is not flammable.
   2. The tank is not located in a diked area with other tanks containing combustible materials.
   3. The tank is located not less than 30 feet (9144 mm) from combustible materials or structures or is shielded by a *fire barrier* complying with Section 3704.3.2.1.1.

2. Filling or dispensing connections shall be provided with a means of local exhaust. Such exhaust shall be designed to capture fumes and vapors. The exhaust shall be directed to a treatment system in accordance with Section 3704.2.2.7.

3. Stationary tanks shall be provided with a means of excess flow control on all tank inlet or outlet connections.

   **Exceptions:**

   1. Inlet connections designed to prevent backflow.
   2. Pressure relief devices.

**3704.2.2.6 Gas rooms.** Gas rooms shall comply with Section 2703.8.4 and both of the following requirements:

1. The exhaust ventilation from gas rooms shall be directed to an exhaust system.
2. Gas rooms shall be equipped with an *approved automatic sprinkler system.* Alternative fire-extinguishing systems shall not be used.

**3704.2.2.7 Treatment systems.** The exhaust ventilation from gas cabinets, exhausted enclosures and gas rooms, and local exhaust systems required in Sections 3704.2.2.4 and 3704.2.2.5 shall be directed to a treatment system. The treatment system shall be utilized to handle the accidental release of gas and to process exhaust ventilation. The treatment system shall be designed in accordance with Sections 3704.2.2.7.1 through 3704.2.2.7.5 and *Chapter 5* of the *California Mechanical Code.*

**Exceptions:**

1. Highly toxic and toxic gases—storage. A treatment system is not required for cylinders, containers and tanks in storage when all of the following controls are provided:
   - 1.1. Valve outlets are equipped with gas-tight outlet plugs or caps.
   - 1.2. Handwheel-operated valves have handles secured to prevent movement.
   - 1.3. *Approved* containment vessels or containment systems are provided in accordance with Section 3704.2.2.3.
2. Toxic gases—use. Treatment systems are not required for toxic gases supplied by cylinders or portable tanks not exceeding 1,700 pounds (772 kg) water capacity when the following are provided:
   - 2.1. A *listed* or *approved* gas detection system with a sensing interval not exceeding 5 minutes.
   - 2.2. A *listed* or *approved* automatic-closing fail-safe valve located immediately adjacent to cylinder valves. The fail-safe valve shall close when gas is detected at the permissible exposure limit (PEL) by a gas detection system monitoring the exhaust system at the point of discharge from the gas cabinet, exhausted enclosure, ventilated enclosure or gas room. The gas detection system shall comply with Section 3704.2.2.10.

**3704.2.2.7.1 Design.** Treatment systems shall be capable of diluting, adsorbing, absorbing, containing, neutralizing, burning or otherwise processing the contents of the largest single vessel of compressed gas. Where a total containment system is used, the system shall be designed to handle the maximum anticipated pressure of release to the system when it reaches equilibrium.

**3704.2.2.7.2 Performance.** Treatment systems shall be designed to reduce the maximum allowable discharge concentrations of the gas to one-half immediate by dangerous to life and health (IDLH) at the point of discharge to the atmosphere. Where more than one gas is emitted to the treatment system, the treatment system shall be designed to handle the worst-case release based on the release rate, the quantity and the IDLH for all *compressed gases* stored or used.

**3704.2.2.7.3 Sizing.** Treatment systems shall be sized to process the maximum worst-case release of gas based on the maximum flow rate of release from the largest vessel utilized. The entire contents of the largest *compressed gas* vessel shall be considered.

**3704.2.2.7.4 Stationary tanks.** Stationary tanks shall be labeled with the maximum rate of release for the *compressed gas* contained based on valves or fittings that are inserted directly into the tank. Where multiple valves or fittings are provided, the maximum flow rate of release for valves or fittings with the highest flow rate shall be indicated. Where liquefied *compressed gases* are in contact with valves or fittings, the liquid flow rate shall be utilized for computation purposes. Flow rates indicated on the label shall be converted to cubic feet per minute ($ft^3/min$) ($m^3/s$) of gas at *normal temperature and pressure (NTP).*

**3704.2.2.7.5 Portable tanks and cylinders.** The maximum flow rate of release for portable tanks and cylinders shall be calculated based on the total release from the cylinder or tank within the time specified in Table 3704.2.2.7.5. When portable tanks or cylinders are equipped with *approved* excess flow or reduced flow valves, the worst-case release shall be determined by the maximum achievable flow from the valve as determined by the valve manufacturer or *compressed gas* supplier. Reduced flow and excess flow valves shall be permanently marked by the valve manufacturer to indicate the maximum design flow rate. Such markings shall indicate the flow rate for air under *normal temperature and pressure.*

**3704.2.2.8 Emergency power.** Emergency power in accordance with the Section 604 and *the California Electrical Code* shall be provided in lieu of standby power where any of the following systems are required:

1. Exhaust ventilation system.
2. Treatment system.
3. Gas detection system.
4. Smoke detection system.
5. Temperature control system.
6. Fire alarm system.
7. Emergency alarm system.

**Exception:** Emergency power is not required for mechanical exhaust ventilation, treatment systems and temperature control systems where *approved* fail-safe engineered systems are installed.

**TABLE 3704.2.2.7.5**
**RATE OF RELEASE FOR CYLINDERS AND PORTABLE TANKS**

| VESSEL TYPE | NONLIQUEFIED (minutes) | LIQUEFIED (minutes) |
|---|---|---|
| Containers | 5 | 30 |
| Portable tanks | 40 | 240 |

**3704.2.2.9 Automatic fire detection system—highly toxic compressed gases.** An *approved* automatic fire detection system shall be installed in rooms or areas where highly toxic *compressed gases* are stored or used. Activation of the detection system shall sound a local alarm. The fire detection system shall comply with Section 907.

**3704.2.2.10 Gas detection system.** A gas detection system shall be provided to detect the presence of gas at or below the PEL or ceiling limit of the gas for which detection is provided. The system shall be capable of monitoring the discharge from the treatment system at or below one-half the IDLH limit.

**Exception:** A gas detection system is not required for toxic gases when the physiological warning threshold level for the gas is at a level below the accepted PEL for the gas.

**3704.2.2.10.1 Alarms.** The gas detection system shall initiate a local alarm and transmit a signal to a constantly attended control station when a short-term hazard condition is detected. The alarm shall be both visual and audible and shall provide warning both inside and outside the area where gas is detected. The audible alarm shall be distinct from all other alarms.

**Exception:** Signal transmission to a constantly attended control station is not required where not more than one cylinder of highly toxic or toxic gas is stored.

**3704.2.2.10.2 Shut off of gas supply.** The gas-detection system shall automatically close the shutoff valve at the source on gas supply piping and tubing related to the system being monitored for whichever gas is detected.

**Exception:** Automatic shutdown is not required for reactors utilized for the production of highly toxic or toxic *compressed gases* where such reactors are:

1. Operated at pressures less than 15 pounds per square inch gauge (psig) (103.4 kPa).
2. Constantly attended.

3. Provided with readily accessible emergency shutoff valves.

**3704.2.2.10.3 Valve closure.** Automatic closure of shutoff valves shall be in accordance with the following:

1. When the gas-detection sampling point initiating the gas detection system alarm is within a gas cabinet or exhausted enclosure, the shutoff valve in the gas cabinet or exhausted enclosure for the specific gas detected shall automatically close.
2. Where the gas-detection sampling point initiating the gas detection system alarm is within a gas room and *compressed gas* containers are not in gas cabinets or exhausted enclosures, the shutoff valves on all gas lines for the specific gas detected shall automatically close.
3. Where the gas-detection sampling point initiating the gas detection system alarm is within a piping distribution manifold enclosure, the shutoff valve for the compressed container of specific gas detected supplying the manifold shall automatically close.

**Exception:** When the gas-detection sampling point initiating the gas-detection system alarm is at a use location or within a gas valve enclosure of a branch line downstream of a piping distribution manifold, the shutoff valve in the gas valve enclosure for the branch line located in the piping distribution manifold enclosure shall automatically close.

**3704.3 Outdoor storage and use.** The outdoor storage and use of highly toxic and toxic *compressed gases* shall be in accordance with Sections 3704.3.1 through 3704.3.4.

**3704.3.1 Applicability.** The applicability of regulations governing the outdoor storage and use of highly toxic and toxic *compressed gases* shall be as set forth in Sections 3704.3.1.1 through 3704.3.1.3.

**3704.3.1.1 Quantities not exceeding the maximum allowable quantity per control area.** The outdoor storage or use of highly toxic and toxic gases in amounts not exceeding the *maximum allowable quantity per control area* set forth in Table 2703.1.1(4) shall be in accordance with Sections 2701, 2703 and 3701.

**3704.3.1.2 Quantities exceeding the maximum allowable quantity per control area.** The outdoor storage or use of highly toxic and toxic gases in amounts exceeding the *maximum allowable quantity per control area* set forth in Table 2703.1.1(4) shall be in accordance with Sections 3701 and 3704.3 and Chapter 27.

**3704.3.1.3 Ozone gas generators.** The outdoor use of ozone gas-generating equipment shall be in accordance with Section 3705.

**3704.3.2 General outdoor requirements.** The general requirements applicable to the outdoor storage and use of highly toxic and toxic *compressed gases* shall be in accordance with Sections 3704.3.2.1 through 3704.3.2.4.

**3704.3.2.1 Location.** Outdoor storage or use of highly toxic or toxic *compressed gases* shall be located in accordance with Sections 3704.3.2.1.1 through 3704.3.2.1.3.

**Exception:** *Compressed gases* located in gas cabinets complying with Sections 2703.8.6 and 3704.1.2 and located 5 feet (1524 mm) or more from buildings and 25 feet (7620 mm) or more from an *exit discharge.*

**3704.3.2.1.1 Distance limitation to exposures.** Outdoor storage or use of highly toxic or toxic *compressed gases* shall not be located within 75 feet (22 860 mm) of a *lot line*, public street, public alley, *public way, exit discharge* or building not associated with the manufacture or distribution of such gases, unless all of the following conditions are met:

1. Storage is shielded by a 2-hour *fire barrier* which interrupts the line of sight between the storage and the exposure.
2. The 2-hour *fire barrier* shall be located at least 5 feet (1524 mm) from any exposure.
3. The 2-hour *fire barrier* shall not have more than two sides at approximately 90-degree (1.57 rad) directions, or three sides with connecting angles of approximately 135 degrees (2.36 rad).

**3704.3.2.1.2 Openings in exposed buildings.** Where the storage or use area is located closer than 75 feet (22 860 mm) to a building not associated with the manufacture or distribution of highly toxic or toxic *compressed gases*, openings into a building other than for piping are not allowed above the height of the top of the 2-hour *fire barrier* or within 50 feet (15 240 mm) horizontally from the storage area whether or not shielded by a *fire barrier.*

**3704.3.2.1.3 Air intakes.** The storage or use area shall not be located within 75 feet (22 860 mm) of air intakes.

**3704.3.2.2 Leaking cylinders and tanks.** The requirements of Section 3704.2.2.3 shall apply to outdoor cylinders and tanks. Gas cabinets and exhausted enclosures shall be located within or immediately adjacent to outdoor storage or use areas.

**3704.3.2.3 Local exhaust for portable tanks.** Local exhaust for outdoor portable tanks shall be provided in accordance with the requirements set forth in Section 3704.2.2.4.

**3704.3.2.4 Piping and controls—stationary tanks.** Piping and controls for outdoor stationary tanks shall be in accordance with the requirements set forth in Section 3704.2.2.5.

**3704.3.3 Outdoor storage weather protection for portable tanks and cylinders.** Weather protection in accordance with Section 2704.13 shall be provided for portable tanks and cylinders located outdoors and not within gas cabinets or exhausted enclosures. The storage area shall be equipped with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1.

**Exception:** An *automatic sprinkler system* is not required when:

1. All materials under the weather protection structure, including hazardous materials and the containers in which they are stored, are noncombustible.
2. The weather protection structure is located not less than 30 feet (9144 mm) from combustible materials or structures or is separated from such materials or structures using a *fire barrier* complying with Section 3704.3.2.1.1.

**3704.3.4 Outdoor use of cylinders, containers and portable tanks.** Cylinders, containers and portable tanks in outdoor use shall be located in gas cabinets or exhausted enclosures and shall comply with Sections 3704.3.4.1 through 3704.3.4.3.

**3704.3.4.1 Treatment systems.** The treatment system requirements set forth in Section 3704.2.2.7 shall apply to highly toxic or toxic gases located outdoors.

**3704.3.4.2 Emergency power.** The requirements for emergency power set forth in Section 3704.2.2.8 shall apply to highly toxic or toxic gases located outdoors.

**3704.3.4.3 Gas detection system.** The gas detection system requirements set forth in Section 3704.2.2.10 shall apply to highly toxic or toxic gases located outdoors.

## SECTION 3705 OZONE GAS GENERATORS

**3705.1 Scope.** Ozone gas generators having a maximum ozone-generating capacity of 0.5 pound (0.23 kg) or more over a 24-hour period shall be in accordance with Sections 3705.2 through 3705.6.

**Exceptions:**

1. Ozone-generating equipment used in Group R-3 occupancies.
2. Ozone-generating equipment when used in Group H-5 occupancies when in compliance with Chapters 18 and 27 and the other provisions in Chapter 37 for highly toxic gases.

**3705.2 Design.** Ozone gas generators shall be designed, fabricated and tested in accordance with NEMA 250.

**3705.3 Location.** Ozone generators shall be located in *approved* cabinets or ozone generator rooms in accordance with Section 3705.3.1 or 3705.3.2.

**Exception:** An ozone gas generator within an *approved* pressure vessel when located outside of buildings.

**3705.3.1 Cabinets.** Ozone cabinets shall be constructed of *approved* materials and compatible with ozone. Cabinets shall display an *approved* sign stating: OZONE GAS GENERATOR—HIGHLY TOXIC—OXIDIZER.

Cabinets shall be braced for seismic activity in accordance with the *California Building Code.*

Cabinets shall be mechanically ventilated in accordance with the *California Mechanical Code* with a minimum of six air changes per hour.

The average velocity of ventilation at makeup air openings with cabinet doors closed shall not be less than 200 feet per minute (1.02 m/s).

**3705.3.2 Ozone gas generator rooms.** Ozone gas generator rooms shall be mechanically ventilated in accordance with the *California Mechanical Code* with a minimum of six air changes per hour. Ozone gas generator rooms shall be equipped with a continuous gas detection system which will shut off the generator and sound a local alarm when concentrations above the permissible exposure limit occur.

Ozone gas-generator rooms shall not be normally occupied, and such rooms shall be kept free of combustible and hazardous material storage. Room access doors shall display an *approved* sign stating: OZONE GAS GENERATOR—HIGHLY TOXIC—OXIDIZER.

**3705.4 Piping, valves and fittings.** Piping, valves, fittings and related components used to convey ozone shall be in accordance with Sections 3705.4.1 through 3705.4.3.

**3705.4.1 Piping.** Piping shall be welded stainless steel piping or tubing.

**Exceptions:**

1. Double-walled piping.
2. Piping, valves, fittings and related components located in exhausted enclosures.

**3705.4.2 Materials.** Materials shall be compatible with ozone and shall be rated for the design operating pressures.

**3705.4.3 Identification.** Piping shall be identified with the following: OZONE GAS—HIGHLY TOXIC—OXIDIZER.

**3705.5 Automatic shutdown.** Ozone gas generators shall be designed to shut down automatically under the following conditions:

1. When the dissolved ozone concentration in the water being treated is above saturation when measured at the point where the water is exposed to the atmosphere.
2. When the process using generated ozone is shut down.
3. When the gas detection system detects ozone.
4. Failure of the ventilation system for the cabinet or ozone-generator room.
5. Failure of the gas detection system.

**3705.6 Manual shutdown.** Manual shutdown controls shall be provided at the generator and, where in a room, within 10 feet (3048 mm) of the main *exit* or *exit access* door.

**CLOSED CONTAINER.** A container sealed by means of a lid or other device such that liquid, vapor or dusts will not escape from it under ordinary conditions of use or handling.

**CONTAINER.** A vessel of 60 gallons (227 L) or less in capacity used for transporting or storing hazardous materials. Pipes, piping systems, engines and engine fuel tanks are not considered to be containers.

**CONTROL AREA.** Spaces within a building where quantities of hazardous materials not exceeding the *maximum allowable quantities per control area* are stored, dispensed, used or handled. See also the definition of "Outdoor control area."

**CYLINDER.** A pressure vessel designed for pressures higher than 40 psia (275.6 kPa) and having a circular cross section. It does not include a portable tank, multi-unit tank car tank, cargo tank or tank car.

**DAY BOX.** A portable magazine designed to hold *explosive* materials constructed in accordance with the requirements for a Type 3 magazine as defined and classified in Chapter 33.

**DEFLAGRATION.** An exothermic reaction, such as the extremely rapid oxidation of a flammable dust or vapor in air, in which the reaction progresses through the unburned material at a rate less than the velocity of sound. A deflagration can have an explosive effect.

**DESIGN PRESSURE.** The maximum gauge pressure that a pressure vessel, device, component or system is designed to withstand safely under the temperature and conditions of use expected.

**DETACHED BUILDING.** A separate single-story building, without a *basement* or crawl space, used for the storage or use of hazardous materials and located an *approved* distance from all structures.

**DISPENSING.** The pouring or transferring of any material from a container, tank or similar vessel, whereby vapors, dusts, fumes, mists or gases are liberated to the atmosphere.

**EXCESS FLOW CONTROL.** A fail-safe system or other *approved* means designed to shut off flow caused by a rupture in pressurized piping systems.

**EXHAUSTED ENCLOSURE.** An appliance or piece of equipment which consists of a top, a back and two sides providing a means of local exhaust for capturing gases, fumes, vapors and mists. Such enclosures include laboratory hoods, exhaust fume hoods and similar appliances and equipment used to retain and exhaust locally the gases, fumes, vapors and mists that could be released. Rooms or areas provided with general ventilation, in themselves, are not exhausted enclosures.

**EXPLOSION.** An effect produced by the sudden violent expansion of gases, which may be accompanied by a shock wave or disruption, or both, of enclosing materials or structures. An explosion could result from any of the following:

1. Chemical changes such as rapid oxidation, *deflagration* or *detonation*, decomposition of molecules and runaway polymerization (usually *detonations*).
2. Physical changes such as pressure tank ruptures.
3. Atomic changes (nuclear fission or fusion).

**FLAMMABLE VAPORS OR FUMES.** The concentration of flammable constituents in air that exceeds 25 percent of their lower flammable limit (LFL).

**GAS CABINET.** A fully enclosed, noncombustible enclosure used to provide an isolated environment for *compressed gas* cylinders in storage or use. Doors and access ports for exchanging cylinders and accessing pressure-regulating controls are allowed to be included.

**GAS ROOM.** A separately ventilated, fully enclosed room in which only *compressed gases* and associated equipment and supplies are stored or used.

**HANDLING.** The deliberate transport by any means to a point of storage or use.

**HAZARDOUS MATERIALS.** Those chemicals or substances which are *physical hazards* or *health hazards* as defined and classified in this chapter, whether the materials are in usable or waste condition.

**HEALTH HAZARD.** A classification of a chemical for which there is statistically significant evidence that acute or chronic health effects are capable of occurring in exposed *persons*. The term "health hazard" includes chemicals that are toxic, highly toxic and *corrosive*.

**IMMEDIATELY DANGEROUS TO LIFE AND HEALTH (IDLH).** The concentration of air-borne contaminants that poses a threat of death, immediate or delayed permanent adverse health effects, or effects that could prevent escape from such an environment. This contaminant concentration level is established by the National Institute of Occupational Safety and Health (NIOSH) based on both toxicity and flammability. It generally is expressed in parts per million by volume (ppm v/v) or milligrams per cubic meter (mg/m$^3$). If adequate data do not exist for precise establishment of IDLH concentrations, an independent certified industrial hygienist, industrial toxicologist, appropriate regulatory agency or other source *approved* by the *fire code official* shall make such determination.

**INCOMPATIBLE MATERIALS.** Materials that, when mixed, have the potential to react in a manner which generates heat, fumes, gases or byproducts which are hazardous to life or property.

**LIQUID.** A material having a melting point that is equal to or less than 68°F (20°C) and a *boiling point* which is greater than 68°F (20°C) at 14.7 psia (101 kPa). When not otherwise identified, the term "liquid" includes both flammable and *combustible liquids*.

**LOWER EXPLOSIVE LIMIT (LEL).** See "Lower flammable limit."

**LOWER FLAMMABLE LIMIT (LFL).** The minimum concentration of vapor in air at which propagation of flame will occur in the presence of an ignition source. The LFL is sometimes referred to as LEL or lower explosive limit.

**MATERIAL SAFETY DATA SHEET (MSDS).** Information concerning a hazardous material which is prepared in accordance with the provisions of DOL 29 CFR Part 1910.1200 or in accordance with the provisions of a federally *approved* state OSHA plan.

29 November 2012

# Technical Memorandum No. 3

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Rodman Houser, P.E., Kennedy/Jenks Consultants

Review: Robert Ryder, P.E., Kennedy/Jenks Consultants

Subject: Evaluation of Alternatives for WWTP Effluent Pump Station Reliability Improvements
K/J 1268007*01

## Purpose

This memorandum presents a condition assessment and evaluation of alternatives for sustaining and improving the effluent pump station (EPS) at the Carmel Area Wastewater District (District/CAWD) wastewater treatment plant (WWTP). This evaluation is being performed as part of a 15-year capital improvement plan currently being developed for the CAWD WWTP.

## Effluent Pump Station Flows

The EPS is used to pump treated secondary effluent and reverse osmosis (RO) concentrate reject to the outfall diffuser system in Carmel Bay. Average daily flow at the EPS was 0.6 million-gallons per day (mgd) over the last four years of record (Jan 2008 – April 2012). In contrast, the maximum-day flow over the same period was 4.1 mgd. A histogram of daily flows for the period of record is shown in Figure 1.

For the four year period of record, daily effluent flow was less than 4.0 mgd 99.8% of the time. During normal dry weather operations, the flow rate to the EPS is limited primarily to the RO concentrate reject stream produced in the recycled water treatment facility, as the rest of the treated wastewater is reused as recycled water. This concentrate reject pumping in the EPS accounts for the majority of pumping in the pump station as shown in Figure 1.

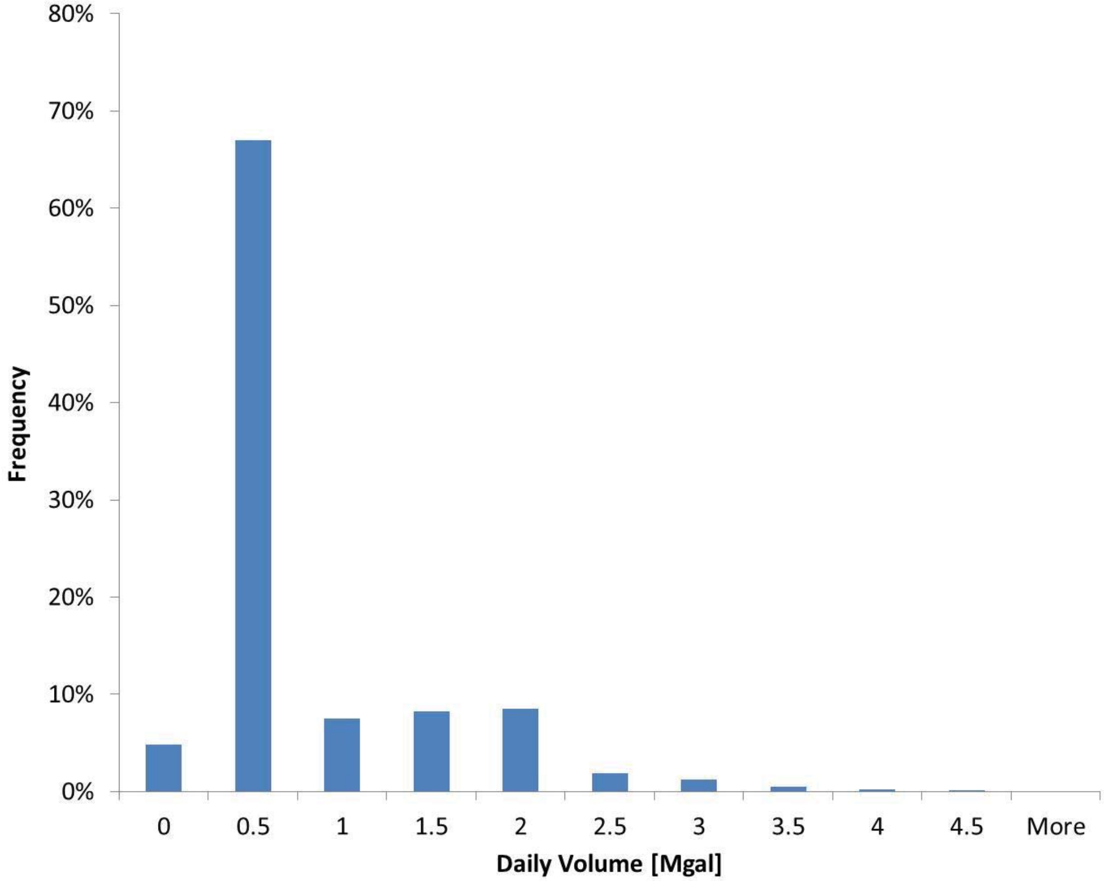



Figure 1: Effluent Pump Station (Jan 2008 - April 2012)

The peak flows that are pumped by the EPS during high wet weather flow conditions are reduced by the fact that CAWD operations staff utilizes 0.5 million-gallons of equalization storage upstream of the EPS to trim the influent peak flows into the treatment train. During the period of record the maximum influent flow rate was 7.8 mgd and the maximum flow rate in the EPS was 5.4 mgd. CAWD staff reports that influent peak wet weather flows have exceeded 10 mgd for brief periods prior to 2008. A sustained influent flow event of 10 mgd lasting over 5 hours could be equalized in the 0.5 million-gallon storage basin to reduce the sustained flow of the EPS to 8 mgd. Furthermore, in extreme cases CAWD operations could utilize the equalization basin below the tertiary building (often referred to as the FEB) to store 272,000 gallons of additional volume.

The information used to determine a basis for the firm capacity for the EPS in this evaluation includes: flow data (Jan 2008 – April 2012), reports of 10 mgd influent peak wet weather flows prior to 2008, and the equalization storage capabilities at the WWTP. From this information an

EPS firm capacity of 8 mgd (5,600 gpm[1]) is used in this pre-design evaluation as a basis for the alternatives evaluations.

The ratio between firm capacity for peak flows of 8 mgd (5,600 gpm) and average-day effluent flow 0.6 mgd (420 gpm) is very high (13:1). This high turndown ratio has resulted in effluent pumps that are sized to meet peak flow demands and are not optimized for common duty conditions.

## Effluent Pump Station Configuration

The pump station is configured with a wet well and dry well. A single dry-pit submersible pump (jockey pump) was installed to handle concentrate reject from the recycled water facility and is used for pumping most of the pump station effluent (Figure 2). This is an end-suction centrifugal pump with a screw-type impeller, suitable for stringy solids. It is driven by a 7.9-hp, 1750-rpm, submersible-duty motor, and has a nameplate duty condition of 390 gpm (0.56 mgd) at 22 feet of head.


Figure 2: Jockey Pump

[1] gpm = gallons per minute

During a recent pump test, the jockey pump produced 780 gpm (1.1 mgd) with a level of 6.7 feet in the wet well. Motor current was measured at 11.1 amps during this test vs. a nameplate current rating of 11.0 amps. Water level in the wet well was higher than usual to facilitate flow testing while flows into the lift station were low. This caused jockey-pump output to be artificially high during the test, but still about as expected when operating at 1750 rpm.

The jockey pump is connected to an adjustable-frequency drive (AFD) that automatically modulates pump speed to maintain wet-well water level within a narrow operating band. CAWD operations staff report no problems with the jockey pump; however, access to the pump discharge valve is limited (Figure 3). This is a difficulty when the District needs to service the check valve.

Figure 3: EPS Discharge Valves

Two high-service pumps are provided for peak-flow events (Figure 4). Their drive shafts connect 75- hp vertical motors on the top floor to the end-suction high-service pumps in the dry well. Each high-service pump is a 1,160-rpm Fairbanks-Morse solids handling unit, with a nameplate duty condition of 5,000 gpm (7.2 mgd) at 41 feet of head.

At full speed (1160 rpm), output from the two high-service pumps far exceeds flows entering the wet well. Thus, adjustable-frequency drives are used to reduce pump speed and rate of flow.

The high-service pumps have been generally reliable, although CAWD staff has observed noticeable vibration during the infrequent times that they operate. There is some concern that the vibration may be related to the drive shafts and bearings, which could lead to total pump failure during a peak-flow event.

Figure 4: High-Service Pumps

In addition to effluent pumps, the dry well also contains two treated-water (No. 3 Water) pumps (Figure 5). These are no longer in use; however, the District wishes to keep these pumps as emergency backup for the primary No. 3 Water Pump System.


Figure 5: Treated Water (No. 3 Water) Pumps

The concrete pump station structure was constructed in the early 1970’s. It consists of below-grade wet and dry wells that contain the pumps and mechanical piping, and an above-grade building structure for the motors and related electrical gear.

District staff report moderate water intrusion through existing pipe penetrations. Water leakage into the dry well is pumped back to the wet well with a small sump pump. CAWD staff is concerned that there is insufficient air gap to separate the sump-pump discharge from water stored in the wet well. This could lead to flooding of the dry well if the sump pump system failed and water levels in the wet well siphoned back to the dry well. Otherwise, the concrete structure appears to be in good condition.

All pumps are controlled automatically from a Tesco programmable logic controller (PLC-6) using level sensing from the wet well (Figure 6). PLC-6 is considered serviceable; however, CAWD staff report that the system is not user-friendly. This was evident during the K/J witnessed performance testing earlier this year when it became difficult for CAWD staff to operate the pumps manually.


Figure 6: Existing PLC-6

Instrumentation (level, flow and pressure) is generally adequate for normal day-to-day needs; however, level feedback to the PLC is limited to a single level transmitter. Failure of this instrument could lead to complete failure of the pump control system, and related alarms.

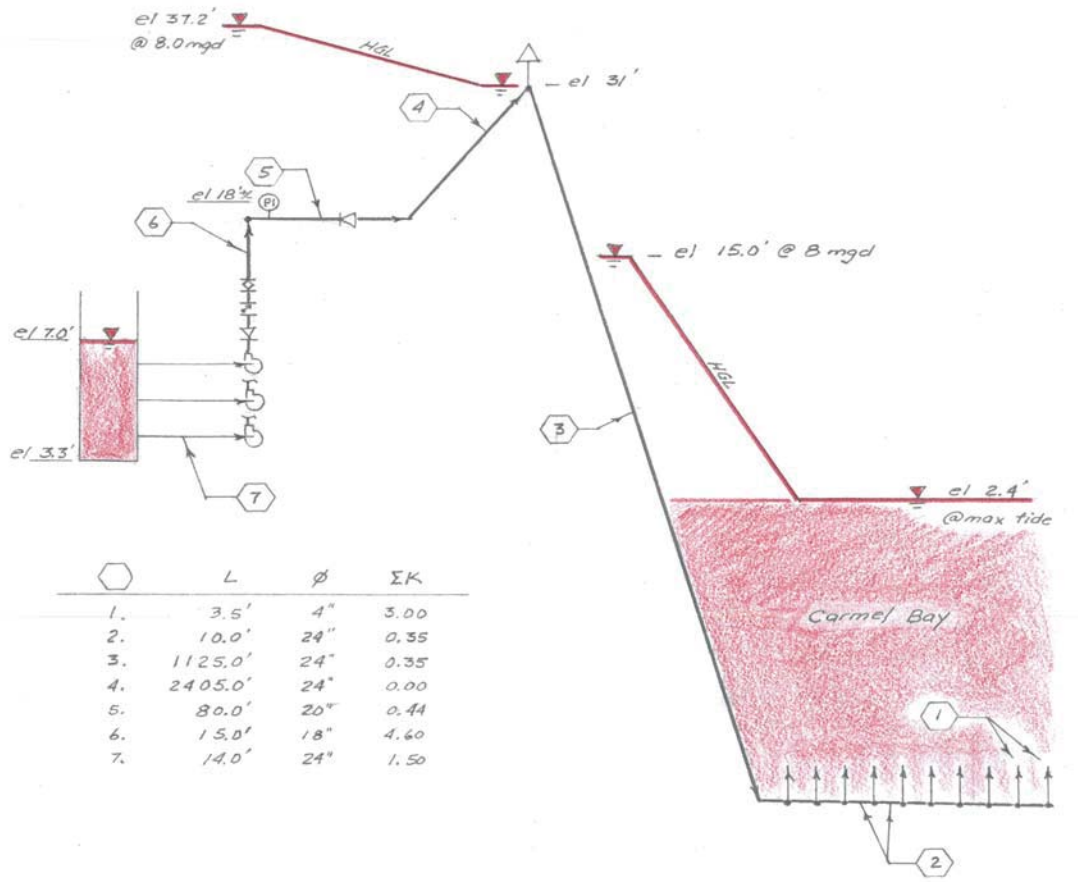
Adjustable-frequency drives are approximately 7 – 8 years old and are considered serviceable. However, the existing electrical switchgear appears to be original equipment (i.e. 1970 vintage), and beyond its useful life. CAWD staff is concerned that there may be reliability and safety issues with this gear, given the corrosive atmosphere in the building and the absence of recent electrical maintenance. In addition, replacement parts for the switchgear are no longer available.

The last known failure of the pump system occurred about 10 years ago during winter high-flow conditions at nighttime. Although the exact nature of the failure is unknown it is known that the failure was related to the pump station electrical or control systems. CAWD operations staff report that the failure resulted in complete non-operation of the pumps and required about three hours for a staff electrical technician to correct the issue, once they were alerted to the problem. A spill would have been likely had the pump station been out of service much longer.

## Pump Station Analysis

### Hydraulics

The EPS conveys treated effluent 0.7 miles to discharge through a subsurface diffuser into Carmel Bay, via a 24-inch transmission main. Although the hydraulic grade elevation in the wet well (el. 8 feet – 10 feet) is higher than Carmel Bay (el. 2.4 feet at max high tide), the maximum elevation of the pipeline, which passes over a ridge, is approximately 31 feet. Therefore, pumping is required to convey effluent to the high point. A vacuum-relief valve at the high point allows water to flow by gravity to Carmel Bay (Figure 7).




| ⬡ | L | Ø | ΣK |
|---|---|---|---|
| 1. | 3.5' | 4" | 3.00 |
| 2. | 10.0' | 24" | 0.35 |
| 3. | 1125.0' | 24" | 0.35 |
| 4. | 2405.0' | 24" | 0.00 |
| 5. | 80.0' | 20" | 0.44 |
| 6. | 15.0' | 18" | 4.60 |
| 7. | 14.0' | 24" | 1.50 |

Figure 7: Hydraulic Profile for Ocean Outfall

Typically, the dry-weather pumping head is in the range of 25 – 27 feet, while approximately 30 feet of total-pumping head is required at 8 mgd.

Backpressure from the outfall diffuser system does not influence pump output until flows would approach 12 mgd, which is considerably higher than historical peak flows. As a result, most of the pumping head is static over the usual range of flows.

## Jockey Pump

The maximum sustainable capacity of the jockey pump is 720 gpm (1.04 mgd) based on the manufacturer’s performance curve. High levels in the wet well can cause the pump to exceed this flow (at full speed); however, this could cause an overcurrent condition for the submersible motor, which is rated for 11.0 amps. The manufacturer's performance curve is shown in Figure 8.

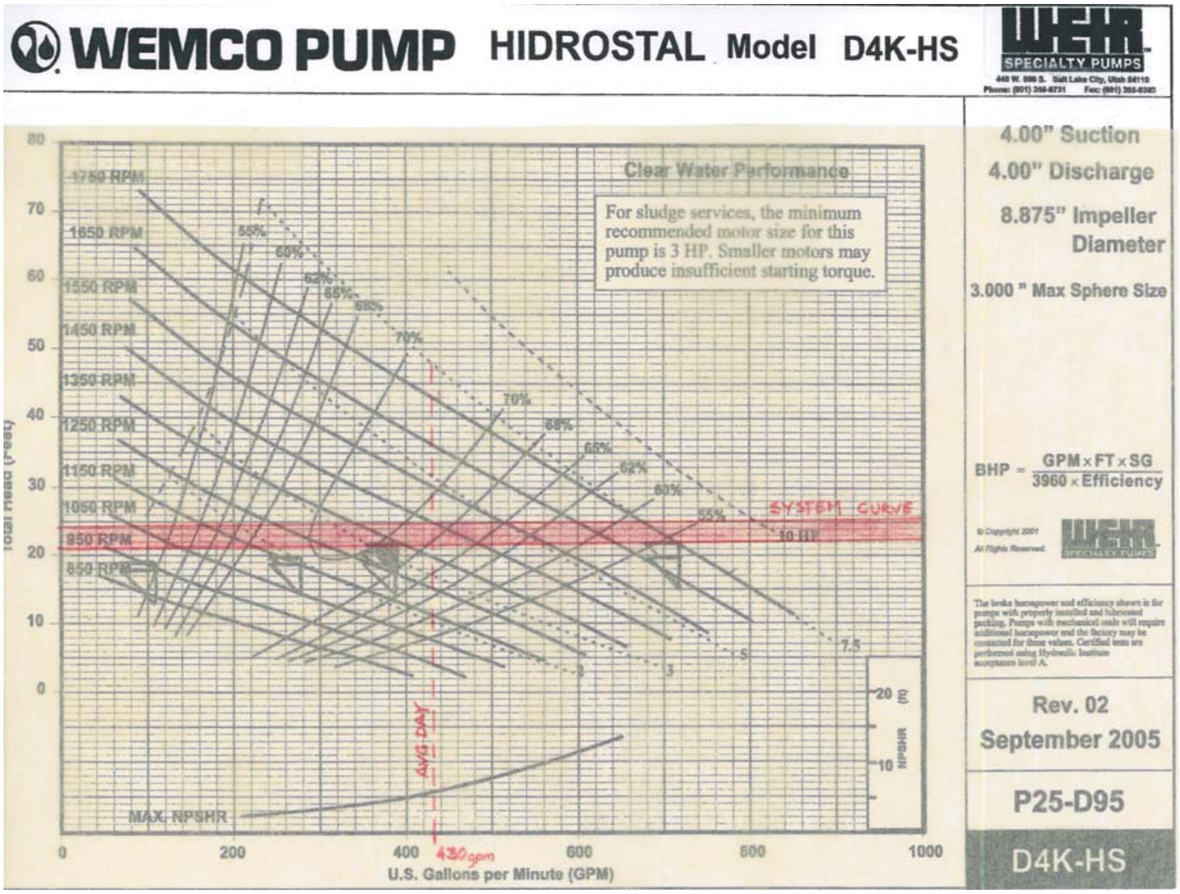



Figure 8: Jockey Pump Performance

As a practical limit, the minimum sustainable flow for the jockey pump is about 200 gpm, which is equivalent to the typical dry-weather night-time flow entering the treatment plant. While the pump can safely produce lower flows, efficiency drops off dramatically below 200 gpm.

Hydraulic efficiency of the jockey pump is about 68%. Motor efficiency is between 80% - 84% at average-daily flows. This yields an effective wire-to-water efficiency of about 56%, which is considerably lower than could be achieved with a pump designed for clean-water service e.g. vertical turbine.

On average, the jockey pump consumes approximately 130 kW-hrs/million-gallon (Mgal) pumped. This is equivalent to about 28,000 kW-hrs per year at an average-daily flow of

0.6 mgd. Annual cost of effluent pumping is about $3,100 assuming an average loaded rate for electricity of $0.11 per kW-hr[2].

## High-Service Pumps

Maximum sustainable capacity of each high-service pump is between 8 – 9 mgd. At maximum speed, the high-service pumps can deliver approximately 7,000 gpm (10 mgd); however, efficiency is low and this would likely cause an overcurrent condition for the existing 75-hp motors (Figure 9). These pumps operate near their best-efficiency point (BEP) when running at 75% speed, which yields about 4,200 gpm.

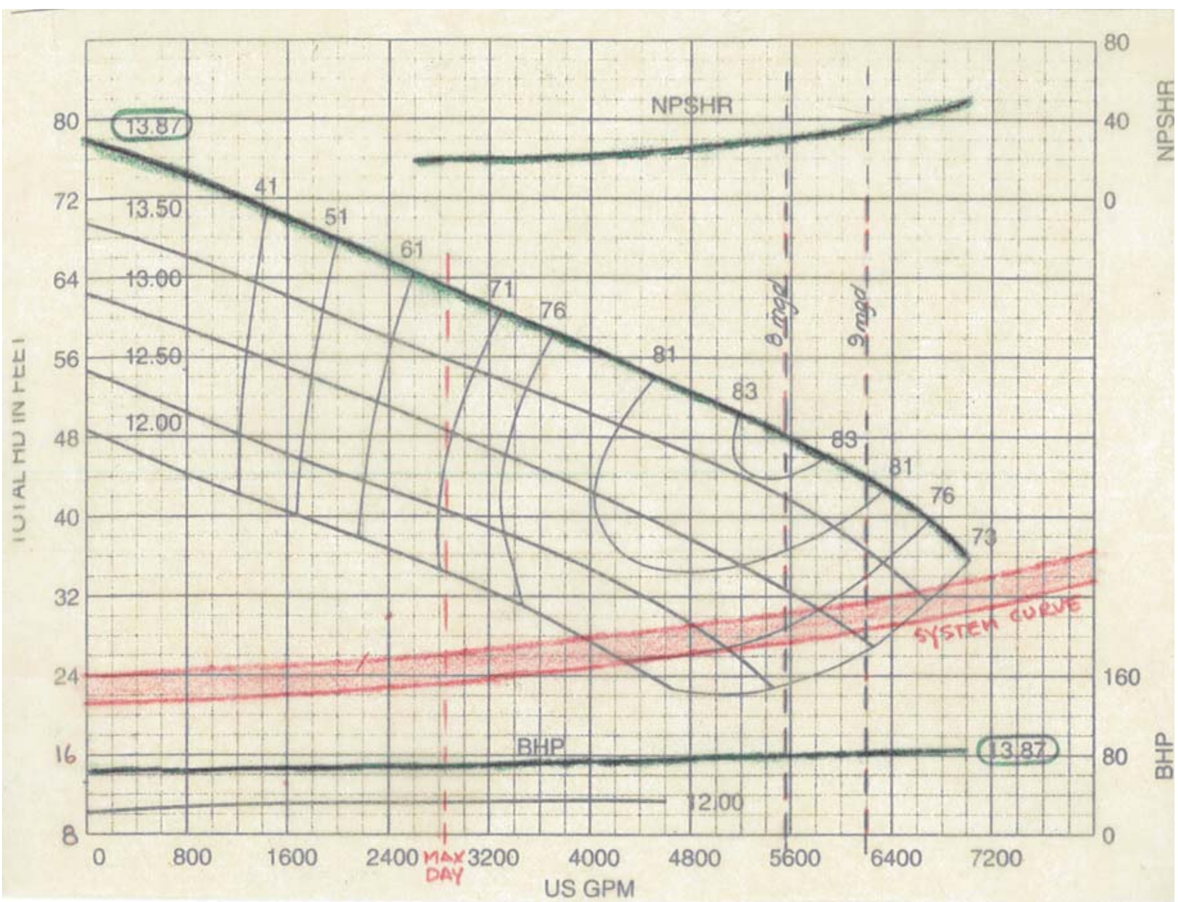



Figure 9: High-Service Pump Performance

[2] Average loaded rate is based on PG&E schedule E-19 and includes both energy and demand charges.

The high-service pumps are more efficient than the jockey pump; however, they operate infrequently compared to the jockey pump, so they have very little effect on annual energy consumption at the effluent pump station.

## Firm-Capacity

The firm-capacity of the existing pump station is approximately 6,100 gpm (8.9 mgd) with one high-service pump operating at 93% speed, and the jockey pump operating at 100% speed. This is the maximum sustainable flow for the pump station, with one high-service pump out of service or as standby.

By comparison, maximum-day influent flow for the pump station is about 4.1 mgd, and the peak flow could reach 5,600 gpm (8 mgd) with equalization reducing reported 10 mgd influent wet weather flows. Thus, the pump station has adequate capacity to handle historical peak flows without causing water to back up into upstream processes at the WWTP.

## Wet Well Capacity

The effluent pumps take suction from an adjacent wet well. Disinfected secondary-treated wastewater from the chlorine-contact tank spills over a weir before entering the wet well. The weir crest is at elevation 10.60 feet; and the pump suction nozzle is at elevation 4.3 feet (approximate).

Under normal conditions, the maximum effective water-surface elevation should be about 10.10 feet, which provides 0.50 feet of freeboard under the weir crest. Water levels above elevation 10.60 could cause water levels to increase in the chlorine-contact tank, which could affect treatment performance.

The minimum recommended water-surface elevation to prevent vortices from forming in the wet well varies depending on the pump output. A minimum of 4.2-feet of submergence is recommended over the suction bell of the high-service pumps, based on criteria established in Hydraulic-Institute Standard 9.8-1998 (Pump Intake Design). Thus, the minimum recommended water-surface elevation for the high-service pumps should be set at elevation 8.5 feet (el. 4.3 feet + 4.2 feet).

Wet-well geometry yields about 2,500 gallons of storage per foot of depth. The maximum and minimum allowable water levels yield a working depth of 1.6-feet, for an effective volume of 4,000 gallons.

The function of the wet well is to provide enough working storage to prevent the pumps from over cycling, which can lead to overheating of the motor and premature failure. Pumps started with adjustable-frequency drives should not cycle more than twelve times per hour in order to prevent the motor windings from overheating. Using this criteria, the high-service pumps require 3,500 gallons of working storage to prevent over cycling, assuming a minimum pump output of 2,800 gpm (4.1 mgd). If the two high-service pumps are automatically alternated between lead and lag, these pumps require 1,700 gallons of working storage. Thus, it appears that the existing wet well has sufficient capacity to prevent excessive cycling of the high-service pumps.

## Evaluation Criteria

### Level of Service Goals

Suggested level of service goals are detailed herein for the EPS to serve as a basis for identifying improvements needed at the EPS to meet required service levels. Table 1 identifies suggested level of service goals for the effluent pump station.

## Table 1: Effluent Pump Station Suggested Level of Service Goals

| Service Category | Service-Level Objective | Service-Level Metrics |
|---|---|---|
| **Functionality** | | |
| Design Capacity | Adequate firm-capacity to prevent flooding of upstream treatment processes. | • Maintain wet-well level below influent weir at all times. |
| Instrumentation | Capability to accurately measure critical performance and maintenance metrics. | • Suction and discharge pressure gages on all pumps.<br>• Gage selection adequate to allow accurate measurements (gage error ≤ 2%) of pressure.<br>• Effluent flowmeter error ≤ 5% over maximum (10:1) operating range.<br>• All instruments inspected weekly and calibrated annually. |
| | Ability to provide real-time process feedback for control automation. | • Level transmitter is suitable for measuring water levels in the wet well.<br>• Backup level instruments installed for emergency control automation and alarms. |
| | Ability to validate NPDES compliance. | • All daily discharge-flow volumes recorded in SCADA database for previous three years<br>• Peak-hour flow recorded for previous three years of record. |
| Controls and Automation | Automatically maintain level in the wet well within allowable limits. | • Limit level excursions to ≤ 2X year. |
| Building Structures | Adequate to protect critical equipment from environment. | • Zero roof leaks.<br>• Zero water intrusion from wet well to dry well. |
| **Financial Efficiency** | | |
| Energy Consumption | Minimize energy costs. | • kW-hrs/Mgal pumped. |
| Maintenance | Minimize maintenance costs. | • $/yr spent on equipment replacement and repairs. |
| Staffing | Minimize staffing costs. | • Maintenance hours/year.<br>• Operations hours/year. |

| Service Category | Service-Level Objective | Service-Level Metrics |
|---|---|---|
| **Reliability** | | |
| Redundancy | Maintain continuous NPDES permit compliance. | • Installed spare for all critical equipment. |
| Emergency Responses | Minimize lead time required to effect equipment repairs. Spare-parts on hand for long-lead critical items. | • Equipment downtime [hrs/yr]. |
| Pump Station Failures | Minimize failure rates for critical systems | • Mean-time between failures. |
| Equipment Selection | Suitable for expected range of operation and service | • NPSH margin ≥ 1.2.<br>• Pumps operate within allowable operating region (AOR)[3]. |
| Equipment Mortality | Replace unserviceable equipment before critical failure occurs. | • Number of emergency repairs/year. |
| **Safety** | | |
| Confined-Space Hazards | Minimize use of confined-spaces for equipment requiring maintenance. | • Confined-space entries / year.<br>• All O&M staff receives annual training.<br>• No OSHA violations |
| Electrical Hazards | Comply with OSHA requirements for arc-flash hazard mitigation. | • Arc-flash labels/placards on all electrical switchgear.<br>• Lockout/tag-out capability for all equipment. |

[3] Hydraulic Institute, *American National Standard for Centrifugal and Vertical Pumps for Allowable Operating Region (ANSI/HI 9.6.3-1997)*.

### Level of Service Failures

While the pump station has adequate capacity to handle anticipated peak-hour and maximum-day flows, the existing pump station does not achieve the following suggested level-of-service criteria:

- Electrical gear and PLC have outlived their useful service life, which reduces EPS reliability.
- Electrical gear has not been verified to meet arc flash safety requirements.
- Instrumentation and other mechanical equipment in the dry well could be subjected to flooding or corrosion failure.
- Absence of backup level instrumentation in the wet well reduces overall reliability of the pump station. Loss of the primary level instrument could cause automatic level control to fail, resulting in flooding of upstream processes, and ultimately, an overflow at the wet well and possible NPDES permit violation.
- Roof leaks could lead to water damage and short circuit in the electrical gear, which could lead to a complete failure of the pump station.
- Sump-pump piping is configured in a way that could lead to back-siphon flooding of the dry well. Existing motors for 3W pumps, and recirculation pumps would be damaged.
- Excessive vibration of high-service pumps will accelerate wear on the pump and motor bearings, leading to premature pump failure and/or cracks in the floor.
- Age of existing electrical switchgear is beyond its functional service life and limits the availability of spare-parts due to obsolescence.
- Wire-to-water electrical efficiency of the jockey pump is approximately 58%, compared to a maximum practical efficiency of about 76%[4]. Optimizing jockey-pump efficiency could potentially save approximately $1,000 in annual energy costs.

## Alternatives Analysis

The following pumping-improvement alternatives were considered:

- Alternative 1: Maintain Existing Pump Configuration and Replace Electrical Gear (with or without Additional Portable Pump Redundancy)
- Alternative 2: Replace All Pumps (Vertical Turbines)

[4] Maximum practical wire-to-water efficiency is the product of hydraulic efficiency (80%) and motor efficiency (95%).

- Alternative 3: Replace All Pumps (Dry-Pit Submersibles)

**Alternative 1: Maintain Existing Pump Configuration and Replace Electrical Gear**

In general, the existing pumps and support systems have been reliable with only one failure noted in the last 10+ years having to do with electrical systems. The existing pumps can provide a firm capacity (6,100 gpm), meeting the peak flow demands (5,600 gpm). This means that the pump station can deliver the maximum anticipated flow with one high-service pump out of service. It is conceivable that the high-service pumps and motors could last for another 15 years or more if excessive vibration is corrected and with routine maintenance and periodic rebuilds.

The existing electrical switchgear, MCC and programmable-logic controller (PLC) should be replaced to improve reliability. It is assumed that the existing pump adjustable frequency drives (AFDs) would be reused.

Flooding of the dry well should not prevent the existing pump station from functioning because:

- The jockey pump is rated for immersible service.
- Motors for the high-service pumps are located above the maximum water surface.

Energy consumption is 130 kW-hr/Mgal, which is equivalent to 28,000 kW-hours per year at an average-daily flow of 0.6 mgd. Annual energy cost is approximately $3,100 assuming an average loaded rate of $0.11 per kW-hr.

Elements of the existing system which have been identified as needing improvement to maintain the desired levels of service include:

- Repair roof leaks / rebuild roof membrane.
- Install backup level instrumentation in the wet well.
- Replace switchgear and MCC and relocate existing AFDs.
- Replace PLC.
- Demolish unused Return-Water Pump.
- Replace and relocate No 3 Water Pumps.
- Elevate sump pump discharge to provide air break above top floor elevation.
- Perform periodic (annual) thermal imaging of switchgear and adjustable frequency drives.
- Megger motor leads (annual).
- Monitor and correct vibration of pumps and motors.

- Install bypass connection to forcemain, purchase trailer-mounted pumps (optional).

Leaks in the roof should be repaired as soon as possible, and the roof membrane rebuilt.

Ambient humidity is high due to the proximity to the coast, and foggy conditions are common. Temperature in the electrical room should be maintained 10 to 15° F above the dew point, at all times or a dehumidifier installed. This should be sufficient to prevent condensation on the concrete walls and other surfaces that could lead to corrosion or other damage.

The No. 3 Water Pumps could be replaced with vertical turbines, located above the wet well.

Condition of the pump and motor bearings can be monitored by taking vibration measurements and noting any excessive upward trends. Quarterly vibration measurements should be taken at multiple speeds between the minimum and maximum operating speeds. If a resonant frequency is observed, the corresponding adjustable-frequency drive should be configured to avoid resonance.

As an option to increase reliability, installing a bypass connection to the existing forcemain pipe to the outfall would allow portable pumps to bypass the effluent pump station. Portable pumps for added redundancy and reliability would only be used on rare occasions at the EPS and so should be sized so they can be used for a wide range of pumping needs around the WWTP for maintenance activities and in emergencies. A pump with an engine rated for approximately 40 horsepower (hp) should be sufficient to discharge the maximum-day flow of 4.1 mgd and therefore two engine pumps of this size could be used to provide emergency pumping up to 8 mgd. Alternatively, three 25-hp portable pumps could be used to provide 8 mgd capacity and may be more desirable as pumps of this size would provide more versatility for other uses around the plant.

### Alternative 1 Estimated Cost

**Capital Cost:** Table 2 shows the estimated probable construction cost for improvements to the existing effluent pump station.

## Table 2: Alternative 1: Replace Electrical Gear and Maintain Existing Pump Configuration Estimated Probable Construction Cost Estimate

| Item | Description | Cost |
|---|---|---|
| | **Effluent Pump Station Building Modifications** | |
| 1 | Repair roof leaks | $5,000 |
| 2 | Rebuild roof membrane | $30,000 |
| 3 | Ventilation System | $30,000 |
| | *Building Subtotal* | *$65,000* |
| | **Mechanical Modifications** | |
| 4 | Replace & relocate backup No 3 Water pumps & piping | $30,000 |
| 5 | Bypass connection to outfall pipeline | $25,000 |
| 6 | Allowance for correcting existing pump vibration issues | $20,000 |
| 7 | Three (3) Trailer-mounted self-priming pumps (25 hp) | $60,000 |
| | *Mechanical Subtotal* | *$135,000* |
| | | |
| | **Electrical Modifications** | |
| 8 | Rewire No 3 Water pump | $10,000 |
| 9 | Install backup level transducer at wet well | $5,000 |
| 10 | Replace MCC and Switchgear | $300,000 |
| 11 | Replace PLC | $90,000 |
| 12 | Conduit & Wire | $40,000 |
| | *Electrical Subtotal* | *$445,000* |
| | | |
| | Project Subtotal: | $645,000 |
| | | |
| | Mobilization/Demobilization: | $65,000 |
| | Contractor Overhead and Profit: | $107,000 |
| | **Project Total:** | **$817,000** |
| | Pre Design Contingency @ 30%: | $245,000 |
| | **Total with Contingency:** | **$1,062,000** |

Typically, engineering and construction management for a project of this size and complexity would be about 30% of construction cost and therefore the projected budget for capital expenditures for Alternative 1 would be **$1,381,000**.

If the trailer-mounted portable pumps were removed from this alternative the projected budget for capital expenditures for Alternative 1 would be **$1,197,000**.

**Operation and Maintenance Costs:** The following recurring costs should be planned for Alternative No. 1:

- $3,100 per year (electricity)

- $2,000 per year (Additional Predictive Maintenance cost to account for age of pumps, i.e Megger Testing and Thermal Imaging)

## Alternative 2: Replace Effluent Pumps with Vertical Turbines

This alternative consists of replacing the existing pumps with vertical turbine units installed outdoors on the deck of the existing wet well. The new pumps and motors would improve reliability, while also providing an opportunity to improve energy efficiency if the pump selection is optimized for typical loadings.

Although the existing pumps are rated for solids handling typical of raw wastewater, disinfected secondary effluent has very low suspended solids and the particles are extremely small. This type of treated wastewater can be safely pumped with conventional water-service pumps. Conventional vertical turbine pumps are often more efficient than end-suction solids-handling pumps (80+% vs. 68%), when properly designed for the typical duty conditions.

Additional energy savings are also realized by using a premium-efficiency vertical motor for all pumps. For example, the immersible-duty motor for the jockey pump has a nominal efficiency rating of 85%, compared to a 94% efficiency rating for a typical premium-efficiency vertical motor.

Three identical pumps, each rated for 2,800 gpm at 30 feet of head, would be sufficient to provide a firm capacity of 5,600 gpm (8 mgd) with one unit as a standby. This configuration assumes that the spare aeration basin could be continued to be used for flow equalization during peak-flow events. Pumps of this size would provide better flexibility and improved efficiency at low flows. Flow at the rated condition should be specified to be 20% - 30% greater than the flow at the best-efficiency point, depending on the shape of the pump curve. Specifying the rated condition in this way will allow energy efficiency to increase as the pump slows down to accommodate average flows.

New adjustable-frequency drives should be installed for the pumps. They should be configured during startup to limit the minimum speed corresponding to the minimum specific energy (i.e. kW-hr/Mgal). This will cause the pump to operate near its best efficiency point when it is operating at minimum speed.

Pump output at minimum speed will exceed the average daily flow, most of the time. This can be accommodated by cycling the pumps to maintain levels in the wet-well between elevation 7-ft and 10-ft.

### Alternative 2 Estimated Cost

**Capital Cost**: Table 3 shows the estimated probable construction cost for Alternative No. 2.

## Table 3: Alternative 2: Replace Effluent Pumps with Vertical Turbines Estimated Probable Construction Cost Estimate

| Item | Description | Cost |
|---|---|---|
| | **Effluent Pump Station Building Modifications** | |
| 1 | Repair roof leaks | $5,000 |
| 2 | Rebuild roof membrane | $30,000 |
| 3 | Ventilation System | $30,000 |
| | *Building Subtotal* | *$65,000* |
| | **Mechanical Modifications** | |
| 4 | Replace & relocate backup No 3 Water pumps & piping | $30,000 |
| 5 | Install 3 X 30 hp vertical turbines (2,800 gpm @ 30 ft) | $80,000 |
| 6 | Discharge laterals w/ check and isolation valves | $60,000 |
| 7 | Demolish existing pumps | $20,000 |
| 8 | Pump manifold and connection to outfall pipeline | $80,000 |
| | *Mechanical Subtotal* | *$270,000* |
| | | |
| | **Structural Modifications** | |
| 9 | Modifications to accommodate 3 vertical turbines | $60,000 |
| | *Structural Subtotal* | *$60,000* |
| | | |
| | **Electrical Modifications** | |
| 10 | Rewire 3W pump and recirculation pump | $10,000 |
| 11 | Install backup level transducer at wet well | $5,000 |
| 12 | New MCC and Switchgear | $300,000 |
| 13 | Replace PLC | $90,000 |
| 14 | Conduit & Wire | $80,000 |
| | *Electrical Subtotal* | *$485,000* |
| | | |
| | Project Subtotal: | $880,000 |
| | | |
| | Mobilization/Demobilization: | $88,000 |
| | Contractor Overhead and Profit: | $145,000 |
| | **Project Total:** | **$1,113,000** |
| | Pre Design Contingency @ 30%: | $334,000 |
| | **Total with Contingency:** | **$1,447,000** |

Engineering and construction management is estimated to be about 30% of construction cost for a project of this size and complexity and therefore the projected budget for capital expenditures for Alternative 2 would be **$1,881,000**.

**Operations and Maintenance Costs:** The following recurring costs should be planned for Alternative No. 2:

- $2,400 per year (electricity)

- Recurring costs for routine preventative maintenance is considered negligible for this alternative.

## Alternative 3: Replace Effluent Pumps with Dry-Pit Submersible Pumps

This alternative consists of replacing the existing pumps with three identical submersible solids-handling pumps. The new pumps and motors would improve reliability, while also providing an opportunity to improve energy efficiency if the pump selection is optimized for typical loadings. Vibration would be reduced by eliminating the drive shafts and the additional rigidity of installing the close-coupled pump and motor assembly to floor of the dry well.

Pump efficiency would be slightly less than for the vertical turbine units (75% - 80%), and motor efficiency for the submersible motors would be around 85%.

Three identical pumps, each rated for 2,800 gpm at 30 feet of head, would be sufficient to provide a firm capacity of 5,600 gpm (8 mgd). Flow at the rated condition should be specified to be 20% - 30% greater than the flow at the best-efficiency point, depending on the shape of the pump curve. Specifying the rated condition in this way will allow energy efficiency to increase as the pump slows down.

New adjustable-frequency drives should be installed for the pumps. They should be configured during startup to limit the minimum speed corresponding to the minimum specific energy (i.e. kW-hrs/Mgal). This will cause the pump to operate near its best efficiency point when it is operating at minimum speed.

Pump output at minimum speed will exceed the average daily flow, most of the time. This can be accommodated by cycling the pumps to maintain levels in the wet-well between elevation 7 feet and 10 feet.

### Alternative 3 Estimated Cost

**Capital Cost**: Table 4 shows the estimated probable construction cost for Alternative No. 3.

### Table 4: Alternative 3: Replace Effluent Pumps with Dry-Pit Submersible Pumps Estimated Probable Construction Cost Estimate

| Item | Description | Cost |
|---|---|---|
| | **Effluent Pump Station Building Modifications** | |
| 1 | Repair roof leaks | $5,000 |
| 2 | Rebuild roof membrane | $30,000 |
| 3 | Ventilation System | $30,000 |
| | *Building Subtotal* | *$65,000* |
| | **Mechanical Modifications** | |
| 4 | Replace & relocate backup No 3 Water pump & piping | $30,000 |
| 5 | Install 3 X 30 hp dry-pit submersibles (2,800 gpm @ 30 ft) | $100,000 |
| 6 | Discharge laterals w/ check and isolation valves | $60,000 |
| 7 | Demolish existing pumps | $20,000 |
| 8 | Pump manifold and connection to outfall pipeline | $80,000 |
| | *Mechanical Subtotal* | *$290,000* |
| | | |
| | **Electrical Modifications** | |
| 9 | Rewire 3W pump and recirculation pump | $10,000 |
| 10 | Install backup level transducer at wet well | $5,000 |
| 11 | Replace MCC and Switchgear | $300,000 |
| 12 | Replace PLC | $90,000 |
| 13 | Conduit & Wire | $80,000 |
| | *Electrical Subtotal* | *$485,000* |
| | | |
| | Project Subtotal: | $840,000 |
| | | |
| | Mobilization/Demobilization: | $84,000 |
| | Contractor Overhead and Profit: | $139,000 |
| | **Project Total:** | **$1,063,000** |
| | Pre Design Contingency @ 30%: | $319,000 |
| | **Total with Contingency:** | **$1,382,000** |

Typically, engineering and construction management for a project of this size and complexity would be about 30% of construction cost and therefore the projected budget for capital expenditures for Alternative 3 would be **$1,797,000**.

**Operations and Maintenance Costs:** The following recurring costs should be planned for Alternative No. 3:

- $2,400 per year (electricity)
- Recurring costs for routine preventative maintenance is considered negligible for this alternative.

## Summary of Alternatives

A summary of the capital and annual operations costs is provided in Table 5.

### Table 5: Estimated Costs Comparison

| | Alternative 1 Maintain Existing Pumps (No Portable Redundancy) | Alternative 1 Maintain Existing Pumps (Add Portable Redundancy) | Alternative 2 New Vertical Turbine Pumps | Alternative 3 New Dry Pit Submersible Pumps |
|---|---|---|---|---|
| Initial Estimated Capital Cost | $1,197,000 | $1,381,000 | $1,881,000 | $1,797,000 |
| Annual Operation and Maintenance Costs | $5,100 | $5,100 | $2,400 | $2,400 |
| 15-Year[(a)] Present Worth of Costs[(b)] | $1,274,000 | $1,456,000[(c)] | $1,917,000 | $1,833,000 |
| 15-year[(a)] Annual Cost | $85,000 | $97,000 | $128,000 | $122,000 |

**Notes:**

(a) 15-year evaluation of present worth is chosen based on expected life extension of existing pumps for Alternative 1. Alternatives 2 and 3 would be expected to have longer useful lives.
(b) Present worth includes capital costs and electricity and additional maintenance costs and assumes zero inflation.
(c) Includes trailer mounted backup pumps as added redundancy (not included in other alternatives).

## Apparent Best Alternative

The three alternatives are similar in that each alternative would improve the reliability of the EPS, and as such each alternative is equally viable. The chosen alternative could be chosen on lowest capital cost (Alternative 1 without portable pump redundancy), or could be based on a combination of cost, increased useful life beyond 15 years, and increased safety and reliability beyond that provided by the lowest cost alternative.

The minor operational cost savings related to improved energy efficiency of different pumps and motors does not appear to significantly drive cost based selection of a preferred alternative. However, there may be benefits in terms of rebate money from PG&E that could be applied to the project if the energy reductions could be significant enough to attract PG&E interest. A more energy efficient EPS could result in a reduction in power usage of approximately 7,000 kW hours per year.

The lowest capital cost alternative would be Alternative 1 without portable trailer-mounted pump redundancy. If the source of existing pump vibration can be easily identified and eliminated maintaining the existing pump station with the improvements under this alternative could extend the life of the pump station such that it could reliably operate for ten to fifteen more years with suitable preventive maintenance. However, the existing pump suction and discharge valves have been identified as assets with potential high risk. It is not known if the existing valves are operable and therefore the valves should be inspected further. If the existing valves need to be replaced, then the cost of Alternative 1 would increase.

Adding a bypass connection and trailer-mounted pumps to Alternative 1 would provide additional redundancy and the trailer-mounted pumps could be used for various other applications around the plant, such as to provide a backup system for the RAS pump station.

Alternative 2 simplifies maintenance on the pumps, and eliminates the need to enter the dry well. Alternative 2 costs more compared to Alternative 1, but reduces annual energy costs by approximately $1,000, annually. This alternative also improves overall reliability by renewing all of the pumps, pump piping, and electrical gear, while eliminating the need for District staff to enter the dry well for maintenance activities. Pumps can be easily pulled with a boom truck without entering the building. The higher cost for this alternative may be justified if a monetary value can be established for improved safety and ease of maintenance and additional life of the pumps beyond 15 years. Alternative 2 does not include backup trailer-mounted pumps which could be used in other areas of the WWTP.

Alternative 3 could pose construction sequencing challenges as the new pumps would need to be built in the same location as the existing pumps. Furthermore, the dry-pit pumps would still require CAWD staff to enter the dry well for pump maintenance. Also, removing the pumps is more labor intensive (compared to Alternative 2), because the pump and motor assemblies would have to be lifted through openings in the top floor. It would likely be necessary to reuse much of the existing pump valves and piping which may not be in suitable condition for use in the long term, therefore as is the case for Alternative 1, if existing piping and valves are found to need replacement Alternative 3 cost would increase. Alternative 3 does not include backup trailer-mounted pumps which could be used in other areas of the WWTP.

20 December 2012

# Technical Memorandum No. 4

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Mike Barnes, P.E., Mr. Patrick Treanor, P.E., Alberto Chong, P.E., Kennedy/Jenks Consultants

Review: Mr. Bob Ryder, P.E., Kennedy/Jenks Consultants

Subject: Digestion System Improvements Pre-Design
K/J 1268007*01

## Introduction

In April 2012, Kennedy/Jenks (K/J) completed a survey and rating of the assets at the Carmel Area Wastewater District (CAWD) wastewater treatment plant (WWTP). In general, many digestion system assets were categorized in less than average condition, and many are in need of maintenance to preserve their ability to perform reliably. The digestion system as it exists today is a composite of several digester improvement projects which began 80 years ago. In 1938 Digester 3 and the Sludge Holding tank were built, in 1960 Digester 2 was built, and in 1976 Digester 1 and the Digester Control Building were built. Because the digestion system was not built as part of one single project the system lacks cohesive design criteria, making it difficult to operate reliably to meet regulatory requirements for sludge treatment. In addition to the phased construction and age of the digestion system, the digestion process does not have the redundancy necessary to insure reliable anaerobic digestion if critical equipment fails. Based on this, K/J recommended a predesign review of the digestion system to determine the improvements necessary to reduce physical failure risks and add sufficient redundancy so that the digestion system will perform reliably. The predesign review is presented in this technical memorandum.

While age alone should not be used to determine when facilities need to be repaired or replaced, it is a useful indicator to compare with industry benchmarks. General guidance of the average useful life for wastewater treatment systems digesters are listed by several state agencies and include:

- State Water Resources Control Board – Division of Water Quality – Bulletin 54C, April 1983
  - Digester Structure – 30 years
  - Digester Equipment – 12 years
- State Controller's Office – Division of Local Governments Affairs – 1979
  - Structures – 40 years
  - Pumps – 15 years

- o Motors – 20 years
- o Heaters – 15 years
- o Pipes – 15 years
- o Dewatering Equipment – 15 years

On this basis, all of the digestion related equipment are now near or beyond their average useful life, and should be carefully evaluated to determine the improvements or maintenance needed to preserve their ability to operate reliably.

## Digestion System Capacity and Level of Service Requirements

Digesters need to be routinely taken out of service for cleaning, inspections, and to conduct repairs and retrofits. Therefore, the digestion system needs to have capacity to handle the sludge flow and solids loading with the largest digester out of service. Meeting capacity with the largest unit out of service is referred to as meeting firm capacity. Furthermore, to operate at effective digestion rates, digesters need to be continuously heated and mixed. For CAWD, this equates to the following capacity and level of service requirements:

- Capacity: The firm capacity of the digestion system working volume needs to be sufficient to provide a minimum of 15 days solids detention time at a sludge temperature of a minimum of 95 degrees Fahrenheit to reliably digest the feed solids to meet Federal Environmental Protection Agency (EPA) 503 Regulations for Class B biosolids and to provide a stabilized non-odorous sludge. Digesters are typically designed with a detention time of greater than 15 days to improve performance, reduce sludge solids for disposal, generate additional methane gas energy, and provide a safety factor.

- Level of Service: Each digester in the system should have reliable equipment systems which allow the digestion process to operate safely and continuously. Digester mixing and heating systems need to be sufficient to achieve a minimum 38% volatile solids destruction to comply with EPA 503 Regulations Class B biosolids. The digester structure/cover needs to be gas-tight and allow collection and distribution of the digester gas produced without inadvertent venting.

## Current Digestion System Deficiencies

Digester 1 alone has the capacity to handle the solids flow and loading for the entire digestion system, however Digesters 2 and 3 have marginally sufficient volume to provide the minimum 15 days detention time. K/J reviewed plant data for solids loading rates and completed a simple solids balance for the WWTP to develop the design parameters of sludge loading rates and digestion capacity. Based on this analysis, the average daily solids flow is likely between 15,000 to 18,000 gallons per day. However, solids flow to the digesters is variable and dependent on plant influent characteristics and primary and secondary process operational conditions. Digesters 2 and 3 are estimated to need a minimum working volume of 225,000 to 270,000 gallons to meet EPA 503 regulations with Digester 1 out of service. Digester 2 has a working volume of only 205,000 gallons, providing 11 to 13 days of detention time which is insufficient to serve as a backup to Digester 1 by itself. Digester 3 has a working volume of about 60,000 gallons which in conjunction with Digester 2 would provide a total of 14 to 17 days of detention time which could meet the minimum capacity; although this digestion capacity is marginal and additional factors of safety in the days of detention time would be desirable. While Digesters 2 and 3 could provide the required detention time, Digester 3 is currently in a state of disrepair and not suitable for service and will need major improvements to serve as a reliable digester. Consequently, the current system does not have sufficient reliable capacity to handle the solids loading with Digester 1 out of service.

## Digestion System: Capacity and Level of Service Failures

The existing digestion process does not currently meet the level of service and capacity criteria described above. A brief summary of the major capacity and level of service deficiencies is as follows:

1. **Capacity Failure - Anaerobic Digestion Process (Lack of Firm Capacity):** In the event Digester 1 needs to be taken out of service for any reason, including cleaning to remove grit and scum at typical ten year frequencies, Digester 2 would then presumably be placed into service. However, Digester 2 alone does not have sufficient capacity to treat the sludge volumes required, so Digester 3 would also need to be placed into service. Even with Digester 2 and 3 in service the sludge detention time and heating may not be sufficient to meet Class B biosolids requirements. Digesters 2 and 3 mixing systems need rehabilitation, the digester gas piping is in poor condition, the reliability of heated sludge recirculation for Digester 2 is questionable, and the structural integrity of Digesters 2 and 3 needs to be checked. Therefore, improvements are needed to provide firm capacity as described under “Digester Firm Capacity Improvements” later in this Technical Memorandum (TM). Firm capacity improvements could involve retrofit of Digesters 2 and 3 or constructing a new digester of sufficient capacity. (As discussed later in this TM, retrofit/rehabilitation of Digesters 2 and 3 does not appear to be a more cost effective alternative than constructing a new digester.)

2. **Level of Service Failure - Anaerobic Digester Heating Reliability (Lack of Reliability/Redundancy):** There is currently only one heat exchanger and one recirculation pump that is shared between Digesters 1 and 2. If either the pump or the heat exchanger were to fail, there would be no way to heat the digesters, and the process would fail within a few days. Possible “Interim Reliability Improvements” to add redundancy to the existing digester heating system are discussed later in this TM.

## Physical Condition Deficiencies: Digester 1

In addition to the above failures, following are specific potential physical failure risks for Digester 1. If Digester 1 fails under one of the following failures, it will be difficult for CAWD to treat sludge to meet Class B biosolids regulations and would likely result in costly emergency actions to maintain service.

1. **Condition of sludge heater:** The only sludge heater has been in service for almost 40 years, and based on age alone is beyond its useful life. However, the useful life has likely been shortened since the sludge passages of the heater have been exposed to sludge containing highly corrosive ferric chloride for the past 8 years. If the interior sludge tubing fails, then CAWD will not be able to heat its digesters, which will cause process failure in a matter of days. Since sludge heat exchangers have long lead items, CAWD would not be able to restore heating for months.

2. **Condition of sludge recirculation pump:** The only sludge recirculation pump is used to pump digested sludge through the sludge heater to heat the circulated sludge, which then heats the digester. The interior of the pump has been exposed to ferric chloride, which has been fed to the suction side of the pump for 8 years. Consequently, this pump has a high probability of failure. If the pump were to fail, it may be possible that a temporary pump could be found and installed in a matter of days to restore digester heating. However, installing a redundant pump to avoid the expense and inconvenience of temporary modifications is desirable.

3. **Condition of Digester 1 mixers:** Digester 1 was designed to be mixed by two external draft tube mixers, but only one mixer is currently operating. One mixer has been out of service for a few years, and while CAWD has a replacement mixer, staff is reluctant to install it for fear that it might “disturb” solids within the digester that could cause problems with the operation of Digester 1, which appears to be functioning well at this time. The mixer in service is making noise, perhaps due to wear, and the continuous service life of this mixer is uncertain. If the mixer were to fail, the digestion performance would suffer, but the digestion process may still be satisfactory due to the long hydraulic detention time in the digester. In addition, staff would likely be able to install the replacement mixer that is on site in a matter of days. While the consequence of mixing failure is not severe, it’s not a desirable condition to operate without immediate mixing redundancy.

4. **Condition of Digester 1 cover:** The cover for Digester 1 is 30 years old, and similar steel covers in service for this length of time often have corrosion damage that requires repairs and recoating. In addition, the rate of corrosion may have increased since CAWD has fed ferric chloride to the digester for the past 8 years. (The cover shows areas of corrosion on the exterior, although this is probably more evident of the exterior coating deterioration.) Typically well engineered and applied coating systems will last for 20 to 30 years before recoating is needed. The consequence of cover failure is significant since digester gas would leak out, thus causing an unsafe condition. The digester would need to be taken out of service to be repaired, which would likely take a matter of weeks, depending upon the severity of the repairs.

5. **Likely Debris Buildup inside Digester 1:** Digester 1 is the largest digester and is heated and mixed for use as a primary digester. This digester has reportedly not been cleaned since 1998. Based on this, the digester likely has a large volume of settled debris and scum to be removed, and will need to be taken out of service to be cleaned and inspected. If debris at the bottom of Digester 1 is disturbed it can clog heating

recirculation piping and result in a failure of the digester heating system. Accumulation of scum and debris in a digester also shortens the effective sludge detention time by reducing the effective digestion volume.

## Physical Condition Deficiencies: Digesters 2 and 3

Following are specific physical deterioration issues relating to Digesters 2 and 3. These physical deficiencies do not pose a direct risk to CAWD's ability to digest sludge because Digester 1 alone can meet the required levels of service. However, the following physical deficiencies do impact the ability of CAWD to meet sludge digestion levels of service if Digester 1 is out of service for any reason:

1. **Structural Integrity of Digester 2:** Based on a structural evaluation of Digester 2, it will need significant structural improvements to repair damage, and to improve reinforcing per the current seismic and structural design standards. Until these retrofit repairs are made, it would be risky to take Digester 1 out of service.

2. **Sludge Heating of Digester 2:** Currently CAWD operations staff is not sure if Digester 2 could be heated using the existing sludge heating recirculation system because of a long period of non-operation. Recirculation piping has been unused for over 10 years and valves have not been exercised in any known frequency which means that sludge heating recirculation loop piping may not convey sludge.

3. **Condition of Digester 2 cover:** Staff reported that this cover appeared to be in good condition based on a general visible inspection five years ago. However, this cover is also 30 years old, and should be thoroughly inspected for corrosion damage. The ferric chloride addition may have increased the rate of corrosion for the cover, but likely not as much as to Digester 1 since Digester 2 has been used as a secondary digester.

4. **Condition of Mixer for Digester 2:** Maintenance staff has reported that the single mixer for Digester 2 is losing a quart of oil every week, which is almost 10% of its total oil capacity of three gallons. This indicates that there is a serious problem with the mixer, and that it may be unable to continue to operate reliably without repairs.

5. **Digester 2 Gas System:** Gas has been observed escaping from the pressure relief valve (PRV) on the digester cover based on odors around the PRV. Correcting this may be as simple as checking and revising the relief setting of the PRV. In contrast, if the PRV is relieving pressure properly, it would indicate that the digester gas pressure controls are not functioning or tuned properly. The continuous venting of digester gas is a significant safety hazard.

6. **Condition of Digester 3:** As noted above, Digester 2 does not appear to have sufficient capacity to provide adequate detention time at the calculated solids feed flow if Digester 1 is out of service. To provide the extra detention time, Digester 3 could be used. Unfortunately, this digester has major deficiencies that would need to be corrected to allow it to be placed into service as a primary or secondary digester. These include

structural modifications, improving mixing, adding heating capacity, replacing digester gas piping, and possibly modifying the sludge piping to and from the digester. In summary, Digester 3 needs to be completely rehabilitated to be operational.

## Interim Reliability Improvements

### Interim Reliability Improvement Alternatives:

Based on the deficiencies described above, the current capacity and level of service deficiencies need to be addressed. Major improvements involving structural and equipment retrofits or a new digester tank would be required to address the current firm capacity reliability issues. These firm capacity improvements would take several years to design, construct and put into service as described later in this TM. Therefore, interim improvements are recommended to provide a more reliable system in the interim period before Digester Firm Capacity Improvements are completed. Interim improvements would also give CAWD the flexibility to postpone Digester Firm Capacity Improvements to allow CAWD to focus on upgrading other systems in the plant with a higher risk profile.

K/J understands that CAWD is considering cleaning Digester 1 in the near future since it has not been cleaned for over 10 years. If Digester 1 is taken out of service for cleaning for 30 to 60 days, CAWD would need to use Digesters 2 and 3 to provide digestion at the current feed sludge flow. However, as previously discussed Digesters 2 and 3 have marginal capacity and have major deficiencies which make these digesters unreliable. Therefore, taking Digester 1 out of service for cleaning at this time is very risky.

Construction of major Digester Firm Capacity Improvements could not be completed until 2015 at the earliest (assuming design begins in early 2013). Without interim improvements Digester 1 will need to continue to operate as is for at least 3 years. As noted above, the major risks to continued reliable operation of Digester 1 are the heating system, sludge circulation system, mixing system, and issues that could arise from collected debris in Digester 1.

There are several alternatives for interim digester improvements presented herein that could increase the reliability of the digestion system before investing in major Digester Firm Capacity Improvements. Interim improvements would increase the reliability of the existing digestion system such that the time before implementing major digester capacity improvements may be prolonged. One of the interim alternatives is the “do nothing” alternative which would not improve reliability in the interim time before major improvements to address capacity issues of Digester 2 and Digester 3. The alternatives considered herein are:

- **Alternative 1:** Increase reliability of Digester 1 equipment such that cleaning of Digester 1 will not be necessary until after Digester Firm Capacity Improvements.

- **Alternative 2:** Increase reliability of Digester 2 and Digester 3 equipment and piping and decrease digester feed volume such that Digester 1 may be taken out of service for cleaning, thus increasing the long term reliability of Digester 1.

- **Alternative 3:** Develop provisions to truck partially digested dewatered primary and waste activated sludge to Monterey Regional Waste Management District Landfill.

- **Alternative 4:** Construct a lime stabilization system as a back-up to the digestion system.

- **Alternative 5:** No interim improvements.

### Alternative 1 – Increase reliability of Digester 1 (w/o cleaning Digester 1)

Increasing the reliability of Digester 1 without cleaning Digester 1 would require that the heating and sludge recirculation equipment be reliable. As previously noted the sludge heating system has physical condition issues which could lead to an unexpected failure. In addition, the equipment needs to be able to handle potential ragging and grit issues that could occur if debris collecting at the bottom of Digester 1 becomes suspended. Rags and other debris collecting at the bottom of Digester 1 could become suspended as a result of changes to mixing intensity from switching out the mixer currently on Digester 1 for maintenance or for replacing the mixer if it fails.

Improvements that would be implemented in Alternative 1 include:

- Install a new heat exchanger: A second heat exchanger is needed to provide redundancy for the existing sludge heat exchanger which has a high likelihood and consequence of failure. A spiral type heat exchanger is recommended which provides space and efficiency advantages. Once this heat exchanger is installed, it would be used as the primary source of heating for Digester 1. The existing sludge heat exchanger would be used as a redundant sludge heater. Alternatively, CAWD could install two new spiral heat exchangers now, and eliminate the existing sludge heat exchanger.

- Install a new boiler to provide reliable hot water loop heating for the sludge heat exchanger.

- Install a new sludge recirculation pump and piping: The new pump and piping would need to be installed in conjunction with the new spiral heat exchanger to provide a fully operational heating system for Digester 1. The existing recirculation pump and piping would serve as a redundant system. Alternatively, two recirculation pumps and piping systems could be installed so that the existing recirculation pump could be removed. This approach would be needed if a second spiral heat exchanger is installed now as described above.

- Develop a plan to replace the sludge mixer with the existing mixer for Digester 1: If the single operational mixer for Digester 1 fails, CAWD can replace it with the standby mixer that is on site. Since the mixer will need to be replaced within a few days, CAWD should develop a specific plan to replace the mixer, to ensure it has all parts on hand, and that outside services (crane, etc.) are identified and can be readily available as needed.

- Install a macerator and cleanouts on sludge recirculation piping: To improve the sludge circulation system such that it can handle rags and grit from Digester 1, a macerator would need to be installed on the recirculation suction point from Digester 1. In addition, new piping would need to be installed to allow operations to flush each run of piping in the sludge recirculation and heating loop. These improvements would increase the reliability of operating Digester 1 without cleaning.

The estimated probable capital construction cost for Alternative 1 is summarized in Table 1. It should be noted that the cost of the new equipment to support Digester 1 will likely be needed in the near future, regardless of which interim or long term alternative(s) are selected.

Table 1: Alternative 1: Increase Reliability of Digester 1 (w/o cleaning Digester 1) Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **Equipment** | |
| 1 | Spiral Heat Exchanger (1) | $70,000 |
| 2 | Hot Water Boiler | $100,000 |
| 3 | Sludge Recirculation Pump (1) | $25,000 |
| 4 | Macerator | $25,000 |
| | *Equipment Subtotal* | *$220,000* |
| | **Mechanical Piping** | |
| 5 | Sludge Piping | $15,000 |
| 6 | Hot Water Piping | $25,000 |
| 7 | Valves | $15,000 |
| | *Mechanical Subtotal* | *$55,000* |
| | **Electrical & Instrumentation** | |
| 8 | Electrical/Instrumentation Work | $60,000 |
| | *Electrical and Instrumentation Subtotal* | *$60,000* |
| | Project Subtotal: | $335,000 |
| | Mobilization/Demobilization: | $34,000 |
| | Contractor Overhead and Profit: | $55,000 |
| | **Project Total:** | **$424,000** |
| | Contingency @ 30%: | $127,000 |
| | **Total with Contingency (Rounded):** | **$550,000** |

Engineering costs associated with equipment replacement for a small project like this are highly variable, but are estimated to be in the range of 20%. Therefore the estimated budget including engineering and rounded for budgetary purposes would be **$660,000**. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District.

### Alternative 2 – Increase reliability of Digesters 2 and 3 to allow cleaning Digester 1

Cleaning and inspecting Digester 1 will provide more certainty as to the condition of Digester 1 in addition to cleaning debris which could clog process piping. However, in order to take Digester 1 down for 30 to 60 days to permit cleaning, Digesters 2 and 3 need significant mechanical and electrical improvements to allow them to operate reliably as digesters. These digesters will also likely need significant structural improvements; although structural improvements are not included in this interim alternative as these structural improvements would be a major retrofit. Consequently, while this is a viable alternative, it is risky in that it assumes that the digester structures would be able to function in the interim without failure. The improvements in this alternative involve reliability improvements only as necessary to take Digester 1 down for cleaning for 30 to 60 days, which means these improvements would not be designed for long term operation.

Improvements that would be implemented to Digesters 2 and 3 in Alternative 2 include:

- Empty Digester 2 and inspect piping systems: The piping systems used to operate Digester 2 as a primary digester have not been used for over 10 years. Therefore, before placing Digester 2 into service as the primary digester it would be prudent to inspect the piping to determine if it can be used and then repair or replace valves and clean piping as is necessary.

- Repair or replace the mixer for Digester 2: The mixer is using an excessive amount of oil, which may indicate that physical mortality is imminent. Prior to relying on this without a backup, it needs to be thoroughly checked and repaired as needed.

- Install mixing system for Digester 3: The pumped mixing system for Digester 3 has been out of service for an extended period. A major rebuild of this pump should be assumed for budgetary purposes.

- Install new sludge piping (temporary or permanent): The existing sludge piping and valves have not been used to operate Digesters 2 and 3 as primary digesters in over 10 years. Therefore, it is likely that valves have seized and piping could be unreliable. Depending on the extent of inoperable valves, piping modifications to allow Digester 2 to operate as a primary digester and Digester 3 to operate as a secondary digester will be required.

- Install new sludge heat exchanger(s) to heat Digesters 2 and 1: As discussed in Alternative 1 a new heat exchanger (or two heat exchangers) is needed to provide redundancy for the existing sludge heat exchanger for Digester 1, which is in poor condition and has a high likelihood of physical failure which could result in a level of service failure for the digestion system.

- Install a new boiler to provide reliable hot water loop heating for the sludge heat exchanger.

- Install new sludge recirculation pump(s) and piping: As discussed in Alternative 1, a new sludge recirculation pump (or two pumps) and piping would need to be installed in conjunction with the new spiral heat exchanger to provide a fully operational heating system for Digester 1 and Digester 2. New piping would improve the ability to heat Digester 2. It would be desirable to provide dedicated new recirculation pumps for Digester 2 and Digester 1.

- Install new gas piping to improve the gas handling system for Digester 3 which does not appear to be adequate to handle gas if Digester 3 is operated. New digester gas piping and appurtenances would be required from Digester 3 to the Digester Control Building.

- Develop a plan to replace the sludge mixer with the existing mixer for Digester 1: As discussed in Alternative 1, if the single operational mixer for Digester 1 fails, CAWD can replace it with the standby mixer that is on site. Since the mixer will need to be replaced within a few days, CAWD should develop a specific plan to replace the mixer, to ensure it has all parts on hand, and that outside services (crane, etc.) are identified and can be readily available as needed.

The estimated probable capital construction cost for Alternative 2 is summarized in Table 2.

### Table 2: Alternative 2: Increase Reliability of Digesters 2 and 3 to allow Cleaning Digester 1 Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **Equipment** | |
| 1 | Spiral Heat Exchanger (1) | $70,000 |
| 2 | Hot Water Boiler | $100,000 |
| 3 | Sludge Recirculation Pump (1) | $25,000 |
| 4 | Digester 3 Mixer Rehabilitation | $20,000 |
| 5 | Repair Digester 2 Mixer | $50,000 |
| | *Equipment Subtotal* | *$265,000* |
| | **Mechanical Piping** | |
| 6 | Sludge Piping | $75,000 |
| 7 | Hot Water Piping | $25,000 |
| 8 | Digester 3 Gas Piping | $10,000 |
| 9 | Valves | $25,000 |
| | *Mechanical Subtotal* | *$135,000* |
| | **Electrical & Instrumentation** | |
| 10 | Electrical/Instrumentation Work | $90,000 |
| | *Electrical and Instrumentation Subtotal* | *$90,000* |
| | Project Subtotal: | $490,000 |
| | Mobilization/Demobilization: | $49,000 |
| | Contractor Overhead and Profit: | $81,000 |
| | **Project Total:** | **$620,000** |
| | Contingency @ 30%: | $186,000 |
| | **Total with Contingency (Rounded):** | **$800,000** |

Engineering costs associated with retrofits for a small project like this are highly variable, but are estimated to be in the range of 25% due to the complexity. Therefore the estimated budget including engineering and rounded for budgetary purposes would be **$1,000,000**. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District.

The above alternative assumes that the cover for Digester 3 is in good enough condition to operate leak free. It is unknown whether this is true. Furthermore, this alternative does not include structural improvements to retrofit Digesters 2 and 3 to meet current seismic and structural codes. For these reasons this alternative is not recommended.

### Alternative 3 – Emergency Disposal of Partially Digested Sludge to Monterey Regional Waste Management District Landfill

Currently CAWD produces approximately 150 tons per month of Class B dewatered sludge of about 16% solids content which until recently were hauled offsite for composting at McCarthy Farms in Lost Hills, Kern County. The sludge hauler for CAWD has since been changed and the dewatered solids are now disposed of at the Monterey Regional Waste Management District Landfill. In the possible event that sludge does not meet Class B requirements because of failures in the digestion system CAWD could potentially still dispose of the dewatered solids at the Monterey Regional Waste Management District Landfill, although the waste would be classified and handled differently at the landfill.

In order to develop this potential alternative, CAWD should contact the Monterey Regional Landfill and discuss the possibility and costs of occasional disposal of biosolids which do not meet Class B regulations. An agreement for this occasional sludge disposal option should be sought with the landfill to have a plan in place when needed. There would not be a significant capital improvement investment required to truck solids to the Monterey Regional Waste Management District landfill however there could be an increase in disposal fees over the current fees. This approach is a “non-asset” approach to dealing with potential asset failure modes, meaning the approach does not involve building new assets or repairing assets.

The potential risk associated with this alternative is that dewatering of partially digested sludge would result in an increase in odors in the dewatering process, and result in the need for odor mitigation. The odors could be mitigated by adding lime upstream of the dewatering system to control odors or to stabilize the sludge to the point that it would meet Class B requirements (Alternative 4).

## Alternative 4 – Lime Stabilization System as a Back-up to Digestion

Lime stabilization inactivates or destroys pathogens if it is used to elevate the pH of the sludge to a pH of 12 for more than 2 hours. To meet vector attraction reduction requirements the sludge must be maintained at a pH of 11.5 for 22 hours which drives the dosage requirements up to 25% to 40% (dry weight basis) lime dose.

Lime usage to stabilize 15,000 gallons per day of liquid sludge would require approximately 800 lbs per day of lime slurry (calcium hydroxide). Calcium hydroxide slurry concentration would be approximately 20% and therefore the daily volume of lime slurry required would be about 400 gallons per day. Lime slurry costs approximately $1 per gallon resulting in a chemical cost of about $400 a day and $12,000 per month.

Lime could be fed after anaerobic digestion in the digesters and before the sludge holding tank which is used to feed the belt filter press. A mix tank constructed of polyethylene with about 1,000-gallon capacity and a propeller mixer could be used to mix the lime into the sludge. New piping between Digester 2 and the mix tank would be required and could be comprised of 8-inch-diameter flexible hose. Both sludge feed into the mix tank and the lime feed into the mix tank would need to be at controlled rates, therefore sludge feed and lime feed pumps would be required to provide accurate mixing ratios in the mix tank.

A lime feed point would also be included into the primary clarifier scum trough upstream of the digesters if the digestion system fails and it is necessary to continue use of the digesters for sludge storage. If the digester heating systems are not functioning and anaerobic digestion fails then the sludge in the digesters would become “sour” and probably cause odor issues, but with lime stabilization upstream the sludge would be stabilized with odors greatly reduced and could be stored in the digesters without resulting in odor issues. Upstream stabilization would however impede any anaerobic sludge digestion from occurring in the digesters after the lime feed.

Costs for equipment would include a lime/sludge mix tank, sludge piping (hose could be used), lime slurry storage tank (with mixer to keep slurry mixed), sludge feed pump, sludge flowmeter, slurry metering pump and electrical power to the equipment.

The estimated probable capital construction cost for Alternative 4 is summarized in Table 3.

Table 3: Alternative 4: Backup Lime Stabilization System Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **Equipment** | |
| 1 | Lime Slurry Storage Tank (w/ mixer) | $20,000 |
| 2 | Sludge/Lime Slurry Mixer (Qty 2) | $20,000 |
| 3 | Sludge/Lime Slurry Mix Tank | $20,000 |
| 4 | Sludge Transfer Pump | $25,000 |
| 5 | Lime Slurry Metering Pumps (Qty 2) | $30,000 |
| | *Equipment Subtotal* | *$115,000* |
| | **Mechanical Piping** | |
| 6 | Sludge Piping | $15,000 |
| 7 | Lime piping and valves | $10,000 |
| 9 | Sludge valves | $10,000 |
| | *Mechanical Subtotal* | *$35,000* |
| | **Electrical & Instrumentation** | |
| 10 | Electrical/Instrumentation Work | $20,000 |
| | *Electrical and Instrumentation Subtotal* | *$20,000* |
| | Project Subtotal: | $170,000 |
| | Mobilization/Demobilization: | $17,000 |
| | Contractor Overhead and Profit: | $28,000 |
| | **Project Total:** | **$215,000** |
| | Contingency @ 30%: | $65,000 |
| | **Total with Contingency (Rounded):** | **$280,000** |

Engineering costs associated with a small project like this are highly variable, but are estimated to be in the range of 20%. Therefore the estimated budget including engineering and rounded for budgetary purposes would be **$340,000**. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District. The total cost of this alternative could be reduced if CAWD staff performed some installation work without the services of a general contractor. However, some work such as electrical work and equipment anchoring work should be assumed to require the services of a contractor. Furthermore, renting chemical tanks from the lime supplier could also reduce the cost to implement this alternative.

### Alternative 5 – No Interim Improvements

By not implementing interim improvements it would be prudent to expedite construction of additional digester capacity and equipment improvements to minimize the length of time that Digester 1 continues to run with the above mentioned deficiencies. By doing nothing, CAWD would be accepting that there is a risk that the digestion system could experience a failure before capacity and equipment improvements are implemented. Firm capacity improvements could take approximately 3 years from inception to completion.

## Digester Firm Capacity Improvements

As previously noted, the existing digestion system is deficient because it does not have reliable firm capacity. Digester firm capacity is defined as the capacity to meet the required digestion system criteria with the largest digester out of service. Currently if the largest digester (Digester 1) is out of service, Digester 2 and Digester 3 would be required to digest sludge to meet Class B biosolids requirements. Digester 2 and Digester 3 have been identified as needing substantial repairs and/or improvements to the structures, mixing systems, heating systems, gas handling systems, piping systems, and possibly the covers in order to adequately and reliably digest sludge. In order for CAWD to be able to take Digester 1 down for routine maintenance and improvements while continuing to operate under current operating procedures, Digesters 2 and 3 would need to be repaired and retrofitted to address structural, equipment, and piping deficiencies. Alternatively, a new digester could be built which is sized to provide adequate capacity in a single digester to serve as a redundant digester for Digester 1. Therefore, two alternatives are evaluated herein to address the current digester firm capacity deficiencies. Each of these alternatives constitutes a major project which would take approximately 3 years to complete, including design, construction and startup.

- **Alternative A:** Repair/Retrofit Digesters 2 and 3
- **Alternative B:** Construct a new Digester

### Alternative A – Repair/Retrofit Digesters 2 and 3

#### Introduction to Alternative A

With Digester 1 out of service the capacity in Digester 2 and Digester 3 could provide 14 to 17 days of sludge detention time, assuming a sludge flow of 18,000 to 15,000 gallons per day. While this capacity leaves only a marginal safety factor for meeting pathogen reduction in the anaerobic digestion process, this detention time would be adequate as long as both digesters were well mixed and heated to over 95 degrees Fahrenheit. Both digesters will also need major rehabilitation of the covers and the gas handling equipment. Because of the extensive improvements, the digesters will need to comply with the latest California Building Code (CBC) requirements. This compliance need will trigger significant structural retrofits to both Digesters 2 and 3 in addition to the improvements to the heating system, covers, gas handling equipment, and mixing equipment.

**Structural Evaluation of Digester 2**

K/J has conducted a detailed structural evaluation of Digester 2 to facilitate estimating the extent of structural improvements and capital investment that would be required to bring Digester 2 to meet current building codes. A detailed structural evaluation was not conducted for Digester 3, however budget allowances for repairing structural deficiencies in Digester 3 are included in the costs for Alternative A. Digester 3 budget allowances were determined based on an assumption that similar retrofit and repairs would be needed for the Digester 3 structure as was determined for Digester 2 in this analysis.

**Digester 2 Structural Background Information**

The original drawings of Digester 2 and the drawings of the replacement cover for Digester 2 in the 1982 Early Start Reclamation Project were reviewed. The structural technical specifications and the relevant geotechnical reports were not available. Digester 2 was built in 1960 and has been in service for more than 50 years. The Digester is a pre-stressed concrete circular tank. The tank is 40 feet in diameter and the wall is 22 feet tall. The tank was designed to hold a maximum of 200,000 gallons of sludge at a depth of 20 feet. The tank walls were partially buried 3 feet below the adjacent grade. The digester was originally designed to have a floating steel cover. In 1982, the cover was removed and replaced with a fixed steel cover. The walls and the floor slab are supported on steel pipe piles.

**Summary of Site Observations**

Two site visits were performed to assess the exterior condition of Digester 2 on 29 December 2011 and 14 March 2012. Structural assessment of the interior condition of the Digester was not performed as the digester was in service during the site visits. The findings of the field observations are summarized below:

1. **Conditions of Exterior Walls:** There were a significant number of cracks in the exterior wall. Most of the cracks were hairline in width. Minor active leakage of sludge was observed leaking from the cracks. A continuous crack around the wall at approximately two-thirds the wall height was observed. This continuous crack may be an indication of overstressing of the hoop reinforcing. There were rust stains on the exterior wall surfaces. Some of the rust stains were observed to be a result of runoff from the rusted gas dome and from the rusted guardrail posts at the roof. However, some of the rust stains were observed at the wall cracks, which is likely an indication that the pre-stressed steel reinforcing or the conventional reinforcing steel in the wall are corroded. See Figures 1, 2 and 3. The rust stains may also be from ferric chloride laden sludge which leaked from the digester at some point in the past. Ferric chloride exhibits similar rust color staining on concrete as observed on portions of Digester 2.

Figure 1: Digester 2 Exterior Wall

Figure 2: Minor Leakage of Sludge at the Wall Crack

Figure 3: Rust Stain coming out from the Wall

2. **Conditions of Fixed Steel Cover:** The floating cover was replaced with a fixed steel cover in 1982. The exterior of the fixed steel cover was in fair condition. The interior condition of the cover was not inspected and should be inspected. The steel cover is likely to be corroded and deteriorated if it has not been recoated in the past 30 years as this is beyond

the expected useful life of sound protective coating systems. The connections of the cover were equally spaced and attached to the top of the wall. The connections were generally in good conditions, except two connections located adjacent to the box were corroded. See Figures 4 and 5.

Figure 4: Rusted Water Seal on Cover

Figure 5: Rusted Roof Cover Connections

3. **Conditions of Elevated Walkways:** The roof of Digester 2 is accessed from either the roof of the storage shed adjacent to Digester 3 or from the roof of the Digester Control Building through elevated walkways. A wide open crack and apparent anchorage failure was observed at the connection of the walkway to the Digester 2 wall for the walkway accessed from the Digester Control Building. See Figures 6 and 7.

Figure 6: Spalled Concrete at Walkway Connection

Figure 7: Cracked Concrete at Walkway Connection (Top View)

4. **Conditions of Guardrails:** The roof guardrails around the perimeter of the Digester were in fair condition. The guardrails are rusted in some areas. See Figure 5.

**Summary of Structural Evaluations**

The 2006 edition of ACI 350.3 – Seismic Design of Liquid Containing Concrete Structures and the 2004 edition of AWWA D110 – Wire- and Strand-Wound Circular Prestressed Concrete Water Tanks was utilized to determine the seismic forces and to evaluate the pre-stressed concrete circular tank, respectively.

The digester is located in a high seismic region; and seismic code requirements are now much more stringent than at the time of design more than 50 years ago. The digester was classified to be an Occupancy Category III structure and assigned a seismic importance factor of 1.25 in accordance with ASCE 7 Table 1-1 and Table 11.5-1. Based on the site location, the site class and the short and 1-second period response acceleration parameters, the digester was assigned to Seismic Design Category D in accordance with ASCE 7 Tables 11.6-1 and 11.6-2.

1. **Evaluation of Wall:** The tank wall is comprised of a 2-inch thick layer of shotcrete over an 8-inch thick cast-in-place concrete core wall. The core wall is lightly reinforced with #4 vertical reinforcing steel at 12 inches on center and #4 horizontal reinforcing steel at 4 feet-0-inch on center. The tank wall was pre-stressed by utilizing ¾-inch-diameter steel rods and turnbuckles. The steel rods were covered with 2 inches of shotcrete for corrosion protection. The use of steel rods and turnbuckles as pre-stressing elements was common for constructing a circular pre-stressed concrete tank in 1960s and the tank wall was typically not connected to the floor slab or to the foundation to allow for radial movement.

   The failure mechanisms of overturning, hoop stress and sliding were evaluated and the results are summarized below:

   a. The overturning moment at the wall base due to the hydrostatic and hydrodynamic loads was determined to be 4,760 k-ft (kip-feet). The weight of the steel cover was assumed to be 20 kips (1 kips = 1,000 pounds). The resisting moment from the weight of the tank wall and the steel cover was determined to be 2,204 kip-ft, which is far less than the overturning moment. The tank wall is thus subject to overturning or lifting in a seismic event. The uplift of the tank may produce pounding damage to the wall and to the footing. The sealant between the wall base and the floor slab may be damaged and may result in leaking of the digester contents through the wall to floor slab joint.

   b. The hoop stress along the height of the wall was evaluated based on the spacing of ¾-inch-diameter steel rods. The spacing of the steel rods progressively increases from 4 inches to 14 inches from the base to the top of the wall. Information about the concrete compressive strength of the core wall and the shotcrete, and the yield strength of the steel rods was not available. The concrete compressive strength was assumed to be 3,000 psi and the ultimate strength of the steel rods was assumed to be 58,000 psi for the evaluation which was typical of design parameters at the time of design. The tensile capacity of the existing steel rods wrapped around the tank was determined to be insufficient in terms of present seismic code conditions.

c. The tank is not anchored to the foundation and is only partially contained by the floor slab. An assumption was made that sliding is primarily resisted by friction between the tank wall base and the footing. A friction coefficient of 0.6 was utilized assuming the construction joint between the tank wall base and the top of the footing was not roughened and normal weight concrete was used. The frictional force was determined to be 164 kips which was less than the design base shear of 535 kips. Therefore, the tank is subject to sliding in a seismic event.

2. **Evaluation of Floor Slab:** The floor slab is 9 inches thick and is reinforced with #5 radial bars at 6 inches on center and #5 circumferential bars at 15 inches on center. The floor slab is supported on circular grade beams and the grade beams are supported on steel piles. The circular grade beams are 2 feet-6 inches wide and are spaced at 6 feet typically. The floor slab has a maximum span of 3.5 feet. The flexural capacity of the floor slab was determined to be adequate for the 22-foot depth of sludge assumed.

   The gap between the floor slab and the tank wall was filled with sealant. Sealants typically lose elasticity and adhesion over time and are less permanent than concrete. The tank is susceptible to leakage at the wall to floor slab joint if the sealant fails or if lateral displacement of the tank occurs in a seismic event.

3. **Evaluation of Deep Foundation:** A total of 44 concrete filled steel pipe piles were driven into the ground and were evenly spaced on the grade beams to support the floor slab and the wall. The piles were embedded 12 inches into the grade beam and dowelled into the grade beam with four #6 reinforcing bars. The dowels extended 5 feet into the pile with #3 ties at 12 inches on center. However, the information about the grade, the size, and the embedment depth of steel pile, and the compressive strength of concrete fill were not documented in the record drawings. There is therefore insufficient information to evaluate the axial and lateral capacity of the existing piles.

4. **Evaluation of Fixed Steel Cover:** The digester was designed to have a floating steel cover. In 1982, the cover was removed and replaced with a fixed steel cover. The fixed steel cover is connected to the top of the tank wall to prevent sliding and upward displacement of the roof caused by a sloshing waves, seismic forces, wind pressure, and pressure generated by the gas. The sloshing height was determined to be 4.61 feet in accordance with ACI 350.3. Since the existing digester only has 2 feet of freeboard, the tank cover is subject to uplift and pounding due to the sloshing wave in a seismic event, which could bend and damage the cover. The existing anchors of the steel cover were not evaluated due to insufficient information, but lifting of the cover is also a distinct possibility. The type, size and embedment depth of the anchors were not documented in the original drawings and the shop drawings of the steel covers were not available for review.

**Structural Rehabilitation of Digester 2**

Two alternatives were considered for strengthening the digester. The first was to remove the existing pre-stressed steel rods and the shotcrete and to replace with new pre-stressing strands around the tank. The second was to remove the pre-stressed steel rods and the shotcrete and to cast a new concrete wall against the existing core wall. It is a code provision that a tank located in a high seismic region have either a non-sliding base or an anchored flexible base.

For a code compliant pre-stressed concrete circular tank, the wall base should be separated from the footing by a neoprene pad and the tank wall should either be anchored with seismic cables to resist the overturning and sliding or be contained inside the footing to prevent sliding if overturning is not a concern. Even though this alternative is viable, it is not cost effective to rehabilitate a concrete tank that is less than 500,000 gallons in capacity and to add seismic cables to a flexible wall base to meet the code requirements.

The second alternative is to cast a new 12-inch thick concrete wall against the existing core wall. This alternative is preferable and is more cost effective than the first alternative. Since the core wall is lightly reinforced and the concrete compressive strength of the existing core wall and the yield strength of the reinforcing steel are unknown, the hydrostatic and the seismic loadings would be resisted by the new wall. The new concrete wall would be anchored to a pile supported ring footing to resist the overturning and the sliding. A PVC waterstop would be installed at the wall to footing joint to prevent leakage of the contents. The existing piles would be capable to continuously support the weight of the tank and the contents since there is not any sign of settlement. See Figure 8 for the conceptual design of strengthening Digester 2.

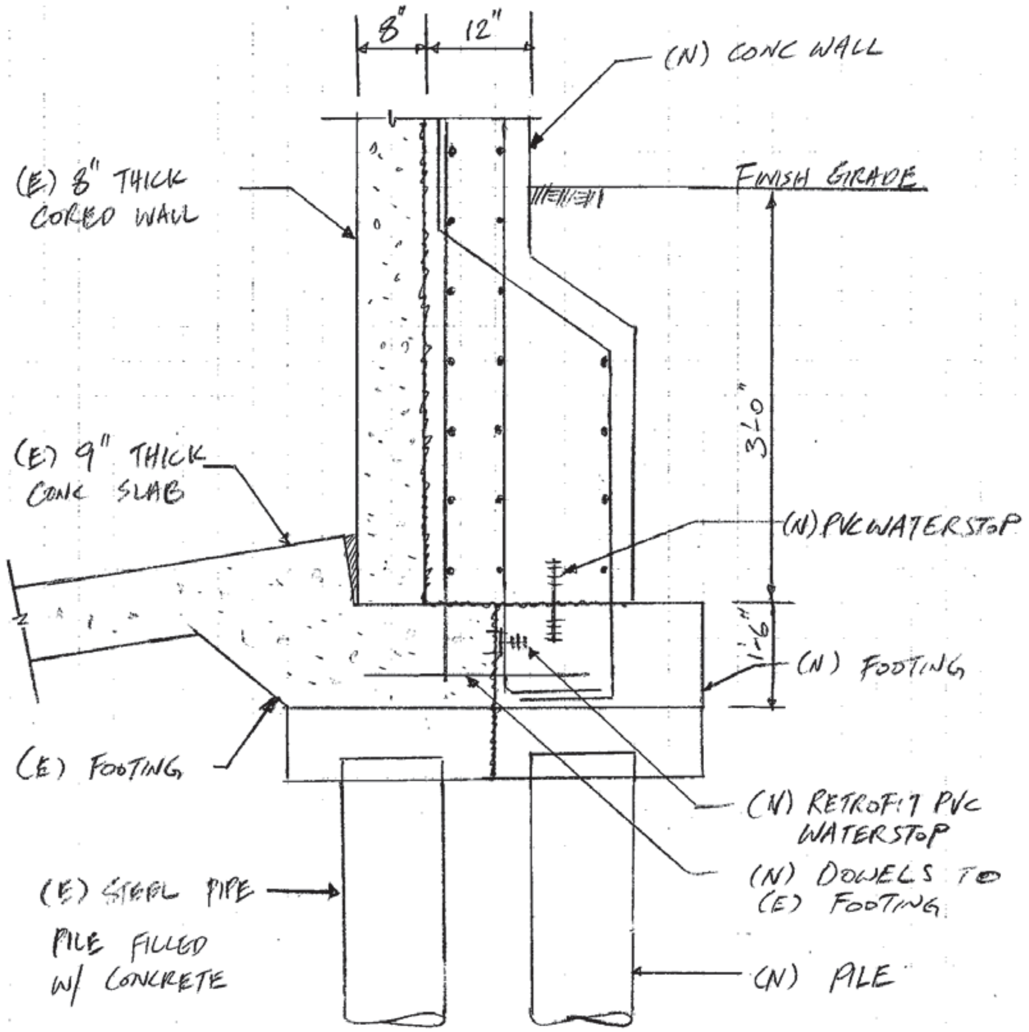



Figure 8: Conceptual Detail of Structural Retrofit of Digester 2

In summary, the recommendations for rehabilitation and strengthening of Digester 2 are as follows:

1. The structural wall of the tank does not have sufficient capacity to resist the overturning moment and hoop stressing. These deficiencies should be addressed by removing the existing shotcrete and the pre-stressing steel rods and replacing them with a new 12-inch thick concrete wall cast outside the existing wall. The cracks in the existing core wall should be repaired. The active leakage of sludge through the cracks should be repaired by injecting hydrophobic polyurethane chemical grout to stop the leakage.
2. A new pile supported ring footing should be constructed to support the new concrete wall to address the uplift due to overturning. The new ring footing should be connected to the existing footing to prevent any differential settlement. The installation of piles may be

challenging due to the proximity of the adjacent facilities and underground piping, especially the high pressure gas and the weak adjacent structures. Appropriate precautions or actions should be taken to prevent damaging the adjacent piping and the structures.

3. The new thickened tank wall should be anchored to the footing to prevent uplift and sliding. The construction joints and the interface of the new and existing footing should be watertight by providing a PVC waterstop.
4. The corroded steel cover connections at the top of the tank wall should be repaired.
5. The cracked concrete at the end connection of the walkway should be repaired.
6. The rusted guardrail at the tank roof should be repaired and recoated.
7. The interior condition of the tank wall, floor slab and the roof cover should be assessed, evaluated and repaired if necessary. The repair scheme and the associated repair cost should be an additional factor to determine the merit of rehabilitating the existing digester.
8. The observed leakage through the cracks on the exterior surface of the tank wall implies that the core wall is cracked through the wall thickness. The interior surface of the concrete wall may be deteriorated since the digester has been operated over 50 years. An elastomeric polyurethane lining should be installed to stop and prevent further deterioration of the concrete.
9. The reuse of the existing digester cover may not be feasible due to the unknown interior condition and the insufficient information to evaluate the anchorage.
10. A new cover is recommended to be included in the budgeting of potential rehabilitation of Digester 2 because the cover is over 30 years old and likely has corrosion damage.

**Mechanical Improvements for Digesters 2 and 3**

In addition to the structural retrofits that would be required for building code compliance, Digesters 2 and 3 would need improvements to the mixing system, gas handling system and heating system to perform reliably as primary digesters when Digester 1 is out of service. Due to the observed condition of Digesters 2 and 3 mechanical systems (piping and equipment), it is estimated that the majority of the equipment either needs to be replaced or is in need of a major rebuild. The mixing systems on both digesters are projected to need major repairs or replacement; heat recirculation piping systems are currently exhibiting signs of failure due to extensive idle periods and are projected to need to be replaced. Gas handling piping and appurtenances to the boiler, microturbines and flare are also projected to need to be replaced due to condition of the piping.

As an option to reduce the primary sludge feed volume to address the capacity concerns with running Digesters 2 and 3 as the only digesters CAWD could reduce the pumping rate from the Primary Clarifiers to optimize solids compaction in the Primary Clarifier sludge hopper which would result in thicker solids feeding to the digesters. We understand that this option may not be practical with the current system, and that installation of smaller pumps with variable frequency drives may be needed to optimize this option. Because this would only be required on a temporary basis, the odor issues associated with longer sludge retention time in the Primary Clarifiers could be an acceptable risk. Furthermore, by also implementing chemically enhanced sedimentation with ferric chloride odor issues can be mitigated. However, even with chemically enhanced sedimentation there is still a potential for elevated odors occurring in the Primary Clarifiers. By implementing these operational changes to the Primary Clarifier Sludge pumping the detention time in Digesters 2 and 3 could potentially be increased. Alternatively, the existing primary sludge pumps could be fitted with adjustable frequency drives to reduce the pumping rate from the clarifiers reducing the velocity at the sludge suction inlet and resulting in intake of less liquid from the tank and more solids.

**Alternative A – Repair/Retrofit Digesters 2 and 3 Probable Construction Cost**

Table 4 provides an engineer's estimate of probable construction cost for Alternative A improvements to retrofit Digester 2 and Digester 3 to provide firm capacity when Digester 1 is out of service.

Table 4: Alternative A: Repair/Retrofit Digesters 2 and 3 Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **Digester 2 Structural Repairs** | |
| 1 | New Concrete Wall/Footing | $200,000 |
| 2 | New Footing Piles | $80,000 |
| 3 | Existing Concrete Wall Crack Repair | $20,000 |
| 4 | Steel Cover Replacement | $150,000 |
| 5 | Elastomeric Polyurethane Internal Tank Coating | $75,000 |
| 6 | Walkway/Guardrail Repairs | $15,000 |
| | *Digester 2 Repairs Subtotal* | *$540,000* |
| | **Digester 3 Structural Repairs (Assumed to be similar to scope as Digester 2 Repairs)** | |
| 7 | New Concrete Wall/Footing | $80,000 |
| 8 | New Footing Piles | $50,000 |
| 9 | Existing Concrete Wall Crack Repair | $10,000 |
| 10 | Cover Replacement | $60,000 |
| 11 | Elastomeric Polyurethane Internal Tank Coating | $40,000 |
| 12 | Walkway/Guardrail Repairs | $10,000 |
| | *Digester 3 Repairs Subtotal* | *$250,000* |
| | **Mechanical Improvements** | |
| 13 | Digester Gas Handling Piping | $60,000 |
| 14 | Sludge Heating Recirculation Piping | $75,000 |
| 15 | Hot Water Piping | $25,000 |
| 16 | Digester 2 Sludge Heating Recirculation Pump | $30,000 |
| 17 | Digester 3 Sludge Heating Recirculation Pump | $30,000 |
| 18 | Hot Water Boiler | $100,000 |
| 19 | Spiral Heat Exchanger (1) | $70,000 |
| 20 | Digester 2 Mixing System Improvements | $100,000 |
| 21 | Digester 3 Mixing System Improvements | $20,000 |
| | *Mechanical Improvements Subtotal* | *$510,000* |
| | **Electrical and Instrumentation** | |
| 22 | Electrical/Instrumentation Improvements | $200,000 |
| | *Electrical Subtotal* | *$200,000* |
| | Project Subtotal: | $1,500,000 |
| | Mobilization/Demobilization: | $150,000 |
| | Contractor Overhead and Profit: | $248,000 |
| | **Project Total:** | **$1,898,000** |
| | Contingency @ 30%: | $569,000 |
| | **Total with Contingency (Rounded):** | **$2,500,000** |

Engineering costs associated with repair/retrofit of existing digesters and equipment replacement is estimated to be in the range of 30% due to the complexity of the project.

Therefore the estimated budget including engineering and rounded for budgetary purposes would be **$3,250,000**. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District.

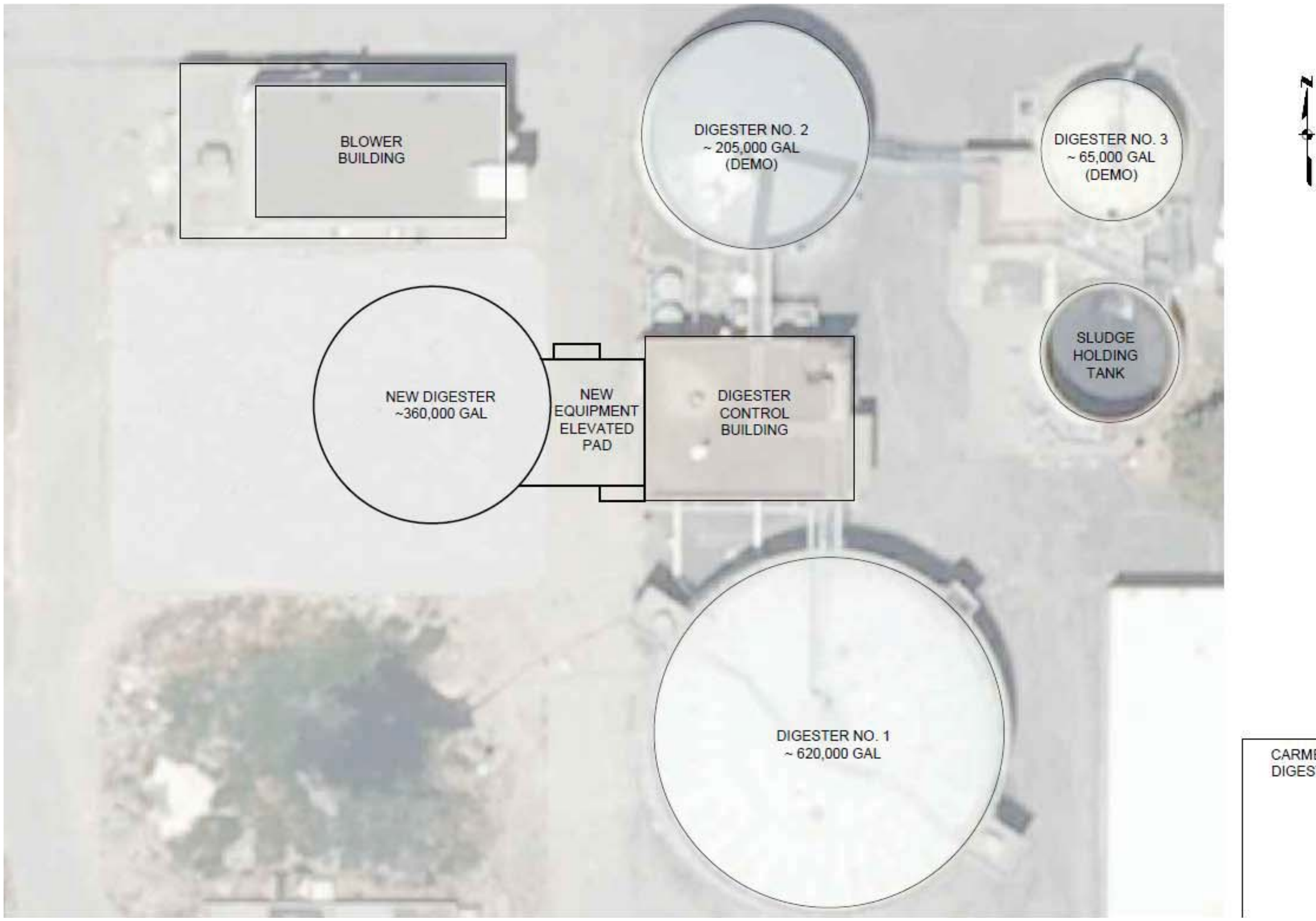
## Alternative B – Construct a new Digester

### Alternative B – Construct a New Digester - Design Criteria

A single new digester could be constructed to replace Digesters 2 and 3 and provide adequate solids retention time with Digester 1 out of service. Sizing a new Digester for 20 days of solids retention time at a loading rate of 18,000 gallons per day of sludge would require a new digester to have a working volume of 360,000 gallons. This size is based on the sludge flow of 15,000 to 18,000 gallons per day which should be further confirmed. Prior to proceeding with work to design a new digester, flow meters should be installed on the digester feed piping to provide more accurate average and peak month flows that can be used for design of the digester. In addition, the design criteria should account for projected future growth in the District. The design criteria of 20 days of solids detention time accounts for losses in detention time as a result of inert solids accumulation in the digester and as a safety factor for peak solids loading.

### Description of Improvements

The cost of constructing a new digester would include the costs of the tank structure which would include foundation piles, concrete floor slab and walls, as well as a new cover for the digester. Furthermore, the new digester would require mixing equipment, sludge heating equipment and gas handling equipment. It is assumed that all of the new digester support equipment would not fit within the existing Digester Control Building and therefore some equipment would need to be located on a new equipment slab on the exterior of the Digester Control Building. The new equipment could be constructed outside, but should be built above the estimated flood elevation. Figure 9 illustrates an overview of where the new digester could be located as well as the new digester equipment slab. Figure 10 provides a conceptual layout of the equipment that could be built on the new digester equipment slab. As an alternative to an exterior elevated equipment slab, the building could be expanded to include a new enclosed room for the equipment if budget were available. The probable estimated construction cost included below does not include this alternative.




Kennedy/Jenks Consultants

CARMEL AREA WASTEWATER DISTRICT
DIGESTER ALTERNATIVES EVALUATION

NEW DIGESTER
CONCEPTUAL LAYOUT

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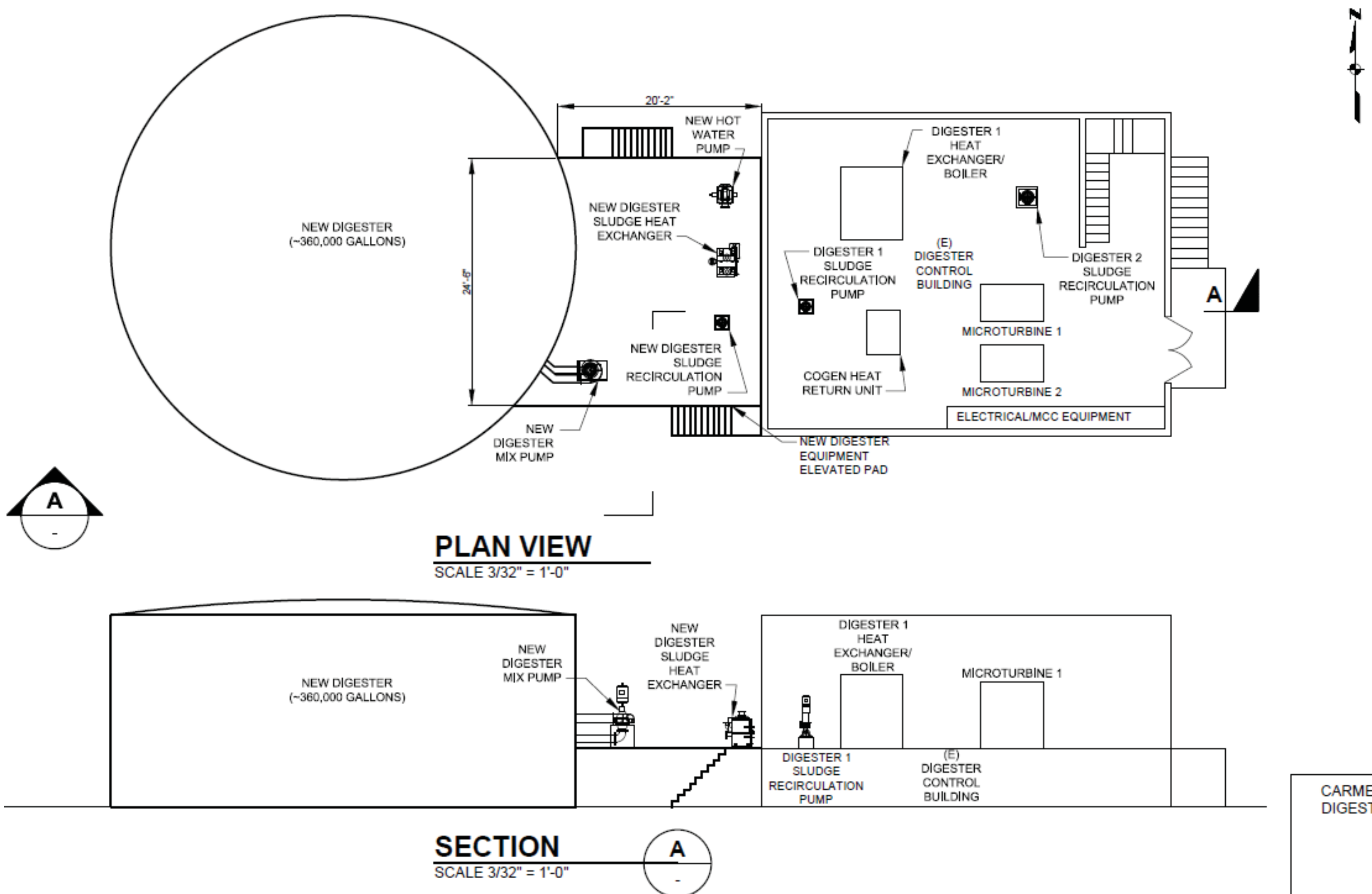
**FIGURE 9**

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DIGESTER ALTERNATIVES EVALUATION

NEW DIGESTER CONCEPTUAL EQUIPMENT LAYOUT

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**FIGURE 10**

**Alternative B – Construct a New Digester Probable Construction Cost**

Table 5 provides an engineer's estimate of probable construction cost for Alternative B to construct a new digester to replace Digesters 2 and 3 and provide firm capacity in the digestion system.

Table 5: Alternative B: Construct a New Digester Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **New Digester Structure** | |
| 1 | Site Work | $50,000 |
| 2 | New Footing Piles | $120,000 |
| 3 | Digester Walls/Footing/Floor Slab | $260,000 |
| 4 | Steel Cover Installation | $140,000 |
| 5 | Elastomeric Polyurethane Internal Tank Coating (Head Space Only) | $60,000 |
| 6 | Walkway/Guardrails/Stairs | $60,000 |
| | *New Digester Subtotal* | *$690,000* |
| | **New Digester Elevated Equipment Slab** | |
| 7 | New Elevated Concrete Slab Structure | $100,000 |
| 8 | New Footing Piles | $50,000 |
| 9 | Walkway/Guardrail/Stairs | $10,000 |
| | *New Digester Elevated Equipment Slab Subtotal* | *$160,000* |
| | **Mechanical Work** | |
| 10 | Digester Gas Handling Piping and Equipment | $60,000 |
| 11 | Sludge Heating Recirculation Piping | $75,000 |
| 12 | Hot Water Piping | $25,000 |
| 13 | Hot Water Boiler | $100,000 |
| 14 | Digester Sludge Heating Recirculation Pump | $30,000 |
| 15 | Sludge Heat Exchanger | $70,000 |
| 16 | Mixing System | $150,000 |
| | *Mechanical Work Subtotal* | *$510,000* |
| | **Electrical and Instrumentation** | |
| 17 | Electrical/Instrumentation Work | $200,000 |
| | *Electrical Subtotal* | *$200,000* |
| | Project Subtotal: | $1,560,000 |
| | Mobilization/Demobilization: | $156,000 |
| | Contractor Overhead and Profit: | $257,000 |
| | **Project Total:** | **$1,973,000** |
| | Contingency @ 30%: | $592,000 |
| | **Total with Contingency (Rounded):** | **$2,600,000** |

Engineering costs associated with construction of a new digester are estimated be in the range of 25%. Therefore the estimated budget including engineering and rounded for budgetary purposes would be **$3,250,000**. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District.

## Conclusions

### Interim Improvements Recommendations

Interim reliability improvements for critical digestion system components are recommended to minimize the high probability of physical mortality. The consequence of failure of these components is significant in that they will cause the digestion process to become inoperable for extended periods of time. The improvements described in Alternative 1 should be completed as soon as possible to achieve this.

In addition to improvements in Alternative 1, a combination of hauling partially digested sludge to the Monterey Regional Landfill and Lime Stabilization (Alternatives 3 and 4) would provide multiple levels of contingency to handle solids residuals in the event of a myriad of foreseeable digestion system failure scenarios. Furthermore, with lime stabilization and landfill disposal it Digester 1 could be taken down for cleaning and repairs without needing to improve Digesters 2 and 3.

Combining Alternative 1 with Alternatives 3 and 4 provides the highest level of reliability in the interim before Major Digester Firm Capacity Improvements are implemented. The capital cost of Alternatives 1, 3 and 4 combined would most likely be in the range of $1,000,000, but would allow postponing completion of “Major Digester Firm Capacity Improvements” for 5 or more years (to 2018 or later). This would free up funding to make improvements in other areas of the plant. Furthermore, the costs associated with Alternative 1 would offset future equipment costs associated with purchasing redundant heating and recirculation equipment during Major Digester Firm Capacity Improvements (Alternative A or B).

Alternative 2 increases the reliability of the digestion system to a degree that would allow taking Digester 1 down for cleaning; however it would not address some foreseeable failure modes of the digestion system such as a failure of the Digester 1 steel cover. Furthermore, Alternative 2 relies on the risky assumption that the seismic structural deficiencies with Digesters 2 and 3 will not result in a failure when these digesters are placed in service as the only digesters. Overall, the potential costs to bring Digesters 2 and 3 into suitable operating condition under this alternative are estimated to be similar in cost to Alternatives 1, 3 and 4 combined and has less benefit.

### Major Digester Firm Capacity Improvements

Major firm capacity improvements are necessary to provide a digestion system where any digester can be taken down for routine maintenance and regular repairs without affecting the ability for CAWD to digest sludge. Alternative B, constructing a new replacement digester, is the recommended alternative for the following reasons:

- Alternative B estimated cost is similar to Alternative A.
- Alternative B would provide greater digestion capacity than Alternative A.
- Alternative B will be all new construction and can be designed to better facilitate operation and maintenance needs since it does not need to be designed around numerous existing constraints.
- Alternative B has the greatest potential to be integrated with and share equipment between Digester 1 and the new digester.
- Having two digesters instead of three would be beneficial, because they can be designed to be fully redundant and interconnected so that the system has redundancy built in to the support systems and centered around the new equipment slab and Digester Control Building.
- Two digesters will be less expensive to operate and maintain than three digesters.

## Summary of Digestion System Capital Improvement Project Alternatives

From the evaluations of the digestion system it appears that three separate projects would be required to maintain the level of service goals of the digestion system. Interim Reliability Improvements and Firm Capacity Improvements would be the first two projects and the third project would be to conduct necessary repairs on Digester 1. Tables 6 and 7 summarize the alternatives developed for the first two projects:

### Table 6: Interim Reliability Improvements Estimated Costs Comparison

| | **Alternative 1** Increase reliability of Digester 1 (w/o cleaning Digester 1) | **Alternative 2** Increase reliability of Digesters 2 and 3 to allow cleaning Digester 1 | **Alternative 3** Emergency Disposal of Partially Digested Sludge to Landfill | **Alternative 4** Lime Stabilization |
|---|---|---|---|---|
| Estimated Construction Cost: | $550,000 | $800,000 | N/A | $280,000 |
| Engineering: | $110,000 | $200,000 | $20,000 | $60,000 |
| Total Capital Cost: | $660,000 | $1,000,000 | N/A | $340,000 |
| Additional Operating Costs: | | | Short Term Increase in Dumping Fees | $12,000 per month lime slurry cost |

Table 7: Firm Capacity Improvements Estimated Costs Comparison

| | Alternative A Repair/Retrofit Digesters 2 and 3 | Alternative B Construct new Digester | Alternative B - After Alternative 1[(a)] Construct new Digester using equipment purchased in Alternative A |
|---|---|---|---|
| Estimated Construction Cost | $2,500,000 | $2,600,000 | $2,200,000 |
| Engineering | $750,000 | $650,000 | $650,000 |
| Total Capital Cost: | $3,250,000 | $3,250,000 | $2,850,000 |

**Notes:**

(a) Constructing Alternative B after Alternative 1 takes advantage of the equipment purchased in Alternative 1 to offset the total cost of Alternative B.

### Digester 1 Physical Condition Improvements

In addition to the previous recommended improvement projects, Digester 1 will need repair or replacement of its cover and may require minor structural repairs which could include coating the inside of Digester 1. The cost of repairs to Digester 1 should be included as an additional capital project expense that would be planned to be completed after firm capacity improvements. Table 8 provides a budgetary estimate of probable construction cost for future physical condition improvements to Digester 1, assuming that Digester 1 will require a new cover and internal coating.

Table 8: Digester 1 Physical Condition Improvements Estimated Probable Construction Cost

| Item | Description | Cost |
|---|---|---|
| | **Improvements** | |
| 1 | Elastomeric Polyurethane Interior Coating | $200,000 |
| 2 | Cover Rehabilitation/Replacement | $350,000 |
| | *Improvements Subtotal* | *$550,000* |
| | Project Subtotal: | $550,000 |
| | Mobilization/Demobilization: | $55,000 |
| | Contractor Overhead and Profit: | $91,000 |
| | **Project Total:** | **$696,000** |
| | Contingency @ 30%: | $209,000 |
| | **Total with Contingency (Rounded):** | **$910,000** |

Engineering costs associated with repairing Digester 1 would be in the range of 20%. Therefore the estimated budget including engineering and rounded for budgetary purposes would be $1,090,000. Estimated engineering costs would include design and construction support services, but not construction management which could be managed by the District.

## Recommended Projects

The recommended projects include Alternatives 1, 3, and 4 in the interim before firm capacity improvements are implemented. The recommended firm capacity improvement project is Alternative B, which can be planned for completion in 2018 or later as interim improvements can be used to maintain the level of service before Digester 1 is taken out of service for cleaning. The cost of Alternative B would be offset as shown in Table 7 with the interim investments in digester heating equipment as part of Alternative 1 (Alternative B - After Alternative 1). After firm capacity improvements are completed, Digester 1 could be taken down to rehabilitate the interior walls with a coating and replace or repair the existing cover. Table 9 summarizes the recommended projects.

Table 9: Recommended Projects Summary

| | Estimated Probable Construction Cost | Engineering | Total Capital Cost |
|---|---|---|---|
| **Interim Reliability Improvements (1 to 3-year timeframe)** | | | |
| Alternative 1: | $550,000 | $110,000 | $660,000 |
| Alternative 3: | N/A | $20,000 | $20,00 |
| Alternative 4: | $280,000 | $60,000 | $340,000 |
| **Firm Capacity Improvements (4 to 6-year timeframe)** | | | |
| Alternative B After Alternative 1: | $2,200,000 | $650,000 | $2,850,000 |
| **Digester 1 Physical Condition Improvements (7 to 10-year timeframe)** | | | |
| Digester 1 Future Repairs: | $910,000 | $180,000 | $1,090,000 |
| **Totals:** | **$3,940,000** | **$1,020,000** | **$4,960,000** |

In summary, three separate stages of digestion system improvement projects should be planned over the next 10 years: Interim Improvements, Firm Capacity Improvements, and Digester 1 Physical Condition Improvements. The estimated sum of capital cost for these three separate digestion system projects over the next 10 years is expected to be in the range of $5,000,000.

7 December 2012

# Technical Memorandum No. 5

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Monty Hazlehurst, P.E., Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Review: Mr. Bob Ryder, P.E., Kennedy/Jenks Consultants

Subject: Standby Dewatering Evaluation of Alternatives
K/J 1268007*01

This memorandum presents alternatives to provide dewatering during required repairs to the digested sludge dewatering system at the Carmel Area Water District (CAWD) Wastewater Treatment Plant (WWTP).

Currently, there are two belt filter presses located side by side on the second floor of the Dewatering Building. Belt Filter Press (BFP) #1 is not functional and is beyond repair. BFP #2 needs to be rebuilt in-place. Because the two presses were installed too close to one another, there is not adequate space to rebuild BFP #2 without first removing BFP #1. BFP #1 is slated to be removed.

The BFP manufacturer estimates it may take up to two and one-half weeks to rebuild BFP #2 in-place, as long as all required replacement parts are on-site. During the two and one-half week period, an alternative method of dewatering will need to be provided.

## Design Criteria

Operations data for the BFP from January 2008 through April 2012 show the largest monthly amount of digested sludge was dewatered in August 2011. The BFP operated for 89 hours and dewatered 422,300 gallons of digested sludge. Operations data also show the average solids concentration for the digested sludge has been approximately 1.5 percent. This solids concentration when applied to the August 2011 peak monthly flow, yields a peak solids production of 52,800 dry pounds (lbs) per month, or 13,200 dry lbs per week. Assuming a BFP though put of 50 gallons per minute (gpm), the peak monthly flow of 422,300 gallons could be processed in 141 hours, or 35 hours per week.

Alternatives developed are based on processing a peak digested sludge flow of 50 gpm over 35 hours per week (operating 5 days per week, 7 hours per day). Since the average solids concentration of the dewatered cake discharged from the existing BFP is approximately 16 percent, dewatering alternatives were based on producing a cake with a minimum solids concentration of 16 percent.

## Alternative 1 – Temporary Sludge Dewatering

This alternative would provide temporary sludge dewatering for the estimated two and one-half week time period required for rebuilding BFP #2. Prior to beginning temporary dewatering operations; however, BFP #1 would need to be demolished to provide the space necessary to make necessary maintenance repairs on BFP #2. This demolition work would require the services of a contractor and would cost an estimated $25,000 with markups and contingency bringing the cost up to an estimated $40,000.

There are over a half dozen companies in the United States that provide temporary sludge dewatering services. Two companies were contacted that provide temporary dewatering; Synagro Technoloigies, Inc. and National Plant Services, Inc. Both are large national companies which have California offices and can provide temporary sludge dewatering on an as-needed basis. Both would provide a trailer mounted BFP and polymer system. They would discharge to the existing cake storage bin for disposal by others. Power would be supplied by the WWTP. They would provide dewatering for 5 days per week and the manpower to operate the dewatering equipment.

Estimated cost for equipment mobilization and demobilization is $10,000. Estimated cost for dewatering is $2,400 per day. For a two and one-half week period (13 days of dewatering), the estimated cost is $41,200.

The estimated time period between the dewatering companies receiving notice to proceed and completing mobilization can be as short as 48 hours during the winter months, but could be weeks during the summer when the demand for dewatering equipment is much higher.

Once the BFP is rebuilt, temporary sludge dewatering may be required in the future due to unforeseen equipment failure. If temporary dewatering equipment were not available in the event of an unforeseen failure of BFP #2, it may be feasible to contract with a company for hauling and disposing of liquid sludge although this would be costly and require multiple truckloads of liquid sludge be hauled from the site for each day that dewatering was not available. The most time consuming part to replace on the existing BFP #2, if it were to fail, would be a roller. The BFP manufacturer estimated that any one of the rollers could be replaced in approximately two and one-half weeks from the time of break down.

The budgetary estimate of capital cost of this alternative is estimated to be approximately $80,000. This alternative would permit necessary repairs to BFP #2 to decrease the probability of failure of the existing dewatering system, but would not provide redundancy.

## Alternative 2 – Permanent Standby Sludge Dewatering

This alternative would provide a permanent means of sludge dewatering during the time that BFP #2 was out of service for repairs. The major advantage of this alternative over Alternative 1 is that standby mechanical dewatering equipment could be operated immediately following an unforeseen breakdown of BFP #2, whereas Alternative 1 may require a period of days or weeks before temporary dewatering could start. While it is not a regulatory requirement to have redundant sludge dewatering capabilities at a WWTP, redundancy in operating systems is always a desirable feature and would mitigate the risk of potential costs associated with an unforeseen dewatering system failure.

In the past ten to fifteen years new mechanical dewatering concepts have been developed and extensively used throughout the United States. The new concepts include screw and rotary presses. These types of dewatering equipment are advantageous in terms of space, reliability, dewatered sludge concentration, removal efficiency, low energy consumption, operations time and maintenance.

Three mechanical dewatering equipment alternatives were evaluated; Huber Inclined Screw Press, Fournier Rotary Press, and FKC Screw Press. All three types of equipment would provide cake with a minimum 16 percent solids concentration. Since the units would only be used as a standby for BFP #2, for relatively short periods of time, the differences in power and polymer requirements between the equipment types have limited importance.

Although equipment sizing has been based on operating at 50 gpm for 35 hours per week (7 hours per day over 5 days), all three types of equipment could be (and often are) run 24 hours per day and during unattended periods.

The existing BFP #2 is an Ashbrook Simon-Hartley 3-Belt Klampress with a 2-meter belt. The manufacturer stated that the ideal maintenance clearance, required on one side of the BFP for removing rollers, is equal to the width of the belt plus 2 feet. With a 2-meter belt, the ideal clearance would be 8.5 feet. The manufacturer stated that the minimum space required is 6 feet. With a space of 6 feet the rollers can be pulled straight out and then angled up to remove them. Thus, all three standby dewatering equipment alternatives are laid out to provide for more than 6 feet of clearance on one side of BFP #2.

All three dewatering equipment types would discharge directly onto the existing belt conveyor.

**Huber Inclined Screw Press:** Huber recommends the Model Ros3Q-620 Screw Press to dewater approximately 50 gpm of digested sludge with a solids concentration of 1.5 percent to a cake concentration greater than 16 percent. The Huber scope of supply would include the inclined screw press manufactured from Type 304 stainless steel with a 5-Hp motor, a Class 1, Division 2, NEMA 4X control panel, and flocculation reactor piping. The Huber Inclined Screw Press conceptual layout is shown in Figure 1. Manufacturer's information on the Huber inclined screw press is included as an attachment to this memorandum.

**Fournier Rotary Press:** The Fournier Rotary Press utilizes parallel screens in rotary "channels" to dewater sludge. Fournier estimates a two-channel press will be required to dewater 50 gpm of anaerobic digested mixed primary and secondary sludge with a solids concentration of 1.5 percent to a cake solids concentration greater than 16 percent. Two additional channels may be added in the future to double the capacity. The press would be provided with a 15-Hp motor, which would be able to operate a total of four channels in the future.

The Fournier scope of supply would include the rotary press, sludge/polymer flocculation tank, piping between flocculation tank and rotary press, sludge flow meter, polymer flow meter, filtrate collector pipe, cake chutes, wash water solenoids for automatic wash sequence, load cells for channel load monitoring, cake sensors for unattended operation, air actuated valves for automatic sludge recirculation, control panel, startup, commissioning, training, and performance testing.

Wash water is required only at shutdown and requires 50 gpm per channel at 60 psi for a period of 5 minutes. Wash water can be delivered to one channel at a time in stages for a total of 50 gpm over 10 minutes for two channels (5 minutes per channel), or to both channels at once for a total of 100 gpm over 5 minutes.

The working space required around the press for maintenance is 3 feet all around. The flocculation tank should be within 20 feet of the press, to ensure the sludge floc maintains good size and consistency. The Fournier Rotary Press conceptual layout is shown in Figure 2. Manufacturer's information on the Fournier Rotary Press is included as an attachment to this memorandum.

**FKC Screw Press:** FKC recommends the Model BHX-700 Screw Press to dewater 50 gpm of digested sludge with a 1.5 percent solids concentration to a cake with greater than 16 percent solids concentration. The FKC scope of supply would include a screw press with a 3-Hp motor, flocculation tank and mixer with a 1-Hp motor, and control panel. All wetted parts would be stainless steel. The FKC Screw Press conceptual layout is shown in Figure 3. Manufacturer's information on the FKC Screw Press is included as an attachment to this memorandum.

**Estimated Construction Costs:** Estimated construction costs for the three types of permanent standby sludge dewatering are shown in Table 1. As shown, the three types of equipment have equipment costs that are relatively equal. Therefore, the type of equipment selected should be based on other factors such as performance, ease of operation, and operator preference. Budgetary costs for equipment were provided by the manufacturers, actual bid prices may be lower.

### Table 1: Estimated Construction Cost of Permanent Standby Sludge Dewatering

| | Huber Screw Press | Fournier Rotary Press | FKC Screw Press |
|---|---|---|---|
| Demo BFP #1 | $25,000 | $25,000 | $25,000 |
| Equipment Cost | $245,000 | $220,000 | $235,000 |
| Equipment Installation Cost (30%) | $73,000 | $66,000 | $71,000 |
| *Subtotals* | *$343,000* | *$311,000* | *$331,000* |
| Electrical and Instrumentation (17%) | $58,000 | $53,000 | $56,000 |
| *Subtotals* | *$401,000* | *$364,000* | *$387,000* |
| Mobilization/Demobilization | $40,000 | $36,000 | $39,000 |
| Contractor Overhead and Profit (15%) | $66,000 | $60,000 | $64,000 |
| ***Subtotals*** | ***$507,000*** | ***$460,000*** | ***$490,000*** |
| Contingency (20%) | $101,000 | $92,000 | $98,000 |
| **Estimated Construction Cost** | **$608,000** | **$552,000** | **$588,000** |

One of the advantages of the Fournier Rotary Press is that its capacity can be increased by adding additional channels. The estimated cost for each future channel is approximately $50,000. A two-channel press having a capacity of 50 gpm could be expanded to four channels with a total capacity of 100 gpm for less than approximately $100,000 in equipment cost.

The two types of screw presses use the least energy, and that can be a savings of several thousand dollars per year. Polymer usage and operator attention is estimated to be nearly equal for the three manufactures. All three manufacturers claim their equipment can run unattended, with little operator attention. Furthermore, with these newer mechanical dewatering equipment types it is very likely that a 20% or higher sludge cake could be produced which then can save nearly a quarter of current sludge hauling and disposal costs. As a result of these advantages it is quite likely that a new screw press or rotary press at CAWD would become the first choice in operation at the WWTP.

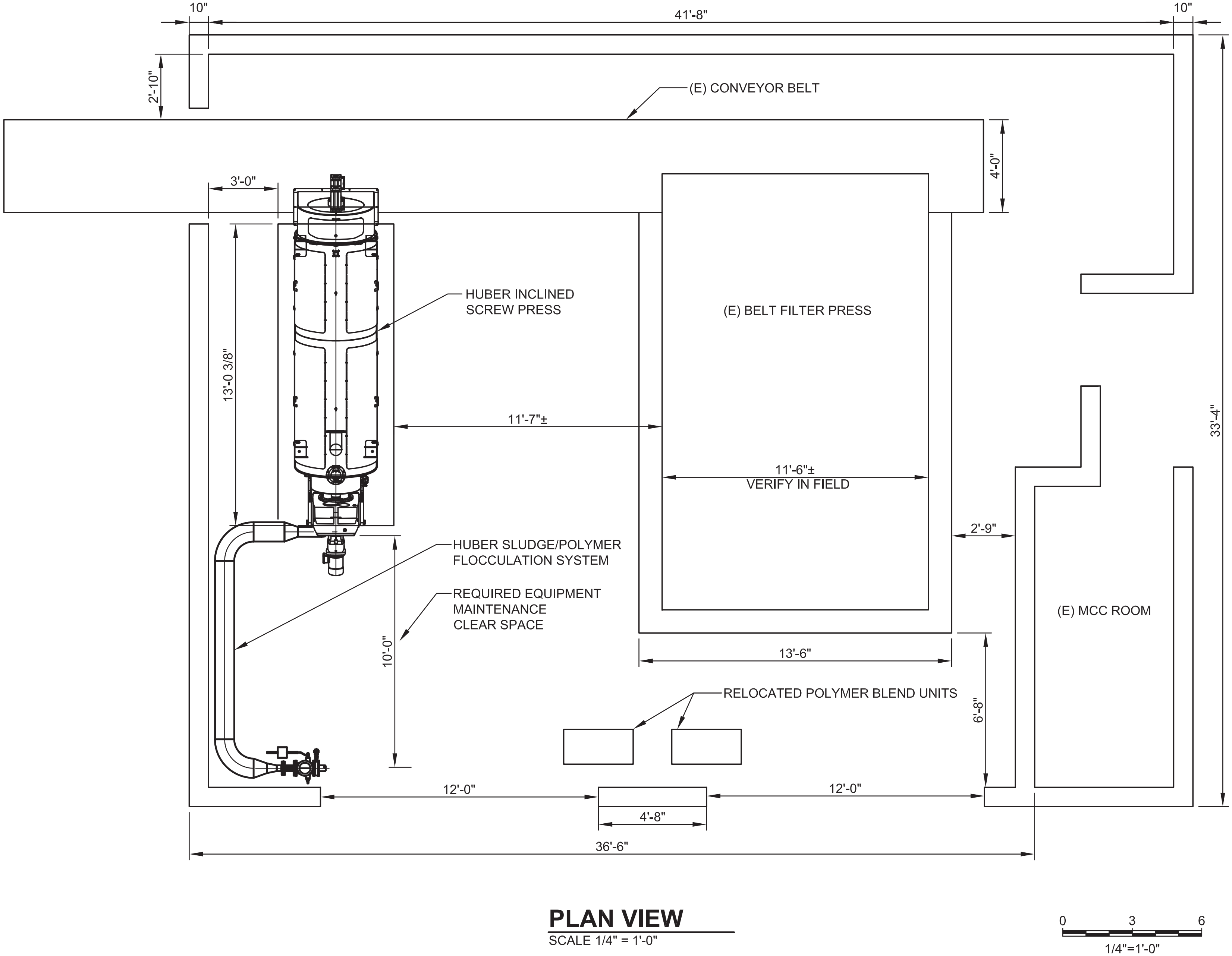
## Conclusion

Although the cost of providing temporary sludge dewatering would be minimal compared to providing permanent standby sludge dewatering, there is a risk that temporary dewatering when required would not be available in a timely manner or at a fair price. A permanent redundant dewatering system that could be operated immediately when required would offer an advantage with a fixed cost, and have significant operations and maintenance advantages as compared to belt filter presses.

If permanent standby dewatering equipment is the selected alternative, all three types of equipment should be further investigated. Because the construction costs would be similar for the three types of permanent standby dewatering equipment, their selection should be based on factors such as performance, ease of operation, compatibility with existing ancillary equipment, and operator preference. References should be contacted to determine operating or maintenance issues and performance. Visits to operating installations are also recommended. All three equipment manufacturers offer laboratory analysis of the digested sludge to better approximate polymer usage and expected performance. In some cases, they can also supply piloting equipment.

**Enclosures:**

Figure 1: Belt Press Building Standby Dewatering – Huber Inclined Screw Press – Conceptual Layout
Figure 2: Belt Press Building Standby Dewatering – Fournier Rotary Press – Conceptual Layout
Figure 3: Belt Press Building Standby Dewatering – FKC Screw Press – Conceptual Layout
Huber Product Information
Fournier Product Information
FKC Product Information




## PLAN VIEW

SCALE 1/4" = 1'-0"

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CARMEL AREA WASTEWATER DISTRICT
BELT PRESS BUILDING
STANDBY DEWATERING
HUBER INCLINED SCREW PRESS
CONCEPTUAL LAYOUT

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**FIGURE 1**

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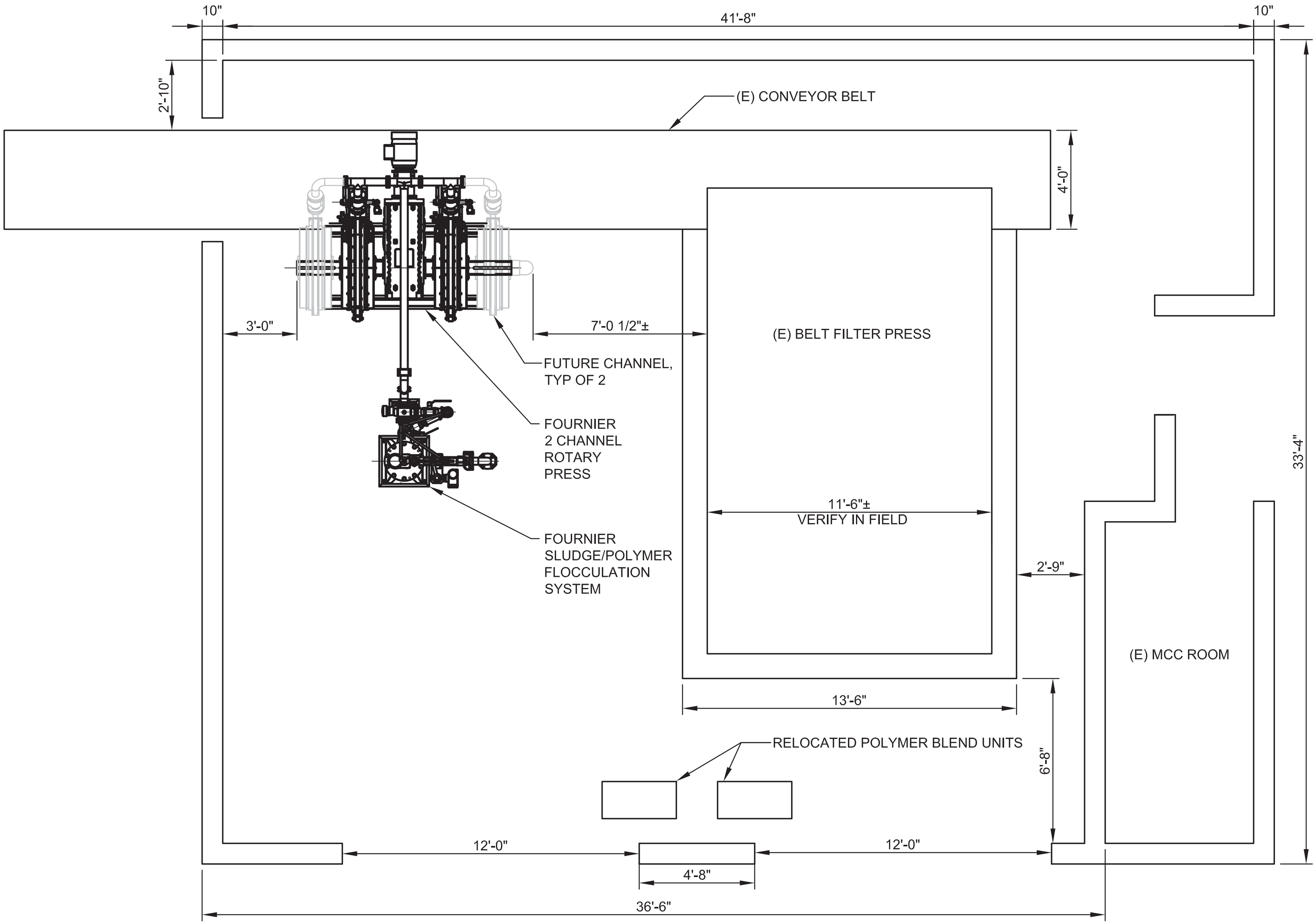


## PLAN VIEW

SCALE 1/4" = 1'-0"

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1/4"=1'-0"

Kennedy/Jenks Consultants

CARMEL AREA WASTEWATER DISTRICT
BELT PRESS BUILDING
STANDBY DEWATERING
FOURNIER ROTARY PRESS
CONCEPTUAL LAYOUT

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**FIGURE 2**

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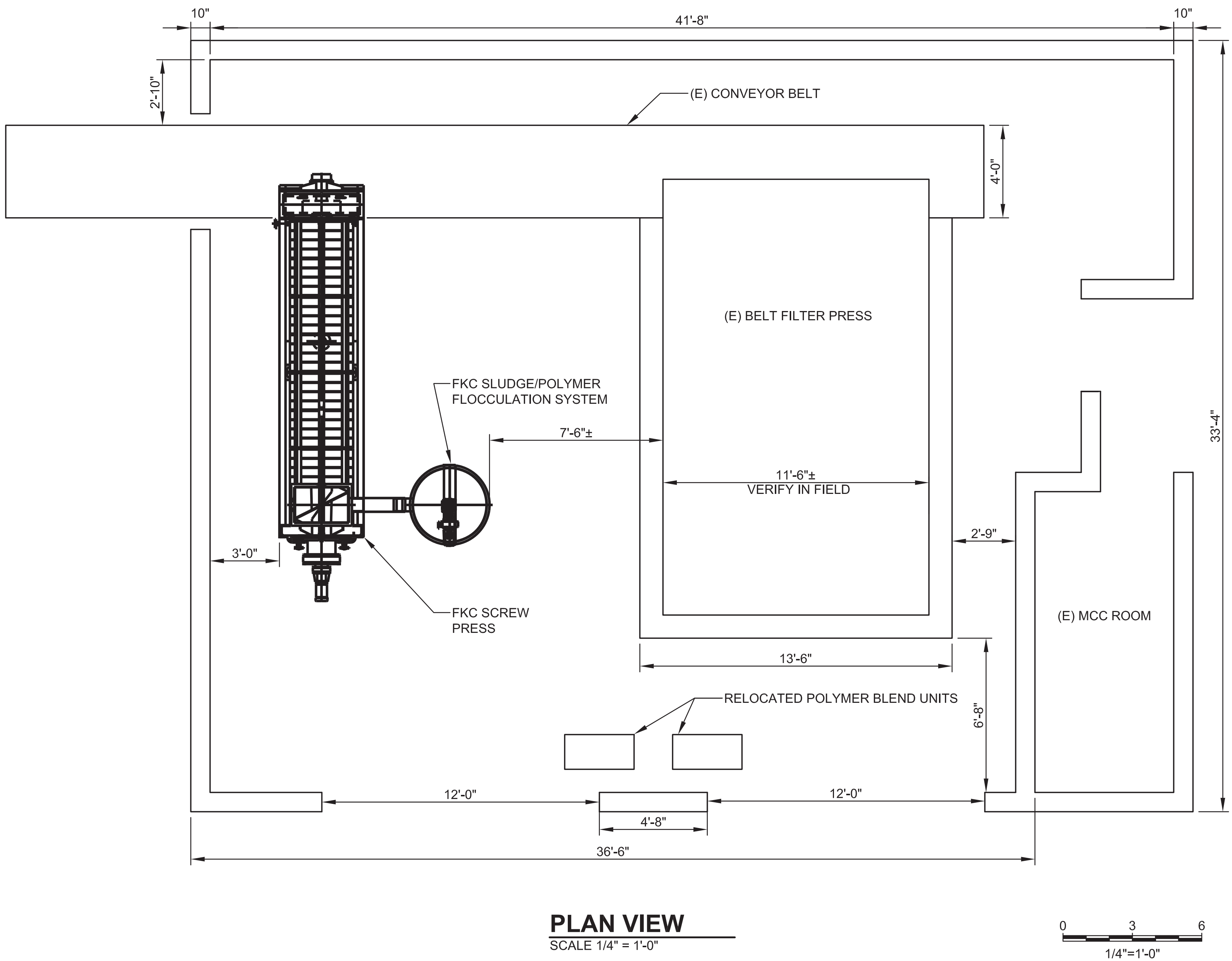


**PLAN VIEW**
SCALE 1/4" = 1'-0"

Kennedy/Jenks Consultants

CARMEL AREA WASTEWATER DISTRICT
BELT PRESS BUILDING
STANDBY DEWATERING
FKC SCREW PRESS
CONCEPTUAL LAYOUT

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**FIGURE 3**

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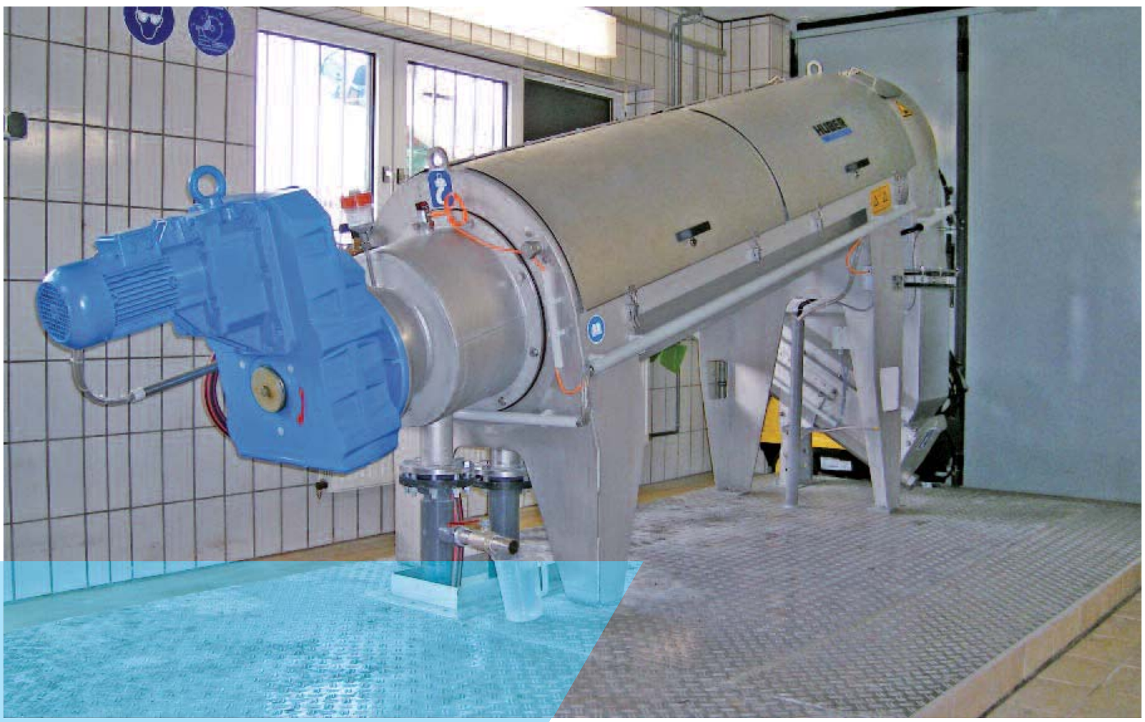
HUBER TECHNOLOGY
WASTE WATER Solutions

# Screw Press
# ROTAMAT® RoS 3Q




The new Screw Press for sludge dewatering:

– outstanding performance
– efficient and reliable operation
– easy operation and maintenance

## The Need for better Sludge Dewatering

Sludge / biosolids disposal becomes ever more difficult and expensive. The better sludges are dewatered, the less mass needs to be hauled and transportation costs are reduced. Advanced biosolids treatment, such as drying or incineration, requires excellent prior mechanical dewatering to avoid excessive energy consumption and costs for water evaroparation.

State-of-the-art sludge dewatering must be:

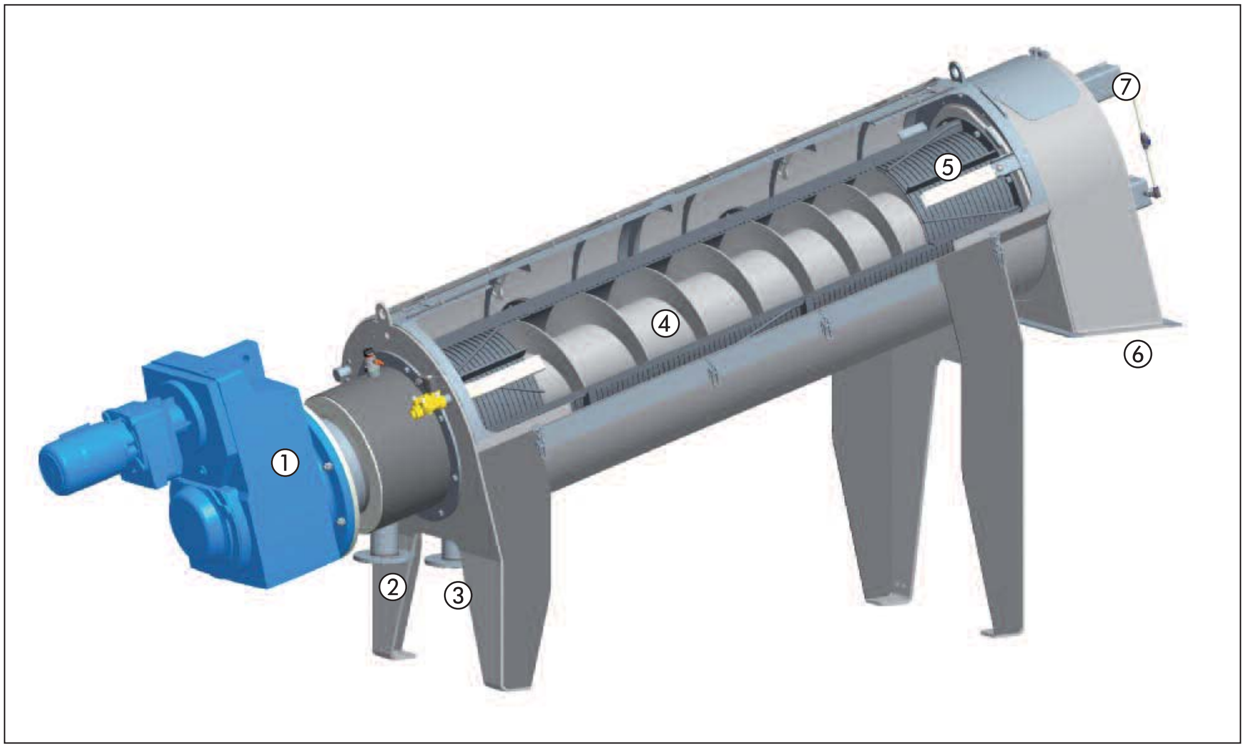
- effective to minimize sludge transportation costs and fuel consumption,
- reliable and automized to minimize downtimes and operator attention,
- easily adjustable to varying sludge characteristics,
- efficient in respect to investment and operation costs.

## Our Screw Press RoS 3Q - Features and Function

Flocculated sludge is pumped into a cylidrical screen basket wherein an auger slowly rotates. The diameter of the auger's shaft increases towards the end of the basket and the gap between its flights decreases. The volume between basket, shaft and flights continuously decreases, and the pressure thus increases, as the sludge is moved through the basket. Sludge water is pressed through the basket's screen.

The auger pushes the increasingly thicker sludge towards an annular clearance, defined by a circular opening and an adjustable discharge cone therein. The cone is pressed against the opening by pneumatic cylinders, thus maintaining a defined sludge pressure at the discharge end.

A brush on the flights cleans the screen from the inside and a spray bar backwashes it periodically from the outside.




① *Screw drive rotating the auger at 0.2 - 1.5 rpm*
② *Sludge feeding connection*
③ *Filtrate discharge connection*
④ *Auger with increasing shaft diameter and decrasing gap between its flights*
⑤ *Screen basket with 1.0 to 0.05 mm spacings*
⑥ *Sludge cake discharge chute*
⑦ *Pneumatic cylinders for maintaining a continuously adjustable pressure of the discharge cone*

# Advantages

**High solids concentrations** in sludge cakes are due to:

- defined sludge volume reduction along the auger
- continuously adjustable sludge pressure at the discharge end
- strong drive torque for effective pressure generation
- continuous screen basket cleaning
- thin sludge cake

**Reliable operation with little downtime** results from:

- virtually no wear because of < 1.5 rpmrotation speed
- few moving parts
- sturdy stainless steel design
- easy access through large inspection openings
- simple self-monitoring control strategy
- possibility of unsupervised 24/7 operation

**Minimum operation costs** because of:

- outstanding energy efficiency
- specific power consumption (<  10 kW/tonDS)
- little operator attention (< 20 min/day)
- minimum wear and tear
- low washwater consumption (< 8 % of sludge feed flow)
- good filtrate quality
- high solids capture rate (usually > 97 %)

**Low investment costs** due to:

- compact design and small footprint
- simple control system
- integrated support legs
- vibration-free and almost noiseless operation
- full enclosure preventing odor emission

*Mobile screw press in a trailer*

*Sturdy screen basket made of stainless steel*

*Installation with a solids capacity of 300 lbs per hour*

## Special Applications

**Dewatering of thin sludges:**

Due to pump feeding, large volumes of sludge water are removed in the pre-dewatering zone (the first feet of its length). This permits dewatering of thin sludges with a solids concentration < 1 %.

**Benefits:**

- sludge dewatering without the need for prior thickening
- no investment and operation costs for sludge thickening
- typical cake solids of 18 – 24 %
- sludge volume reduction > 97 % in a single step
- little operator attention

**Variable sludge characteristics**

Dewatering performance is usually impaired and operator attention increased by frequently varying sludge quality .

Our ROTAMAT® Screw Presses automatically self-adjust to over- and underloading. A control loop makes sure that optimal operation is always maintained.

**Benefits:**

- always optimum performance
- reliable operation
- minimized operator attention

**Sizes and Data**

| Size | Solids Capacity [lbs/hr] | Nominal Power [kW] |
|---|---|---|
| 280 | 150 | 0.37 |
| 440 | 300 | 1.5 |
| 800 | 1,100 | 4.0 |

*Contract dewatering with a trailer-mounted unit size 440*

*Screw press for 24/7 unattended operation*

*Complete size 280 installation with a 133 ft² footprint*

HUBER TECHNOLOGY, Inc.

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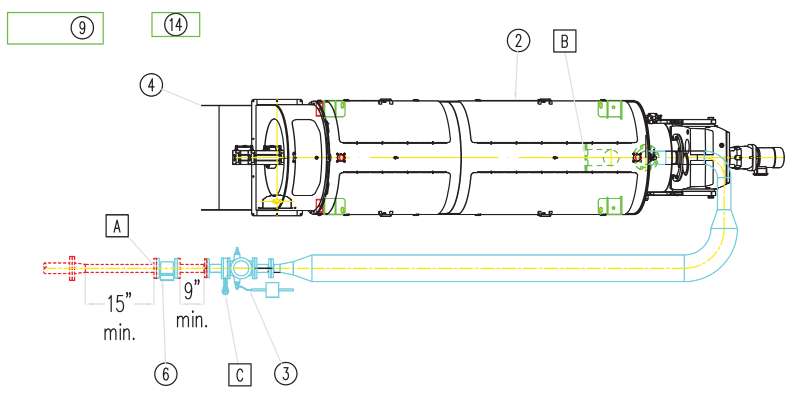
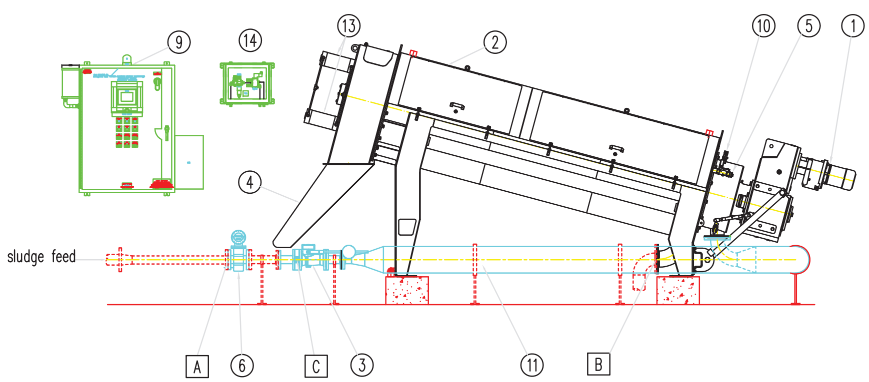
Phone: (704) 949 - 1010 · Fax: (704) 949 - 1020
huber@hhusa.net · http://www.huber-technology.com

Subject to technical modification
0,15 / 2 – 9.2010 – 7.2010




## BILL OF MATERIALS – HUBER SCOPE OF SUPPLY

(1) Motor–Screw Press, 5.0hp, 3ph/460/60Hz, Cl.1, Div.2
(2) RoS3 Q620 Screw Press, 304SS
(3) Polymer injection and mixing appliance (size TBD)
(4) Discharge chute 304SS – configured to site conditions
(5) Solenoid valve, Brass body, 110VAC/60Hz, Cl1, Div. 2
(6) Flow Meter *, E&H Promag 10 * (sludge feed) – size TBD
(7) Flow Meter *, 1"ø E&H Promag 10 * (polymer feed – not shown)
(8) Polymer Blending System – Velodyne Model # TBD
(9) Control Panel, 460V/60Hz
(10) Pressure Sensor, IFM
(11) Flocculation Reactor pipe assembly – size/length TBD
(12) Air compressor, 125psi max, field locate
(13) Pneumatic cylinders –¼" compressed air connection
(14) Pneumatic controls – field locate
(18) Spare Parts: (1) set of brushes w/ mounting hardware
(1) bearing for shaft
(1) replacement solenoid valve
(10) replacement spray bar nozzles

*minimum straight pipe run required for flowmeters as follows:
5x diameter upstream
3x diameter downstream

## FIELD CONNECTIONS:

(A) ANSI flange – Thin sludge influent (size TBD)
(B) 6"ø ANSI flange – Filtrate drain
(C) polymer feed to polymer injection device (size TBD)

Feed pump by others (optional supplied by Huber)

| DATE | REVISION | NO. | BY | CK | APP | |
|---|---|---|---|---|---|---|
| | | | | | | DESIGNED |
| | | | | | | DETAILED |
| | | | | | | CHECKED |
| | | | | | | APPROVED |
| | | | | | | DATE |


HUBER TECHNOLOGY
9735 NorthCross Center Court, Suite A
Huntersville, NC 28078
Tel. 704-949-1010
info@huber-technology.com


RoS3 Q620 Typical Installation

| Fig No. 2/2 | RoS3 Q620 Installation Layout | Scale: 1/4" = 1'–0" |
|---|---|---|
| Project No. | | Drawing No. Q620 TYPICAL LAYOUT.dwg |

# OPTIMUM-CV ROTARY PRESS DEWATERING...

## Municipal and Industrial Waste Water Applications


fournier

# THE FOURNIER PRESS TECHNOLOGY

The FOURNIER PRESS is in the forefront of municipal and industrial sludge dewatering technology.

The principle of operation is simple. Sludge is fed into a rectangular channel, and rotates between two parallel revolving stainless steel chrome plated screens. The filtrate passes through the screens as the flocculated sludge advances within the channel. The sludge continues to dewater as it travels around the channel, eventually forming a cake near the outlet side of the press.
The frictional force of the slow moving screens, coupled with the controlled outlet restriction, results in the extrusion of a very dry cake.

The benefits derived from using the FOURNIER ROTARY PRESS have been well documented and are translated into huge savings for the customer by means of performance, operation and maintenance.

fournier

# HOW IT WORKS...

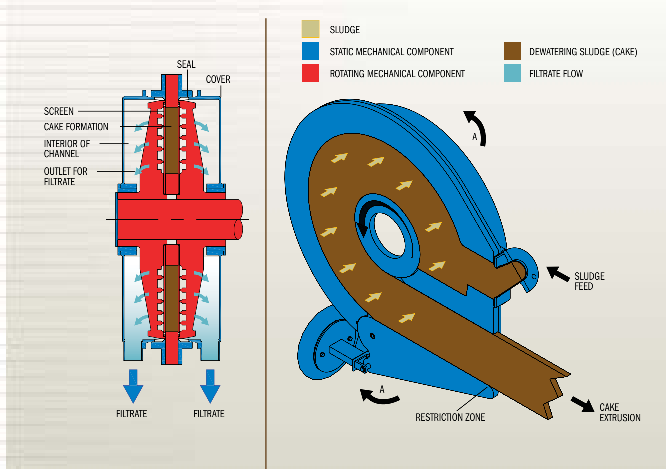
Sludge is fed at low pressure into a space between two parallel filtering elements.

As the free water comes away from the sludge, solids accumulate in the channel until enough pressure is generated against the outlet gate.

The filtering element's slow speed rotation generates enough back pressure to dewater the remaining solids and extrude a dry cake.

Low maintenance, low power consumption and reduced polymer usage translate into lower operating costs.

## Principle of operation



# ADVANTAGES

- > Totally enclosed
- > Low odor levels
- > Low speed
- > Little maintenance
- > Low power consumption
- > Small footprint
- > New Optimized 36" dia. channel surpasses previous models

## Performance

- Consistently high cake dryness
- Competitive throughput
- High capture rates
- Reduced airborne contaminants

## Operation

- Continuous process
- Equipment totally enclosed with reduced odor concerns
- Easy start-up and shut-down procedures
- Very simple to operate
- Requires very little supervision
- Can be completely automated and remotely controlled

## Maintenance

- Robust construction
- Small number of mechanical parts
- Slow rotation speed
- Reduced corrosive exposure to nearby equipment
- Automated 5 minutes/day self-cleaning cycle (optional)

## Economy

- Savings on final disposal costs
- Minimal space requirements
- Low maintenance costs
- Reduced labor costs
- Low energy consumption
- Low potable water usage

# THE NEW CV-OPTIMUM PRESS

The Fournier CV-Optimum Rotary Dewatering Press is the latest development in the 20-year history of the technology.

Winner of the 2002 WEF Innovative Technology Award, this Canadian invention has undergone several upgrades over the years.

From the first version, involving a large shaft-mounted gear unit, large support bearings and base, the units are now manufactured with a 36" diameter dewatering channel that far surpasses earlier versions.

A single-width channel has now proven itself able to dewater all varieties of sludge, allowing a single machine to be used anywhere, without physical modification.

With more than 140 units installed and running in over a dozen countries, the Fournier Rotary Press is the market leader in its category.

A dedicated team of more than 160 employees approaches each new year as a challenge, charged with finding new ways to improve the current model without increasing costs.

A large parts inventory is maintained for all previous models of the Rotary Press, ensuring that customers who enjoy their own model year can rest assured they will always be able to obtain replacement parts.

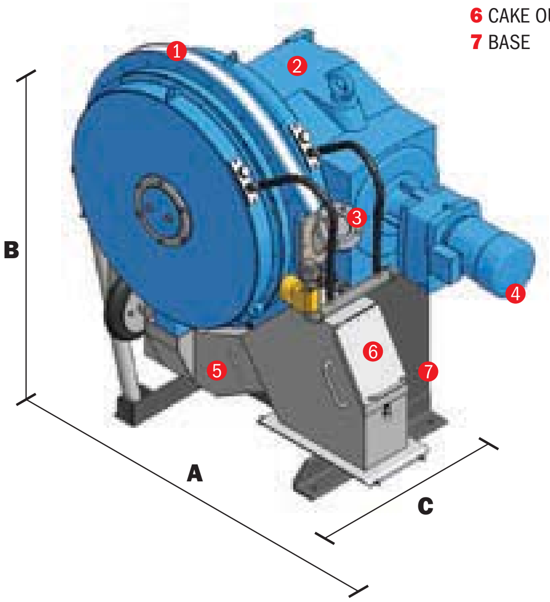
Retro-fit kits are available for those customers wishing to upgrade their unit to the newest technology available.

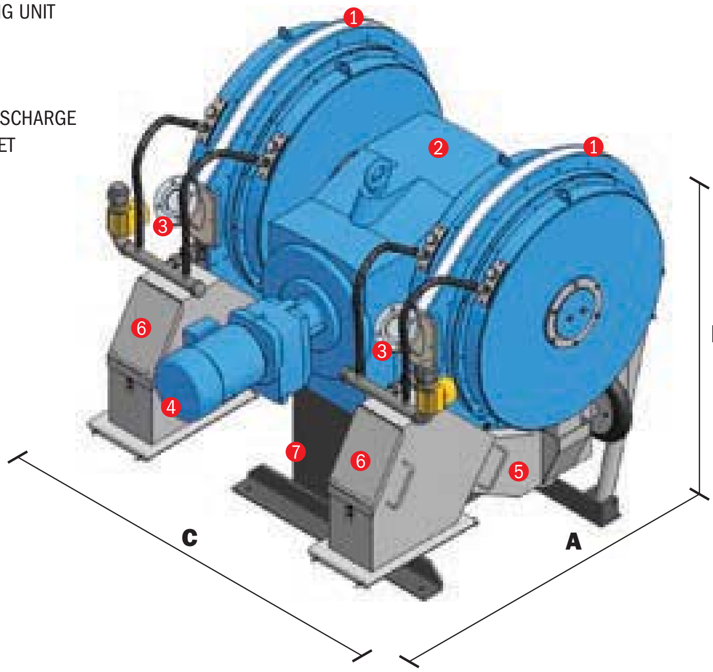
### Expandability

Another unique feature of the Rotary Press is the ability to order units that can be expanded at a future date. This allows customers to benefit from lower capital cost at time of purchase and flexible expansion as the need arises. Common configurations are 1 to 2 channel(s), 2 to 4 channel(s) and 4 to 6 channel(s); however any combination of channels can be obtained, up to the maximum of 6 channels per machine.

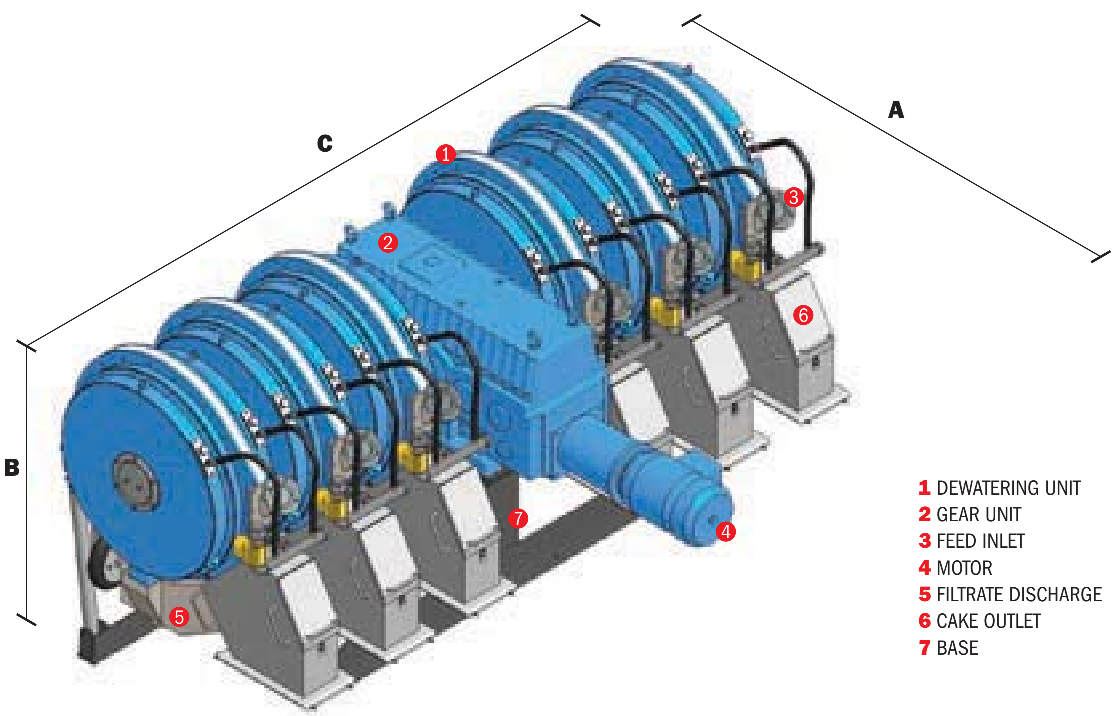
# SPECIFICATIONS

**1** DEWATERING UNIT
**2** GEAR UNIT
**3** FEED INLET
**4** MOTOR
**5** FILTRATE DISCHARGE
**6** CAKE OUTLET
**7** BASE




| MODEL NO. | MODEL | | DEWATERING AREA Ft$^2$ (m$^2$) | DIMENSIONS In. (mm) | | | WEIGHT Lb (kg) | MOTOR HP (kW) |
|---|---|---|---|---|---|---|---|---|
| | CHANNEL | WHEEL Ø In. (mm) | | A | B | C | | |
| 1-900/1000CV | 1 | 36 (900) | 10,8 (1,00) | 70,3 (1785) | 72,0 (1830) | 40,5 (1028) | 4559 (2068) | 5,0 (3,7) |
| 2-900/2000CV | 2 | 36 (900) | 21,5 (2,00) | 77,5 (1969) | 72,0 (1830) | 64,8 (1646) | 7967 (3614) | 7,5 (5,6) |
| 3-900/3000CV | 3 | 36 (900) | 32,3 (3,00) | 79,0 (2007) | 72,0 (1830) | 85,8 (2180) | 10128 (4594) | 10,0 (7,5) |

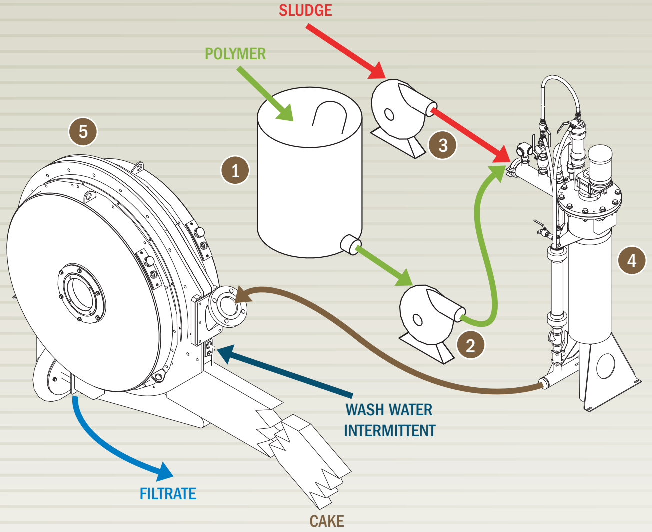



**1** DEWATERING UNIT
**2** GEAR UNIT
**3** FEED INLET
**4** MOTOR
**5** FILTRATE DISCHARGE
**6** CAKE OUTLET
**7** BASE

| MODEL NO. | MODEL | | DEWATERING AREA Ft$^2$ (m$^2$) | DIMENSIONS In. (mm) | | | WEIGHT Lb (kg) | MOTOR HP (kW) |
|---|---|---|---|---|---|---|---|---|
| | CHANNEL | WHEEL Ø In. (mm) | | A | B | C | | |
| 4-900/4000CV | 4 | 36 (900) | 43,1 (4,00) | 91,3 (2320) | 75,4 (1915) | 101,6 (2580) | 12377 (5614) | 15,0 (11,1) |
| 5-900/5000CV | 5 | 36 (900) | 53,8 (5,00) | 92,8 (2358) | 75,4 (1915) | 123,0 (3124) | 14581 (6614) | 20,0 (15,0) |
| 6-900/6000CV | 6 | 36 (900) | 64,6 (6,00) | 92,8 (2358) | 75,4 (1915) | 144,4 (3668) | 16676 (7564) | 20,0 (15,0) |

# CUTTING EDGE TECHNOLOGY

## Process schematic




Fournier Industries inc. specializes in the manufacturing of mechanical equipment and has done so since 1960. The company's technical abilities and expertise involve design, lab and pilot testing, commissioning and training. The FOURNIER PRESS' performance can be demonstrated through the use of our mobile units.

Resulting from many years of research and development, the technical advances implemented in the FOURNIER PRESS are well demonstrated in numerous applications throughout the world. Due to its reliability, the FOURNIER ROTARY PRESS requires very little supervision. It is the only dewatering technology that is safe for stand-alone automatic operation and can be monitored and operated by remote control.

| | |
|---|---|
| 1 | **Polymer Storage Tank** |
| 2 | **Polymer Metering Pump** |
| 3 | **Sludge Feed Pump** |
| 4 | **Flocculator** |
| 5 | **Rotary Press** |

**Full-size Pilot Machine**
Our utilization of a full-scale pilot eliminates the need for uncertain scale-up values in the final installation. What you see is what you get!

**ISO-9001 : 2000**
Fournier Industries inc. is an ISO-registered manufacturer, assuring the highest level of quality-control. All parts are subjected to rigorous verification before they are installed in your machine.

# ACCESSORIES & MORE

## Polymer feed systems

A wide variety of manual and fully automatic liquid and dry-feed polymer systems are available.

Off-the-shelf units as well as custom systems respond to every customer's individual needs.

From the smallest flow to clarifier-feed systems, any size can be quickly assembled and shipped to your site or included for delivery with your dewatering system.

## Shaftless screw conveyors

Custom-engineered for your application, hollow-flight (or shaftless) screw conveyors can be fitted with any accessory for total plant automation.

Standard screw sizes from 8" to 16" allow a variety of feed rates for different size systems.

Lengths from 10 ft to over 100 ft can be combined for virtually any layout.

## Sludge blenders and other accessories

Having many years of custom-fabrication experience, our engineering staff can tackle any project and provide a complete package solution to your biosolids handling application.

Truck bodies and customized mobile containers can be equipped with a host of features particular to your requirements, allowing you to optimize your operation for the most beneficial use.

**Spare Parts Inventory**
Fournier Industries inc. maintains a full inventory of spare parts for all models of our Rotary Press. Our parts department can ship orders for next day delivery within much of continental North America.

**Machining Capability**
Many large multi-function machining centres are used in the manufacturing of Rotary Press components.

**Production Capabilities**
Parts for Rotary Presses are produced in series. This allows us to reduce production costs and improve quality of the individual components.

## Expertise since 1960

Fournier Industries Inc. has been manufacturing machinery since 1960. At our head office and factory, located in the Quebec mining area, we continue to provide quality products and service to a wide range of international customers.

Printed in Canada GRAPHISSIMO

Your local representative

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Quebec, Canada G6H 2B5

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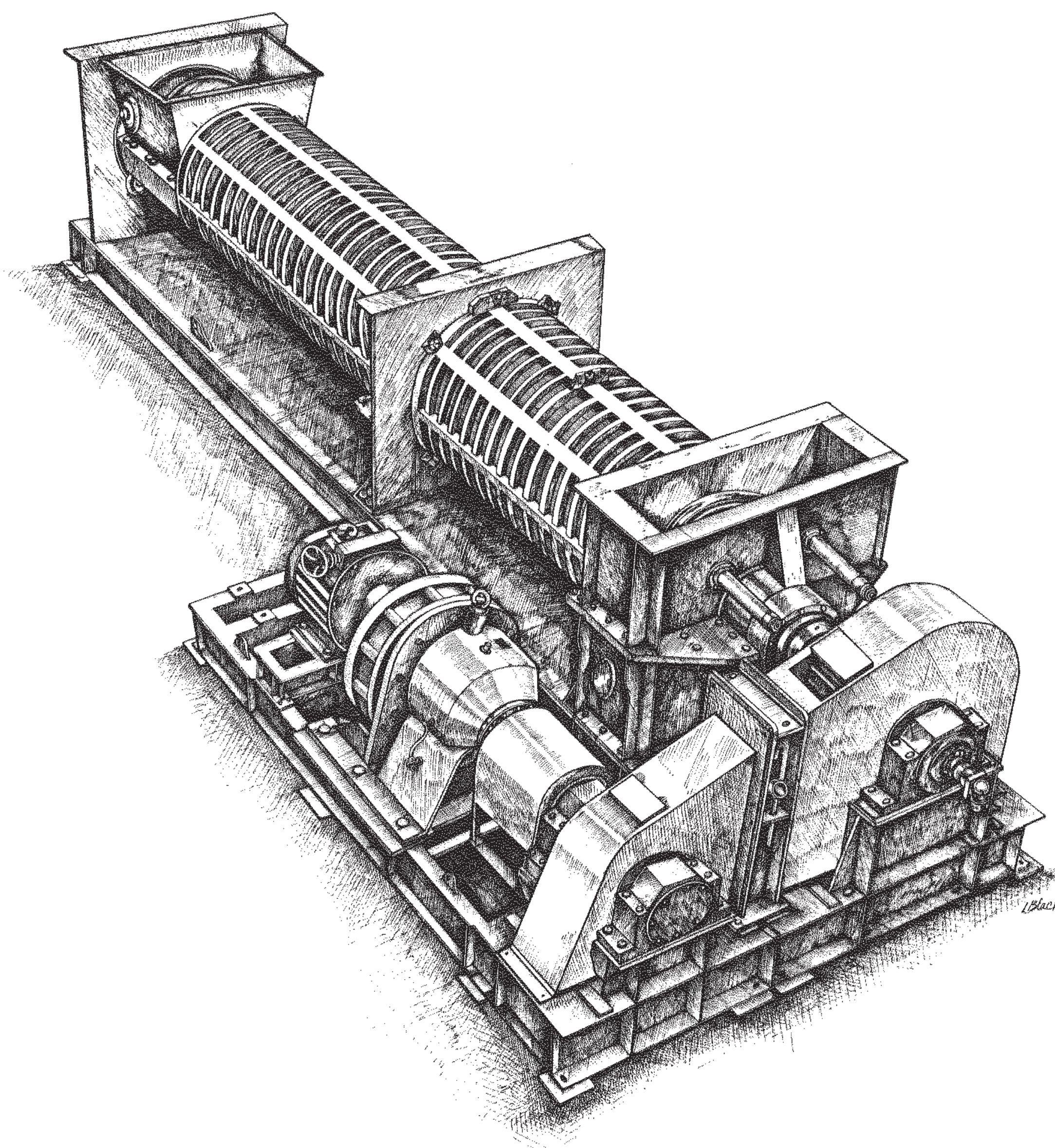
general@fournierindustries.com

www.rotary-press.com

FKC

# SCREW PRESS



# A. Proposed Equipment

## 1. Screw Press –

| Qty. | Description | | Unit Price Delivered |
|---|---|---|---|
| 1 | **FKC Screw Press**<br>Model BHX-700x4000L | | **US$ 235,000** |
| | Material: | Anaerobically Digested Municipal Sludge | |
| | Capacity: | 4.5 dry tons per day operating 24/7 – Each<br>**Dewatering Only**<br>377 Dry Lbs. / HR. - Each | |
| | Inlet consistency: | 1.0% TS or higher | |
| | Outlet consistency: | 16% or higher with polymer addition<br>Sample Required to Verify Performance | |
| | Nonvolatile solids content: | 50% or higher | |
| | Materials of construction: | SS-304 wetted parts,<br>Base coated CS<br>Non-wetted parts coated CS | |
| | Screw design: | Suitable for Water Treatment Residuals only | |
| | Screens: | Punched SS-304 | |
| | Speed reducer: | Sumitomo Cyclo reducer | |
| | Motor: | 3.0 HP, 1800 rpm, NEMA B, 480 VAC, 3 Ph, 60 Hz, included<br>Suitable for variable speed operation w/ PWM constant torque inverter | |
| | Other: | 1 set standard tools<br>1 set drum covers<br>1 motor coupling<br>4 spare screens | |
| | Approx. shipping weight: | 15 tons | |
| | Delivery: | Delivery within 5 (five) months after receipt of written purchase order | |

# A. Proposed Equipment

## 2. Flocculation Tank

| Qty. | Description | Unit Price Delivered |
| --- | --- | --- |
| 1 | Flocculation Tank 175 gal with variable speed agitator | Included |

| | |
| --- | --- |
| Drive: | SEW Eurodrive Varimot gearmotor with mechanical speed variator |
| Motor: | 1 HP, 1800 rpm, manufactured by SEW 480 VAC, 3 Ph, 60 Hz included |
| Materials of construction: | SS-304 wetted parts |
| Approx. shipping size/ weight: | 55 cubic feet / 500 Lbs |
| Delivery: | Delivery within 5 (five) months after receipt of written purchase order |

## A. Proposed Equipment –

## Dewatering Package

### 4. Ancillary Equipment

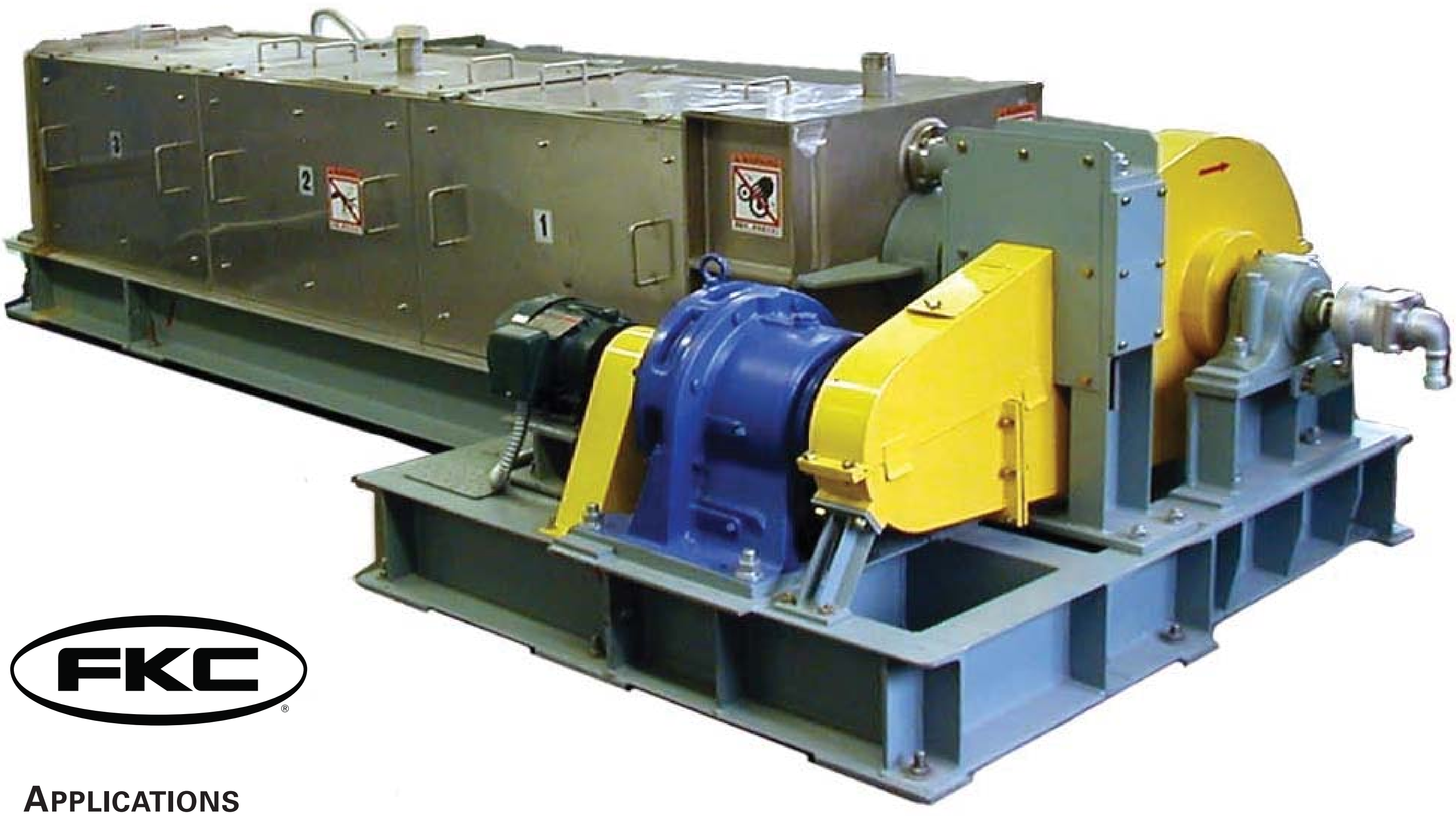
| **Ancillary Equipment** | **Unit Price Delivered** |
| --- | --- |

**Control Panel including:**

Enclosure, NEMA 4x
*PLC – Allen Bradley Micrologix 1500*
*Operator Interface - Allen Bradley Panelview 600*
Software, Programming, & Documentation
Screw Press VFD
Sludge flow meter
Headbox level transmitter
Sludge Pump VFD,
Motor starter for Flocculation Tank
Motor starter for Conveyor
Discrete Output for Polymer System On/Off
Analog Output for Polymer System Speed Control
Discrete Input for Polymer System alarm
Discrete Input for Conveyor zero speed switch
Discrete Input for Conveyor emergency stop

# BIOSOLIDS DEWATERING

FKC screw presses provide a unique, cost effective solution for dewatering of municipal and industrial biosolids. While relatively new to this market in North America, FKC screw presses have been dewatering various non-fibrous sludges and other materials for over 20 years in a wide variety of industries.




FKC®

Small 12" diameter screw press installed at the City of Forks, WA

## APPLICATIONS

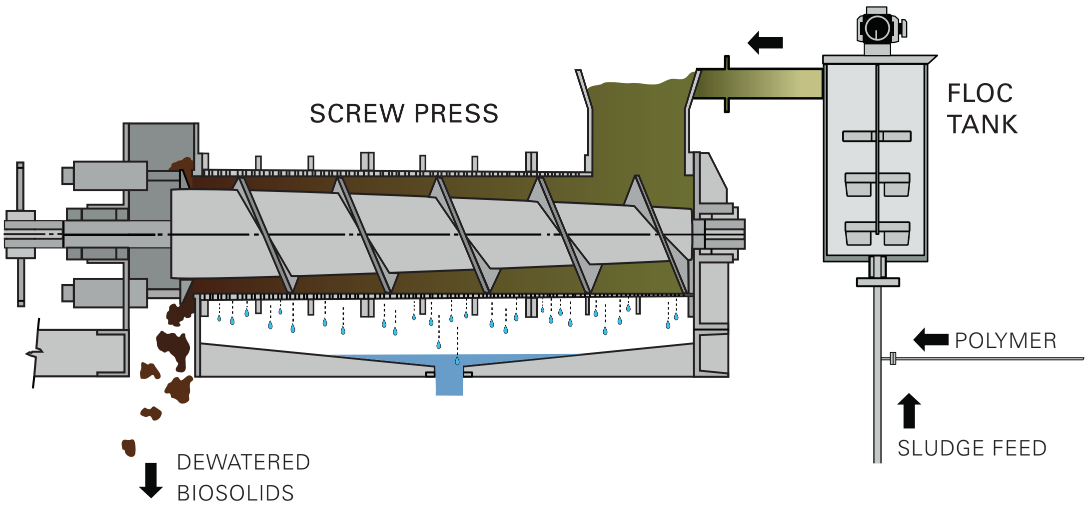
- Municipal WWTP Sludges of All Types (Aerobically Digested, Anaerobically Digested, Raw)
- Primary, Secondary, or Mixed Sludges
- Industrial Biosolids
- Septage & Grease Trap

## FEATURES OF THE FKC BIOSOLIDS DEWATERING SCREW PRESS

- Heavy Duty Construction
- High Outlet Consistency
- Slow Speed
- Few Moving Parts
- Very Low Maintenance
- Upgradeable to Produce Class A Biosolids
- Stainless Steel Wetted parts
- Low Power Consumption
- Fully Enclosed covers
- Simple, Unattended Operation
- Automated Washdown
- High Quality Construction

Two 1.25 meter diameter class A capable screw presses in Monterey, CA

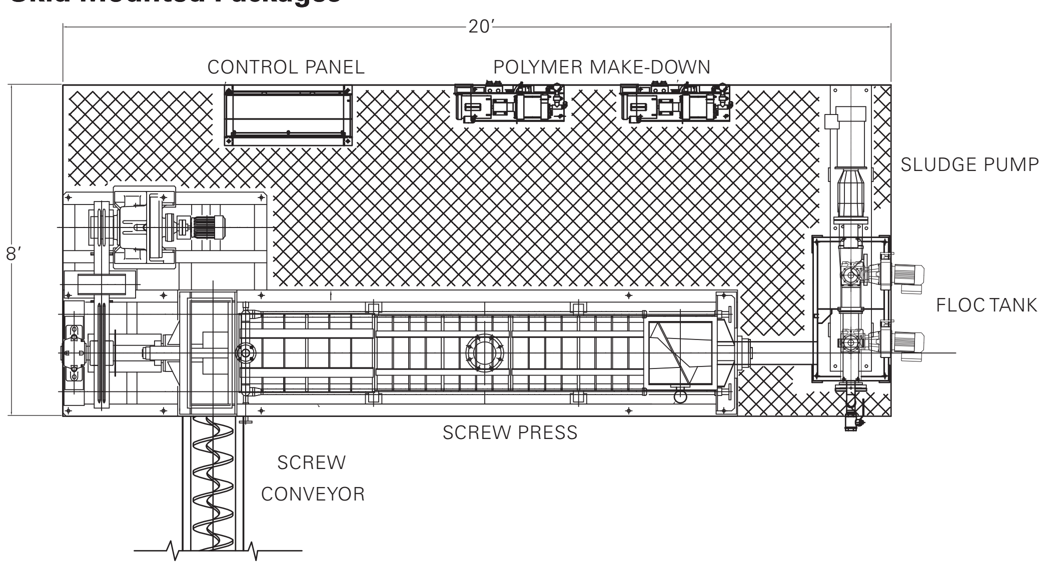
## Typical Sludge Dewatering Process Flow Diagram




## Dewatering Skid Systems for Small Applications

Sludge Dewatering Skid

## Skid Mounted Packages

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Asset Management
Technical Memoranda

# Carmel Area Wastewater District Wastewater Treatment
# Capital Improvement Program 15-year Master Plan

Kennedy/Jenks Consultants

3 August 2012

# Technical Memorandum No. 1

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Review: Mr. Doug Stewart, P.E., Kennedy/Jenks Consultants

Subject: Preliminary Capital Projections – "Replace Assets at the End of Estimated Residual Life"
K/J 1268007*01

This memorandum presents cost estimating data developed for the replacement costs of the Carmel Area Wastewater District (CAWD) wastewater treatment plant assets. Each individual asset in the asset registry (approximately 680 assets) is provided with an individual asset replacement cost. The replacement cost for each individual asset includes materials and installation costs. In addition to the materials and installation costs, the replacement projections include other costs associated with replacing assets. These other costs include: contractor's construction markups, retrofit contingencies, and engineering/construction management.

The focus of the cost projections is on the treatment plant assets which do not fall under the reclamation project. Major assets located on the treatment plant site which are not included in the cost projections herein are: Reclamation assets (Tertiary Building & MF/RO pad assets), lab facilities, civil site work (paving, landscaping, etc.), and SCADA software/computers. The collection system assets are also not included in the costs.

The preliminary cost projections are considered a Class 4 estimate based on planning level information with an estimate accuracy of -30% to +50% for replacement costs of assets in accordance with the Association for the Advancement of Cost Engineering (AACE) . The projected time of replacement of assets are based on the asset survey visual observations conducted by Kennedy/Jenks in March 2012, and by Beecher Engineering for the electrical assets.

A simplified asset management strategy scenario is assumed for the preliminary cost projections; this strategy is "*replacement of assets when they reach the end of their estimated residual life*". This asset management strategy does not incorporate asset failure modes such as financial inefficiency, level of service failures, or capacity related asset failures. Furthermore, risk management, and rehabilitation alternatives life cycle cost analyses are not included. Furthermore, the data of the physical condition of assets is limited to the extent that visual observations are limited and also due to the fact that many assets (such as buried pipelines) were not accessible for visual inspection during the March 2012 asset survey or for Beecher Engineering investigations. To account for assets that were not given condition ratings during the observations the cost of replacement of these assets is averaged over a 30-year period to facilitate cost projections.

The preliminary cost projections developed are a starting point for budgetary planning and provide a general range of estimated probable capital cost expenditures related to replacement of assets. Subsequent asset management and pre-design tasks related to the capital improvement projects planning will improve decision making criteria and appropriately schedule projects. These subsequent tasks will refine the timeframes for expenditures and the yearly budget costs from those shown in these preliminary projections.

The estimated total replacement costs include:

- **Materials and Installation:** These costs include the asset material costs and the cost of installation without markups.
- **Construction Cost:** These costs include the materials and installation cost as well as the markups associated with construction. The construction markups include: contractor mobilization, bonding, overhead and profit, and sales tax. Adding these markups results in an estimated construction cost of 30% over the Materials and Installation cost.
- **Retrofit Contingency:** These costs account for additional materials and installation costs that are typically required to build improvement projects within an existing operating facility. Retrofit projects typically cost about 20% to 30% more than “green field” projects. The Retrofit Contingency used in this analysis is 25% of the Construction Cost.
- **Engineering:** Engineering costs include planning, design, environmental permitting and construction management. Engineering is estimated to be 20% of the Construction Cost and Retrofit Contingency.
- **Total Replacement Cost:** The Total Replacement Cost is the summation of the Construction Cost, Retrofit Contingency and Engineering costs.

Note: Some assets may be able to be replaced by CAWD maintenance staff without the need of a contractor, and would therefore reduce total replacement cost by eliminating the costs of the markups for some assets. The savings associated with in house replacement is not specifically included in the estimates, but could reduce the estimated total replacement cost by approximately 10%.

## Asset Replacement Cost By Area

Table 1 shows the replacement cost for the assets categorized by area of the plant.

## Table 1: Asset Replacement Cost By Area

| Area | Materials & Installation | Construction Cost | Retrofit Contingency | Engineering | Total Replacement Cost |
|---|---|---|---|---|---|
| ***Influent*** | | | | | |
| Influent Bldg | $2,894,675 | $3,764,000 | $941,000 | $941,000 | $5,646,000 |
| Influent Manhole | $121,525 | $158,000 | $40,000 | $40,000 | $238,000 |
| **Influent Totals:** | ***$3,016,200*** | ***$3,922,000*** | ***$981,000*** | ***$981,000*** | ***$5,884,000*** |
| ***Primary Treatment*** | | | | | |
| Headworks | $1,435,300 | $1,866,000 | $467,000 | $467,000 | $2,800,000 |
| Primary Clarifiers | $1,631,000 | $2,121,000 | $531,000 | $531,000 | $3,183,000 |
| **Primary Treatment Totals:** | ***$3,066,300*** | ***$3,987,000*** | ***$998,000*** | ***$998,000*** | ***$5,983,000*** |
| ***Secondary Treatment*** | | | | | |
| EQ/Aeration | $5,791,510 | $7,529,000 | $1,883,000 | $1,883,000 | $11,295,000 |
| Blower Bldg | $1,991,215 | $2,589,000 | $648,000 | $648,000 | $3,885,000 |
| RAS Pump Bldg | $1,057,285 | $1,375,000 | $344,000 | $344,000 | $2,063,000 |
| Secondary Clarifiers | $2,382,000 | $3,097,000 | $775,000 | $775,000 | $4,647,000 |
| **Secondary Treatment Totals:** | ***$11,222,010*** | ***$14,590,000*** | ***$3,650,000*** | ***$3,650,000*** | ***$21,890,000*** |
| ***Disinfection/Disposal*** | | | | | |
| Chlorine Contact | $2,040,000 | $2,652,000 | $663,000 | $663,000 | $3,978,000 |
| Chlor/Dechlor Building | $1,868,000 | $2,429,000 | $608,000 | $608,000 | $3,645,000 |
| Effluent Bldg | $1,674,040 | $2,177,000 | $545,000 | $545,000 | $3,267,000 |
| Outfall | $1,126,800 | $1,465,000 | $367,000 | $367,000 | $2,199,000 |
| **Disinfection/Disposal Totals:** | ***$6,708,840*** | ***$8,723,000*** | ***$2,183,000*** | ***$2,183,000*** | ***$13,089,000*** |
| ***Solids Treatment/Disposal*** | | | | | |
| DAF Thickener | $456,750 | $594,000 | $149,000 | $149,000 | $892,000 |
| Digester Control Bldg | $1,578,500 | $2,053,000 | $514,000 | $514,000 | $3,081,000 |
| Digesters | $2,620,000 | $3,406,000 | $852,000 | $852,000 | $5,110,000 |
| Belt Press Bldg | $2,282,040 | $2,967,000 | $742,000 | $742,000 | $4,451,000 |
| FOG Facility | $192,000 | $250,000 | $63,000 | $63,000 | $376,000 |
| **Solids Treatment/Disposal Totals:** | ***$7,129,290*** | ***$9,270,000*** | ***$2,320,000*** | ***$2,320,000*** | ***$13,910,000*** |
| ***Site Utilities and Yard Piping*** | | | | | |
| Yard Piping | $1,866,850 | $2,427,000 | $607,000 | $607,000 | $3,641,000 |
| 3W System | $187,000 | $244,000 | $61,000 | $61,000 | $366,000 |
| 1W System | $94,000 | $123,000 | $31,000 | $31,000 | $185,000 |
| **Site Utilities and Yard Piping Totals:** | ***$2,147,850*** | ***$2,794,000*** | ***$699,000*** | ***$699,000*** | ***$4,192,000*** |
| ***Misc Buildings*** | | | | | |
| Ops Building | $1,691,000 | $2,199,000 | $550,000 | $550,000 | $3,299,000 |
| Misc Structures | $897,000 | $1,167,000 | $292,000 | $292,000 | $1,751,000 |
| **Misc Buildings Totals:** | ***$2,588,000*** | ***$3,366,000*** | ***$842,000*** | ***$842,000*** | ***$5,050,000*** |

## Asset Replacement Cost By Asset Class

Table 2 shows the replacement cost for the assets categorized by asset class.

### Table 2: Asset Replacement Cost By Asset Class

| *Asset Class* | *# Assets* | *Materials & Installation* | *Construction Cost* | *Retrofit Contingency* | *Engineering* | *Total Replacement Cost* |
|---|---|---|---|---|---|---|
| **Structural** | 84 | $17,580,000 | $22,854,000 | $5,714,000 | $5,714,000 | **$34,282,000** |
| **Electrical** | 115 | $5,148,000 | $6,693,000 | $1,674,000 | $1,674,000 | **$10,041,000** |
| **Process Equip (Liquid)** | 57 | $2,466,790 | $3,207,000 | $802,000 | $802,000 | **$4,811,000** |
| **Process Equip (Solid)** | 30 | $1,993,000 | $2,591,000 | $648,000 | $648,000 | **$3,887,000** |
| **Process Equip (Chemical)** | 35 | $615,000 | $800,000 | $200,000 | $200,000 | **$1,200,000** |
| **Process Equip (Gas)** | 11 | $550,000 | $715,000 | $179,000 | $179,000 | **$1,073,000** |
| **Support Equipment** | 59 | $708,500 | $922,000 | $231,000 | $231,000 | **$1,384,000** |
| **Instrumentation** | 54 | $537,000 | $699,000 | $175,000 | $175,000 | **$1,049,000** |
| **Bldg Mechanical** | 32 | $708,500 | $922,000 | $231,000 | $231,000 | **$1,384,000** |
| **Valve/Gate** | 72 | $981,790 | $1,277,000 | $320,000 | $320,000 | **$1,917,000** |
| **Pipe (Process Exposed)** | 56 | $1,512,620 | $1,967,000 | $492,000 | $492,000 | **$2,951,000** |
| **Pipe (Process Buried)** | 41 | $2,839,890 | $3,692,000 | $923,000 | $923,000 | **$5,538,000** |
| **Pipe (Chemical)** | 8 | $120,000 | $156,000 | $39,000 | $39,000 | **$234,000** |
| **Pipe (Misc)** | 24 | $117,400 | $153,000 | $39,000 | $39,000 | **$231,000** |
| **Totals:** | **678** | **$35,878,490** | **$46,648,000** | **$11,667,000** | **$11,667,000** | **$70,000,000** |

## Replacement Cost Summary

Table 3 summarizes the estimated replacement costs for the CAWD treatment assets in the asset registry (excluding reclamation project assets).

### Table 3: Total Treatment Plant Replacement Cost

| | **Estimated Total** |
|---|---|
| **Total Materials & Installation:** | $35,900,000 |
| **Replacement Construction Total:** | $46,700,000 |
| **Total Replacement (w/ Retrofit Contingency and Engineering):** | $70,000,000 |

## Preliminary 15-year Capital Budget Projection

Table 4 summarizes the estimated total replacement cost for assets that are projected to need replacement within the next 15-years. The -30% to +50% cost estimate range reflects the probable range of costs which could be invested in capital improvements, depending on the decisions made during upcoming planning efforts and asset management analyses.

### Table 4: 15-year Treatment Plant Estimated Asset Renewal Liability

| | -30% Estimate[(a)] | Estimated | +50% Estimate[(a)] |
|---|---|---|---|
| **Materials & Installation (assets with less than 15-yr estimated residual life):** | $11,200,000 | $15,960,533 | $24,000,000 |
| **15-yr Replacement Construction Total:** | $14,600,000 | $20,749,033 | $31,200,000 |
| **15-year Replacement (w/ Retrofit Contingency and Engineering):** | $21,800,000 | $31,125,033 | $46,700,000 |

(a) -30% to +50% estimate range is based on AACE recommended practice.

Figure 1 illustrates the asset replacement cost data in terms of yearly budgetary expenditures with a 15-year look ahead. Figure 2 shows the average yearly budget over a 15-year period based on the replacement projection.

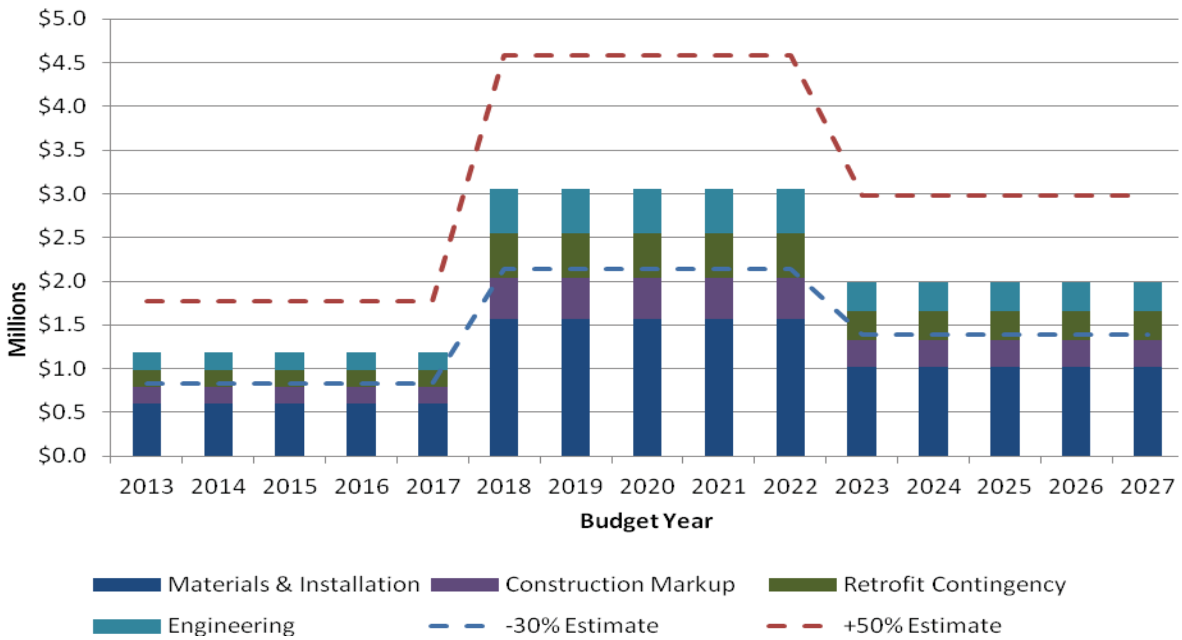


Figure 1: Estimated Preliminary 15-year Capital Replacement Budget Projection

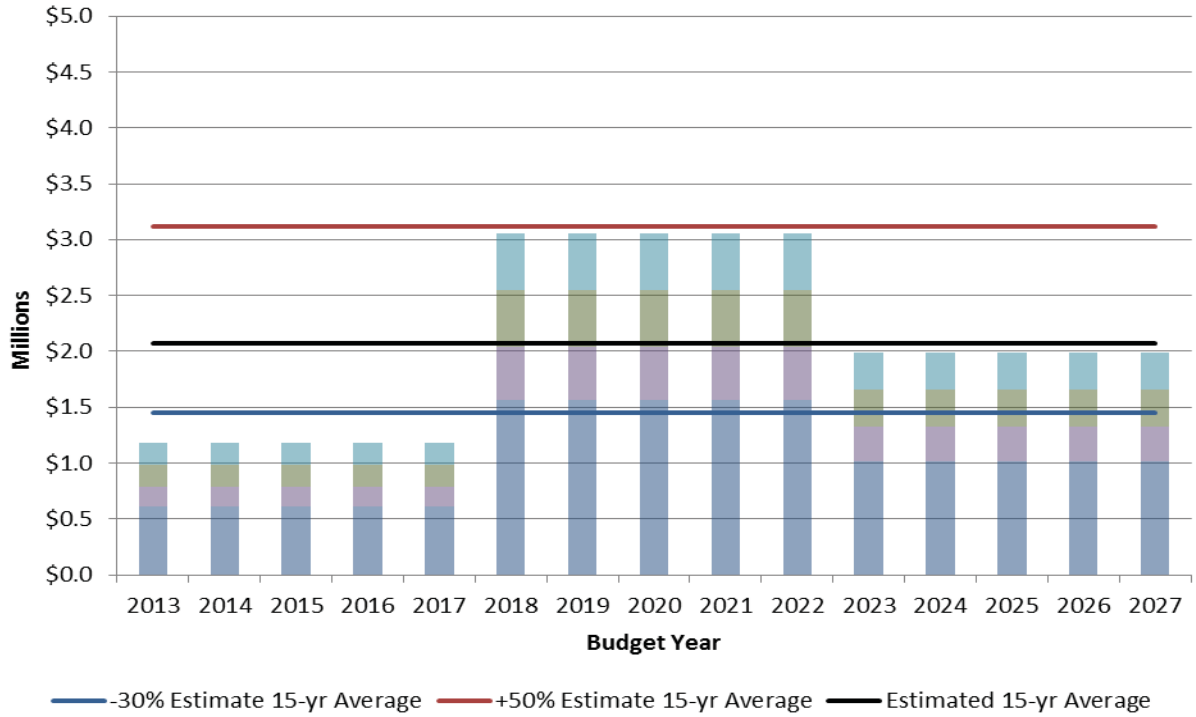


Figure 2: Estimated Preliminary 15-year Capital Replacement Budget Projection: Average Budget

## Preliminary 30-year Capital Budget Projection

Table 5 summarizes the estimated total replacement cost for assets that are projected to need replacement within the next 30-years. The -30% to +50% cost estimate range reflects the probable range of costs which could be invested in capital improvements, depending on the decisions made during upcoming planning efforts and asset management analyses.

Table 5: 30-year Treatment Plant Estimated Asset Renewal Liability

| | -30% Estimate[(a)] | Estimated | +50% Estimate[(a)] |
|---|---|---|---|
| **Materials & Installation (assets with less than 30-yr estimated residual life):** | $19,900,000 | $28,293,740 | $42,500,000 |
| **30-yr Replacement Construction Total:** | $25,800,000 | $36,782,740 | $55,200,000 |
| **30-year Replacement (w/ Retrofit Contingency and Engineering):** | $38,700,000 | $55,176,740 | $82,800,000 |

(a) -30% to +50% estimate range is based on AACE recommended practice.

Figure 3 illustrates the asset replacement cost data in terms of yearly budgetary expenditures with a 30-year look ahead. Figure 4 shows the average yearly budget over a 30-year period based on the replacement projection.

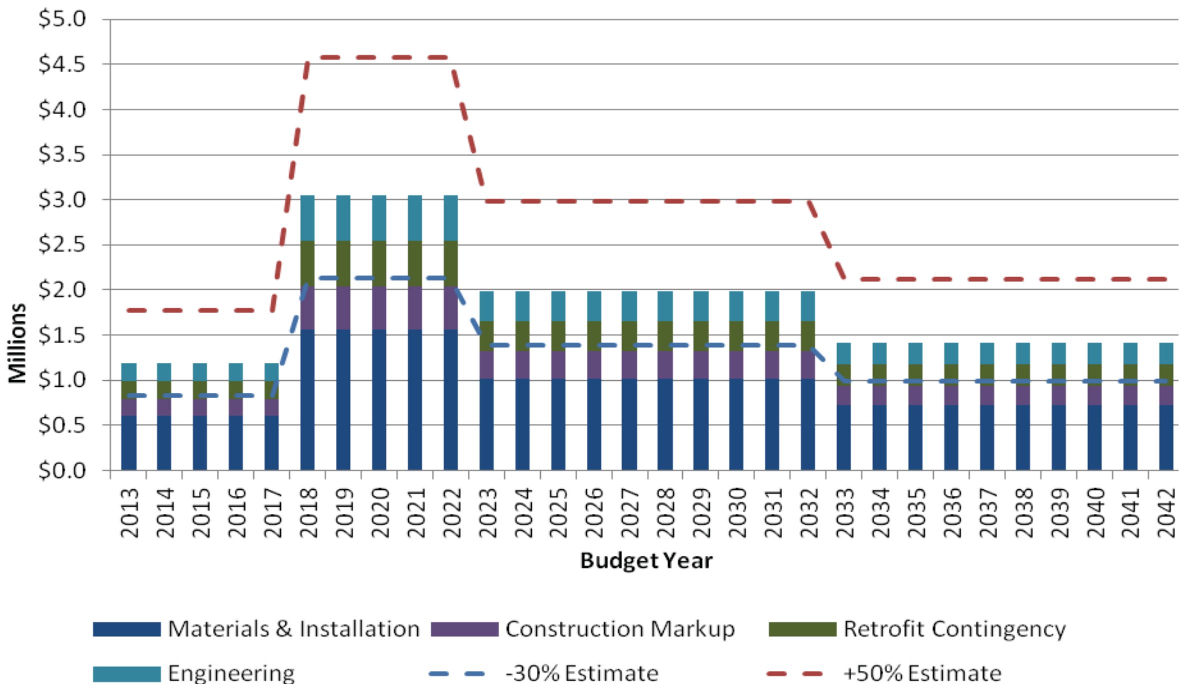


Figure 3: Estimated Preliminary 30-year Captial Replacement Budget Projection

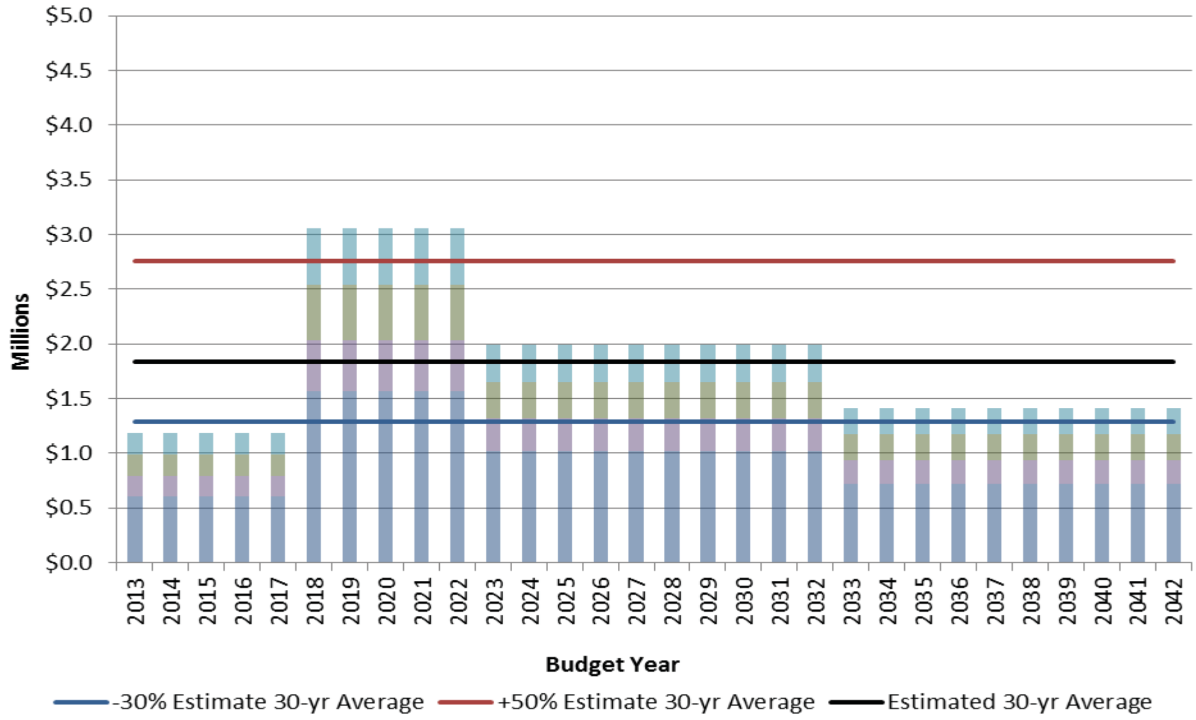


Figure 4: Estimated Preliminary 30-year Capital Replacement Budget Projection: Average Budget

## Subsequent Work and Continuous Data Improvement

The budget projections provided herein do not assess asset failure modes of financial inefficiency, level of service failures, or capacity failures. The projections are solely based on asset physical mortality failures, based on limited visual observations of physical condition. Approximately one third of the assets in the asset registry were not given a condition rating in the Kennedy/Jenks March 2012 asset survey and Beecher Engineering electrical surveys. Therefore, the replacement cost of these non-rated assets is evenly distributed over a 30-year period in the cost projections.

Further inspections would improve the physical mortality data and better define the time of replacement required to reduce physical mortality failures. Continuing to improve the overall WWTP asset mortality data will require ongoing inspection and testing of: buried piping (CCTV), electrical assets (wire tests), structures (concrete tests/seismic analysis), and other assets that are not readily visible for inspection.

Level of service evaluations of individual assets may identify assets which are not meeting their level of service and therefore need to be replaced or modified to meet the asset service goal.

Alternatively, an asset may not be needed as it is not required for meeting strategic levels of service. Kennedy/Jenks will assist CAWD in strategic level of service evaluations for the treatment plant, which is a precursor to defining the level of service for each individual asset. It is recommended that CAWD continuously improve its understanding of the individual assets levels of service as this can drive the decisions made regarding an individual asset's replacement.

Risk management is not included in the preliminary projections and therefore it is likely that assets with high consequences of failure will need to be replaced earlier than is reflected in the projections contained herein. The data herein assumes no risk management and that assets would be replaced at the end of their physical life regardless of risk. This type of asset management strategy will not necessarily mitigate against potential failures that would result in fines or other damages. Kennedy/Jenks will conduct risk evaluations prior to producing the 15-year Capital Improvement Plan.

Rehabilitation projects may extend the useful life of assets and have a lower lifecycle cost than replacement of assets. For high value assets, engineering analysis are warranted to determine whether repair, replacement, or improvement is the best approach for extending the life of the asset.

## Conclusion

The projected cost data contained herein is preliminary. Subsequent asset management evaluations to be conducted by Kennedy/Jenks will better define decision making criteria to develop yearly budgets and improvement projects that should be included in the 15-year capital improvement program. The current projection indicates that a potential range of yearly average capital improvement expenditures could be between $1.5-million and $3-million a year.

16 November 2012

# Technical Memorandum No. 6

To: Ms. Barbara Buikema and Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Reviewed by: Mr. Robert Ryder, P.E., Kennedy/Jenks Consultants

Subject: Levels of Service – Wastewater Treatment Plant
K/J 1268007*01

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This memorandum presents a preliminary summary of levels of service goals for the Carmel Area Wastewater District (District/CAWD) wastewater treatment plant (WWTP). Kennedy/Jenks Consultants has met with the District to generally discuss the strategic goals that CAWD has for the WWTP in order to develop the goals summarized herein. The input received from the District has been very valuable in confirming the vision for the CAWD WWTP.

By understanding the strategic goals of the WWTP, the levels of service for specific treatment processes and asset classes can be established such that these serve the WWTP strategic goals. Subsequently, individual assets would have level of service goals to serve both the WWTP levels of service, individual process levels of service, and the asset class levels of service. This concept is referred to as the roll-up of level of service and is shown graphically in Figure 1.

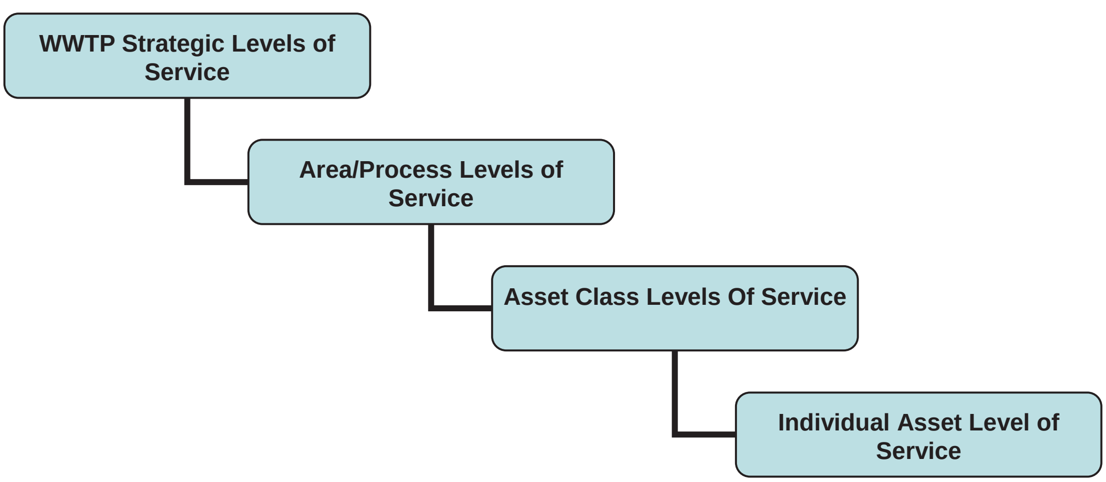


Figure 1: Level of Service Roll-Up

The levels of service summarized herein are meant to serve as a basis for strategic decision making in the upcoming 15-year Capital Improvements Plan (CIP) Master Plan. By clearly outlining what levels of service the WWTP should achieve, the capital improvements will be spent on projects which best serve the fundamental goals of CAWD. The focus of the 15-year CIP is on the secondary treatment plant and therefore the 15-year CIP plan does not include projects involving the Reclamation Project, or the CAWD sewage collection system.

Levels of service can be modified by the District at any time to respond to changes in regulations, customer demands, growth, operational cost changes, or other external or internal factors.

As shown in Figure 1, there are several “levels” where level of service can be applied. These levels are explained below:

- **WWTP Strategic Levels of Service:** Levels of service which encompass the general purpose and fundamental mission of the WWTP as an institutional facility.

- **Area/Process Levels of Service:** Levels of service associated with individual processes such as the Sludge Digestion System, Operations Building, or Influent Building. Each area or process has its own unique purpose and therefore has unique levels of service it is meant to provide. For instance, the Influent Building has a principal level of service to transfer plant influent to the headworks.

- **Asset Class Levels of Service:** Asset Classes categorize assets into groups such as structure, process equipment, piping, etc. The levels of service for asset classes are unique to the class of asset.

- **Individual Asset Level of Service:** Individual assets can be assigned a level of service although it takes significant effort to do so for the vast numbers of individual assets. Given the current level of detail of CAWD’s asset management and planning efforts, and the effort required to establish service levels for individual assets, these are not being defined at this time, but may be introduced into the decision making for individual assets at any time in the future when warranted.

## WWTP Strategic Levels of Service

### Fundamental Strategic Levels of Service for the CAWD WWTP

As an institutional facility, the fundamental mission of the CAWD WWTP is to safely, reliably and cost-effectively treat wastewater to meet regulatory compliance and return this treated wastewater back into the environment. The fundamental levels of service for the WWTP encompassed by this mission are:

- To be compliant with all current regulatory waste discharge permits and to be positioned to comply with probable future regulations.

- To be cost effective in operating and maintaining the WWTP.

 

- To invest in safety practices to eliminate personal injuries or environmental hazards from occurring at the WWTP.

- To apply fail safe systems and redundancy to maintain reliability.

Additional strategic goals which are in support of the fundamental levels of service include:

- To provide secondary treated wastewater to the Reclamation Project tertiary microfiltration/reverse-osmosis (MF/RO) plant.

- To plan for and appropriately handle severe flooding events which can occur at the WWTP.

## Regulatory Compliance

The level of service of the treatment process is to be compliant with the Regional Water Quality Control Board (RWQCB) waste discharge permit. The discharge permit requires a monthly average limit of 30 mg/l for five-day biological oxygen demand ($BOD_5$) and 30 mg/l total suspended solids (TSS). The permit does not contain nitrogen or phosphorous limits, which is likely a result of the ocean discharge point. Other water quality limits are set for coliform and toxic pollutants.

In addition to the RWQCB waste discharge permit, the CAWD secondary wastewater treatment process is to be compliant with EPA biosolids disposal regulations. Currently, CAWD transports dewatered Class B biosolids to McCarthy Farms in Lost Hills, Kern County. McCarthy Farms land applies un-composted biosolids to farmland as organic nutrients in King County. McCarthy Farms is also a composting facility which processes biosolids into Class A solids for beneficial reuse as organic nutrients to both agricultural and urban landscape/golf course uses.

The Reclamation Project involves a partnership between CAWD and Pebble Beach Community Services District (PBCSD). Regulations concerning the recycled water produced by the Reclamation Project are not summarized in this evaluation as the focus of the current CIP and asset management evaluations is on the secondary treatment plant.

## Cost Effectiveness

Because CAWD is a public agency which is in service of the community and is funded by the dischargers, CAWD is obligated to be cost effective. Where multiple alternatives are available CAWD should choose the probable least expensive life-cycle options which meet all other fundamental levels of service.

## Safety

The safety of the community and the CAWD employees are of the utmost importance. Safety practices should be applied to meet all OSHA Guidelines with the intent to eliminate personal injury at the WWTP. Aside from the human impact, lawsuits associated with personal injuries, environmental hazards, or nuisances could have financial impacts that would also impair CAWD's cost effectiveness.

### Reliability

Equipment and processes may fail which can lead to upsets in treatment processes and subsequent regulatory non-compliance. It is not enough for systems to provide for regulatory compliance most of the time. Systems should be in place to continue to meet regulatory permits nearly all of the time even in the event of a system failure or unexpected conditions.

### Recycled Water Production

CAWD is contractually obligated to provide secondary treated wastewater for the Reclamation Project which produces recycled water in the MF/RO system owned by PBCSD and operated by CAWD. The reclamation project is a benefit to cost effectiveness of CAWD, because PBCSD contractually pays one-third of treatment capital improvement costs at the CAWD secondary treatment plant.

### Planning for Flooding at the WWTP

In addition to meeting levels of service of regulatory compliance, cost effectiveness, safety, and reliability, the WWTP is facing potential future challenges associated with increased storm intensity and flooding as a result of global climate change and/or land form changes that may result in increased runoff. The WWTP is located in the Carmel River Flood Plain and has been subjected to major floods. When the first major phases of the current treatment plant were built in the 1970's and 1980's the primary and secondary treatment liquid process tanks were built with sidewalls elevation at 21 feet above mean sea level to protect the treatment facilities from floods.

A distinct level of service should be established for the WWTP in regards to flooding. Currently, it is unclear how the plant will withstand the next major flood. It is recommended that CAWD assess the flood planning issue in detail in the next 5 years to identify improvements that would be necessary to improve reliability of the WWTP process during future floods.

### Summary of WWTP Strategic Levels of Service

Table 1 summarizes the fundamental strategic levels of service for the WWTP. These are the principal strategic levels of service that are being used to guide the decision making for the 15-year CIP planning.

### Table 1: Strategic WWTP Strategic Levels of Service

| | |
|---|---|
| Be Compliant with all Regulatory Requirements | Be Cost Effective |
| Invest in Safety Practices to Eliminate Personal Injuries or Environmental Hazards at the WWTP | Apply Fail-Safe Systems and Redundancy to Maintain Treatment Reliability |
| Supply Secondary Treated Wastewater to Reclamation Project | **Level of Service for the WWTP in the Event of Severe Flooding – *Currently Undefined* |

## Area/Process Levels of Service

The levels of service for areas and processes within the WWTP should be set such that they help achieve the strategic goals of the WWTP. The following is a list of the areas/processes that are currently being used in the asset registry hierarchy:

- **Influent:** Influent Building, Influent Manhole
- **Primary Treatment:** Headworks, Primary Clarifiers
- **Secondary Treatment:** Aeration Tanks, Blower Building, Return Activated Sludge (RAS) Pump Building, Secondary Clarifiers
- **Equalization Tank**
- **Disinfection and Disposal:** Chlorination/Dechlorination, Chlorine Contact, Effluent Building, and Outfall
- **Solids Treatment:** Dissolved Air Floatation (DAF) Thickener, Digester Control Building, Digesters, Belt Press Building, Fat-Oils-Grease (FOG) Facility
- **No. 3 Water System**
- **No. 1 Water System**
- **Operations Building**
- **Miscellaneous Buildings:** Maintenance Shop, Lunch Room, Blacksmith Shop, Vehicle Storage, and Safety Officer Trailer

## Influent – Levels of Service

The current level of service provided by the Influent System is to receive wastewater influent which flows into the Influent Building from across the Carmel River at an elevation below grade and pump via the influent pumps to the influent manhole, which is high enough to allow gravity flow through the wastewater treatment processes. The influent pump system is critical to delivering wastewater for treatment and us variable speed to match influent flows. The influent system does not provide any treatment of the wastewater influent except for the scum/grease pump which removes grease and scum which collects along the water surface in the influent wet well. A flow meter is located in the Headworks Building, which provides plant influent flow measurement.

In addition to serving as the influent pump station, the Influent Building also houses the backup engine generators for the WWTP, which provide power to the critical processes in the event of a power outage.

Table 2: Influent Levels of Service

| | |
|---|---|
| Influent Building - Pumping Influent to Headworks | Influent Flow Monitoring (located in Headworks Basement) |
| Influent Building - Removal of Grease/Scum from Influent Wet Well | Influent Building – Power Outage Reliability Backup Generators |

## Pretreatment and Primary Treatment - Levels of Service

The WWTP Pretreatment includes the Headworks and the WWTP Primary Treatment includes the Primary Clarifiers. The Headworks is designed to remove rags and grit and discharge the rags and grit into garbage dumpsters for hauling offsite to a landfill. The Primary Clarifiers are designed to remove settleable solids and scum from the liquid process water. The Primary Treatment process area also includes sludge and scum pumps located in the Headworks basement which pump primary sludge to the digesters.

Table 3: Pretreatment and Primary Treatment Levels of Service

| | |
|---|---|
| Headworks - Remove rags and grit from the liquid treatment process and collect in dumpsters. | Primary Sludge/Scum Pumps - Pump settleable solids sludge and scum to digesters. |
| Primary Clarifiers - Remove settleable solids from the liquid treatment process. | |

 

## Secondary Treatment - Levels of Service

The WWTP Secondary Treatment utilizes an activated sludge process for biological stabilization and is comprised of the anoxic selector, aeration basins, secondary clarifiers, the Blower Building and the Return Activated Sludge (RAS) Pump Building. The level of service for the secondary treatment process is to further reduce BOD and TSS to meet the RWQCB waste discharge permit.

The aeration basins convert BOD of organic matter to biomass through the cellular consumption, growth and respiration of suspended aerobic microorganisms. Air from the Blower Building is supplied to the aeration basins to introduce dissolved oxygen to help maintain aerobic respiration. Secondary clarifiers located downstream of the aeration basins settle and remove the biomass from the aeration basin effluent (mixed liquor). The secondary clarifier sludge is returned via RAS pumps to the aeration basins to maintain the desired effective concentration of aerobic microorganisms in the aeration basins. Excess RAS is sent to the thickener as a Waste Activated Sludge (WAS) before ending up in the digesters.

Table 4: Secondary Treatment Levels of Service

| | |
|---|---|
| Anoxic Selector – Provides suppression of activated sludge bulking organisms. | Secondary Clarifiers - Remove suspended and floatable solids biomass from mixed liquor. |
| Aeration Basins - Convert BOD to biomass. | Secondary Clarifiers – Collect activated sludge. |
| Blower Building – Provide air to aeration basins to maintain sufficient dissolved oxygen levels. | RAS Pump Building – Pump activated sludge collected in secondary clarifiers to anoxic selector (before aeration basins). |

## Equalization Tank - Levels of Service

The Equalization Tank can store approximately 0.5-million gallons and is used to diminish flow variations resulting from diurnal flows. This function allows operations to supply a more uniform flow to the Reclamation Project MF/RO tertiary treatment process during the day shift. Furthermore, during wet weather the Equalization Tank can be used to trim the peak wet weather flows that need to be treated.

Table 5: Equalization Tank Levels of Service

| | |
|---|---|
| Reduce Influent Flow Peaks Resulting from Diurnal Flow Variations – Maximize volume of water delivered to the Reclamation Project. | Reduce Influent Flow Peaks Resulting from Diurnal Flow Variations – Trim peak wet weather flows. |

## Disinfection and Disposal – Levels of Service

The WWTP disinfection process utilizes chlorine disinfection to remove or inactivate pathogenic microorganisms (bacteria, viruses, protozoa, and fungi) in the wastewater before discharge to the environment. Chlorine residuals must be completely removed from the treated wastewater by use of the reducing chemical, liquid Sodium Bisulfite (SBS), prior to discharge to the ocean. The Chlorination/Dechlorination Building houses the chemicals which are used in disinfection oxidation (chlorine gas) and dechlorination reduction (liquid SBS). Secondary effluent is dosed with chlorine through a Water Champ induction mixer for initial dispersion and then travels through the chlorine contact channels which provide almost 2 hours of detention time at a 1.5-MGD flow rate.

After disinfection and dechlorination, the WWTP effluent is pumped out the Outfall Pipeline via the Effluent Building Pump Station. The Outfall Pipeline terminates with diffusers which contribute to mixing and dispersing the treated effluent into the ocean environment.

Water delivered to the Reclamation Project is not dechlorinated with SBS and flows by gravity to the Flow Equalization Basin (FEB) upstream of the MF/RO equipment. Chloramine is formed in the Chlorine Contact Channel as chlorine reacts with ammonia. A chloramine residual is maintained in the secondary treated water delivered to the MF equipment to discourage biofouling slimes from developing on the MF membranes.

### Table 6: Disinfection and Disposal Levels of Service

| | |
|---|---|
| Chlorination/Dechlorination Building – Dose and disperse chlorine upstream of chlorine contact channel and dose SBS downstream of chlorine contact channel. | Chlorine Contact Channel – Produce chloramine for water delivered to Reclamation Project to control biofouling of MF membranes. |
| Chlorine Contact Channel – Provide contact time for chlorine to sufficiently remove or inactivate pathogens. | Effluent Building – Pump treated effluent out the outfall. |
| Chlorine Contact Channel – Monitor effluent flow rate and residual concentration. | Outfall Pipeline – Transport treated effluent to offshore ocean environment and provide initial diffusion and dispersion into the ocean. |

## Solids Treatment - Levels of Service

The level of service provided by the solids treatment is to treat solids to meet Class B EPA biosolids requirements by reduction and stabilization of solids so they do not constitute a public health or toxicity concern and may be disposed of by land application. The Digestion System receives sludge from the Primary and Secondary Treatment. Sludge is stored in the Digesters where it is continually mixed as it is digested by anaerobic bacteria. The sludge is circulated through a sludge heater in the Digester Control Building to increase the rate of digestion by maintaining the optimum mesophilic temperature of 98$^{o}$ Fahrenheit ± 2$^{o}$ in the Digesters. The anaerobic digestion process reduces solids as well as pathogens so the sludge meets Class B EPA requirements.

The sludge thickener thickens WAS from the secondary clarifiers to reduce the flow and volume of sludge being sent to the digesters thereby increasing the effective sludge digestion time.

The FOG Receiving Facility receives FOG waste from pump trucks that are charged tipping fees for disposal at the WWTP. The addition of FOG increases the biodegradable materials load for the anaerobic bacteria in the digesters and thus increases the methane gas production which can be used to generate power onsite.

A byproduct of the anaerobic digestion process is digester gas which contains methane. Digester gas is conveyed to a cogeneration system (micro turbines) to generate power, or may be used to fuel the hot water boiler which heats water for use in heating digester sludge. Digester gas not used up in the micro turbines or the boiler may be burned off at the flare per air quality requirements.

Digested sludge is dewatered in the Belt Filter Press Building to reduce by about 90% the volume that has to be trucked offsite for land application disposal. A Belt Filter Press is operated to dewater digested sludge and the operation of the press is supported by the addition of polymer into the sludge upstream of the press which enhances the degree of dewatering.

### Table 7: Solids Treatment Levels of Service

| | |
|---|---|
| Digesters – Provide anaerobic digestion of adequate duration to reduce pathogens in sludge to meet Class B Solids requirements. | FOG Facility – Receive FOG deliveries to collect disposal fees and increase methane production for power production in microturbines. |
| Digesters – Digester gas byproduct is used for power cogeneration or for fueling sludge heating. | Belt Filter Press – Dewater digested sludge to reduce volume of sludge that needs to be transported. |
| Sludge Thickener – Thicken WAS to reduce volume of sludge sent to digesters. | Belt Filter Press Building – Polymer addition to digested solids to enhance the degree of dewatering. |
| Digester Control Building – Heat digester sludge to facilitate necessary pathogen removal rates in Anaerobic Digesters. | Flare – Burn off excess digester gas to meet air quality regulations. |

## No. 3 Water System - Levels of Service

The No. 3 Water System is a plant water system that utilizes chlorinated secondary treated effluent for general use around the plant and also is used by the Collections Department for filling the vactor truck to use for jet cleaning sewers. Uses at the treatment plant includes: process spray water, belt filter press spray water, wash down water, pump seal water, and irrigation water.

### Table 8: No. 3 Water System Levels of Service

| | |
|---|---|
| Various Areas – Provide pump seal water which must be fed to pumps to prevent damage of pump seals and substantial pump leaks. | Secondary Clarifiers – Spray water for scum collection. |
| Various Areas – Wash down water and flushing water. | Belt Filter Press – Spray water for continuous belt cleaning. |

## No. 1 Water - Levels of Service

The No. 1 Water system at CAWD serves potable water around the plant for potable uses in restrooms, locker rooms, and in the lab. Furthermore, No. 1 Water is used for emergency eyewash showers around the plant. In the event of a failure of No. 3 Water, No. 1 Water is also available for pump seal water.

### Table 9: Water System Levels of Service

| | |
|---|---|
| Various Areas – Potable use, restroom and locker room use, sinks, lab, etc. | Various Areas – Emergency eyewash showers |
| Various Areas – Pump seal water | |

## Operations Building – Levels of Service

The Operations Building is the center of operations and control of the WWTP. Currently the Operations Building is a multi-purpose building with: office space with computer stations, restrooms/locker rooms, electrical MCC equipment room, and plant library. The Operations Building electrical room also houses the WWTP potable water booster pump system.

To meet the strategic WWTP levels of service of Reliability and Regulatory Compliance, the Operations Building should serve primarily as the central Supervisory Control and Data Acquisition (SCADA) interface location where the plant processes can be effectively monitored and controlled.

### Table 10: Operations Building Levels of Service

| | |
|---|---|
| Operations Building – SCADA Monitoring and Control Center | Operations Building – Office space with adequate workspace for operations staff. |
| Operations Building – Library | Operations Building – Restroom/Locker Rooms |
| Operations Building – Electrical Building | Operations Building – WWTP potable water pumping |

### Miscellaneous Buildings - Levels of Service

There are several miscellaneous buildings around the plant that support the functioning of the WWTP in meeting strategic levels of service. These include the Maintenance Shop, Lunch Room, Blacksmith Shop, Safety Officer Trailer, and Vehicle Storage Building. The Maintenance Shop stores tools and provides a workspace for repair of equipment. The Lunch Room is a break room where staff can conduct meetings, or take breaks and eat lunch. The Blacksmith Shop appears to be primarily an equipment storage building. The Safety Officer Trailer is an office for the WWTP Safety Officer. The Vehicle Storage Building is a garage for CAWD vehicles.

### Table 11: Miscellaneous Buildings Levels of Service

| | |
|---|---|
| Maintenance Shop – Store tools and workspace for equipment maintenance. | Lunch Room – Eating area for staff. |
| Blacksmith Shop – Store equipment | Safety Officer Trailer – Office space for safety officer. |
| Vehicle Storage Building – Garage for CAWD vehicles. | |

## Asset Class Levels of Service

The levels of service for each asset class within the WWTP should be set such that they help achieve the strategic goals of the WWTP as well as the levels of service of the areas and processes. The following is a list of the asset classes that are currently being used in the asset registry hierarchy:

- Structures
- Electrical
- Instrumentation
- Process Equipment

- Support Equipment
- Building Mechanical
- Valves/Gates
- Piping

## Structures Asset Class - Levels of Service

Structures at the treatment plant are designed and constructed to withstand earthquakes per the seismic codes in effect at time of construction. Structures should not catastrophically fail under any foreseeable conditions, but could be damaged to some degree from major earthquakes. Structures can weather or deteriorate over the life-cycle; and when major upgrades occur should be designed for current seismic codes. Structures should meet California Fire Code in terms of ingress and egress and ventilation for safety of staff. Structures should be designed to protect critical process elements (equipment, electrical panels, etc) during flood, wind, and rain storm events.

Table 12: Structures Asset Class Levels of Service

| | |
|---|---|
| Structure – Meet seismic codes at time of construction will not catastrophically fail under any conditions. | Structure – Upgrades to structures should meet current seismic codes. |
| Structures – Protect critical process elements during flood, wind, and rain storm events. | Structure – Meet California Fire Codes |

## Electrical Asset Class - Levels of Service

Electrical assets should provide electrical power and signals to equipment, instrumentation, and lighting. Electrical assets that are part of the treatment process should be reliable as electrical failures can be catastrophic to the treatment and disposal process. All electrical assets should meet current arc-flash safety standards, because of the high risks associated with electrical accidents.

Table 13: Electrical Asset Class Levels of Service

| | |
|---|---|
| Electrical – Provide power and signals to pumps, process equipment, instrumentation, lighting, etc. | Electrical – Reliable and redundant such that electrical system failures do not affect the ability to treat and pump/convey wastewater at the WWTP. |
| Electrical – Meet current California Electrical and Fire Codes and current Arc Flash Safety Standards. | |

## Instrumentation Asset Class – Levels of Service

Instrumentation assets should monitor and control the treatment process to allow operators to respond to changes in operating conditions and keep a record of treatment characteristics for permit compliance and process optimization. Instrumentation should alert operations of deterioration of a systems performance or sudden failure. Instrumentation should be used to improve operations. For reliability, instruments should have redundancy or a manual means of monitoring and controlling the treatment process should be available.

Table 14: Instrumentation Asset Class Levels of Service

| | |
|---|---|
| Instrumentation – Monitor and control treatment process. | Instrumentation – Reliable and redundant such that instrument failures do not affect the ability to treat and pump wastewater where redundancy is not provided a manual means of control shall be available. |
| Instrumentation – Improve operations | Instrumentation – Alert operations of deterioration of system performance or sudden system failure. |
| Instrumentation – Keep a record of treatment characteristics for permit compliance and process optimization. | |

## Process Equipment Asset Class - Levels of Service

Process equipment should function in the service of the treatment process. These assets should be reliable and redundant such that if a failure occurs it does not adversely affect the treatment or disposal processes. Process equipment should be able to be easily maintained and operated safely.

Table 15: Process Equipment Asset Class Levels of Service

| | |
|---|---|
| Process Equipment – Function in the service of treatment of wastewater. | Process Equipment – Reliable and redundant such that process equipment failures do not affect the ability to treat and pump wastewater at the WWTP. |
| Process Equipment – Safe to operate and to maintain. | |

## Support Equipment Asset Class - Levels of Service

Support equipment cover a broad range of equipment which is not directly critical to the treatment process, but supports the treatment process. Support equipment should be used to improve operations, safety, and maintenance at the plant. For the most part, these assets can fail without causing an adverse upset to the treatment process.

Table 16: Support Equipment Asset Class Levels of Service

| | |
|---|---|
| Support Equipment – Improve operations, safety and maintenance. | Support Equipment – Provide support to critical process equipment. |

## Building Mechanical Asset Class - Levels of Service

Building mechanical equipment provides heating ventilation and cooling (HVAC) for buildings. HVAC should function according to California Building, Plumbing and Fire Codes and provide adequate ventilation to support health of staff occupying building.

Table 17: Building Mechanical Asset Class Levels of Service

| | |
|---|---|
| Building Mechanical – Meet current California Building, Plumbing and Fire Codes. | Building Mechanical – Support health of staff occupying building. |

## Valves/Gates Asset Class - Levels of Service

Valves and gates should provide isolation of piping, pumps and other equipment for maintenance as well as for process control. Valves and gates should be in working condition and be able to be easily opened and/or closed as desired in an emergency.

### Table 18: Valves/Gates Asset Class Levels of Service

| | |
|---|---|
| Valves/Gates – Provide isolation of equipment for maintenance. | Valves/Gates – Provide process control. |
| Valves/Gates – Should be in working condition and operable in an emergency. | |

## Piping Asset Class – Levels of Service

Process piping should carry process liquids without major leaks or corrosion deterioration. Process piping should have a low probability of failure, because a process pipe break can lead to major regulatory fines if wastewater is spilled offsite into the environment. With regular maintenance and periodic closed-circuit television (CCTV) inspection of process pipe systems pipe failures can be eliminated.

Hazardous chemical piping should deliver chemicals safely and have multiple safeguards from pipe leaks, which include double containment of pipes or leak detection instruments installed to immediately detect a pipe leak and to prevent a spill or hazardous condition. Chemical piping should have a low probability of failure because of environmental as well as human safety risks.

Gas piping should convey gas without leaks because of the potential for explosive conditions of emissions caused by leaking gas pipes.

Miscellaneous piping with low consequences of failure should carry liquids without leaks, however leaks can be repaired when they are detected and require a less proactive approach than process, chemical, or gas piping.

### Table 19: Piping Asset Class Levels of Service

| | |
|---|---|
| Process Piping – Carry process liquids without leaks/breaks/excessive corrosion. leaks/breaks/corrosion should be proactively mitigated to avoid spills to the environment. | Chemical Piping – Carry chemicals without leaks/breaks. leaks/breaks should be proactively mitigated and multiple safeguards such as double containment and leak detection should be included in pipe system. |
| Gas Piping – Convey gas without leaks/break/excessive corrosion. leaks/breaks/corrosion should be proactively mitigated to avoid explosive conditions. | Miscellaneous Piping – Convey liquids without leaks/breaks/excessive corrosion. leaks/breaks can occur, but should be repaired promptly. |

## Conclusions

The fundamental and strategic levels of service are the guiding principles for what the WWTP and the individual assets should be set to accomplish. These fundamental WWTP levels of service includes: regulatory compliance, cost effectiveness, safety, and reliability. There can be several different situations where individual assets within the WWTP do not serve in meeting these fundamental levels of service. If assets are not serving to meet the above strategic levels of service or the levels of service of the Area/Process or the Asset Class, then these assets should be rehabilitated, replaced, phased out of operation, or removed from service.

The levels of service established herein at the “Strategic WWTP Level”, “Area/Process Level”, and the “Asset Class Level” can be used to determine if an individual asset is meeting its level of service. If the asset is not contributing to the greater goals of the WWTP then the asset is not meeting its intended level of service. Figures 2 and 3 provide examples of how the level of service hierarchy can be used as a thought process to determine if an individual asset is providing an adequate level of service. For potential future projects, examples like those shown in Figures 2 and 3 illustrate how a project may be justifiable or not based on level of service analysis.

**WWTP Strategic Levels of Service – Regulatory Compliance, *Reliability, Flooding***

**Area/Process Levels of Service – *Primary Treatment (Table 3)***

- Remove Settleable Solids from the Liquid Treatment Process

**Asset Class Levels Of Service – *Structure (Table 12)***

- Meet Seismic Codes At Time Of Construction or Rehabilitation. Will Not Catastrophically Fail Under Any Conditions.
- Protect Critical Process Elements During Flood, Wind and Rain Storm Events

**Individual Asset Level of Service – *Primary Clarifiers***

**Do the Primary Clarifiers Meet the Above Levels of Service?**

**YES**

- The Primary Clarifiers do not appear to have major structural deficiencies that would result in a catastrophic failure.
- The Primary Clarifiers have sidewalls about 20-ft above sea level to continue to operate during a flood.
- Two Primary Clarifiers so that if one fails or is out of service for maintenance the other can continue to treat wastewater.

Figure 2: Example Individual Asset Level of Service – Primary Clarifiers

**WWTP Strategic Levels of Service – *Regulatory Compliance, Reliability***

**Area/Process Levels of Service – *Secondary Treatment - Blower Building (Table 4)***

- Provide Air to Aeration Basins to Maintain Sufficient Dissolved Oxygen Levels

**Asset Class Levels Of Service – *Process Equipment (Table 15)***

- Reliable And Redundant Such That Process Equipment Outages or Failures Do Not Affect The Ability To Treat Wastewater At The WWTP

**Individual Asset Level of Service – *Blowers***

**Do the Blowers Meet the Above Levels of Service?**

**NO**

- There is only one appropriately sized blower in the blower building. If this blower fails a Backup Blower will need to be started promptly.
- The Backup Blowers sit idle for long periods of time because they are oversized.
- When a Backup Blower is put on line it has been observed to vibrate excessively due to a bent shaft, which is a sign of a probably early failure.
- The Backup Blowers do not appear to be reliable due to excessive vibration.

Figure 3: Example Individual Asset Level of Service – Blowers

An asset that is not meeting its level of service goal should be considered as a failed asset. However, this does not always necessitate that the asset be immediately repaired or replaced. The consequences of the level of service failure need to be evaluated to determine the risk and the strategy for addressing the failure. Consequences of failure and risk will be evaluated for areas of the plant in Technical Memorandum No. 8. The strategies for managing the assets based on the relative risk will be presented in Technical Memorandum No. 9.

20 December 2012

# Technical Memorandum No. 7

To: Ms. Barbara Buikema, Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Review: Mr. Doug Stewart, P.E., Kennedy/Jenks Consultants

Subject: Assessment of WWTP Asset Failure Modes Other than Physical Mortality
K/J 1268007*01

To improve asset management best practices and develop an effective Capital Improvement Plan (CIP), Carmel Area Wastewater District (CAWD) is beginning to assess its assets relative to four basic performance failure modes. These failure modes include financial efficiency, level of service, capacity and physical mortality. To date many of the evaluations conducted to support the 15-year CIP Master Plan by Kennedy/Jenks Consultants (K/J) have focused primarily on physical mortality failure modes. This is because during the Asset Survey conducted in March 2012 by K/J many assets were found to be in “poor” physical condition. During the Asset Survey other failure modes besides physical mortality (such as level of service failures) were identified, although they were not the primary focus of the observations. These other failure modes besides physical mortality are explained in more detail herein and several examples of these other failure modes are identified to support project development in the 15-year CIP master plan.

The four failure modes are:

- **Level of Service Failure:** When the functional requirements for the asset exceed the designed capability of the asset. Regulatory requirements and an organization’s fundamental goals (mission) are used to define levels of service that assets are expected to meet.

- **Capacity Failure:** When the demand imposed on the asset exceeds its design capability. Capacity metrics include (hydraulic retention time, flow, temperature, concentration, etc.).

- **Financial Efficiency Failure:** When the cost of operation of the asset exceeds the cost of other feasible alternatives. The measurement of financial efficiency failures is often related to the life-cycle cost of alternatives and the payback period for the investment in implementing a more cost efficient alternative.

- **Physical Mortality:** Physical condition of an asset prevents it from operating at an acceptable level. This is apparent when an asset no longer functions normally due to damage or deterioration of that asset.

All assets are subject to the four failure modes and several of the failure modes could be occurring concurrently for a single asset. Therefore, assets should be evaluated in terms of which failure mode is most imminent. The process of determining which failure mode is most imminent in a single asset or system is illustrated in Figure 1 below.

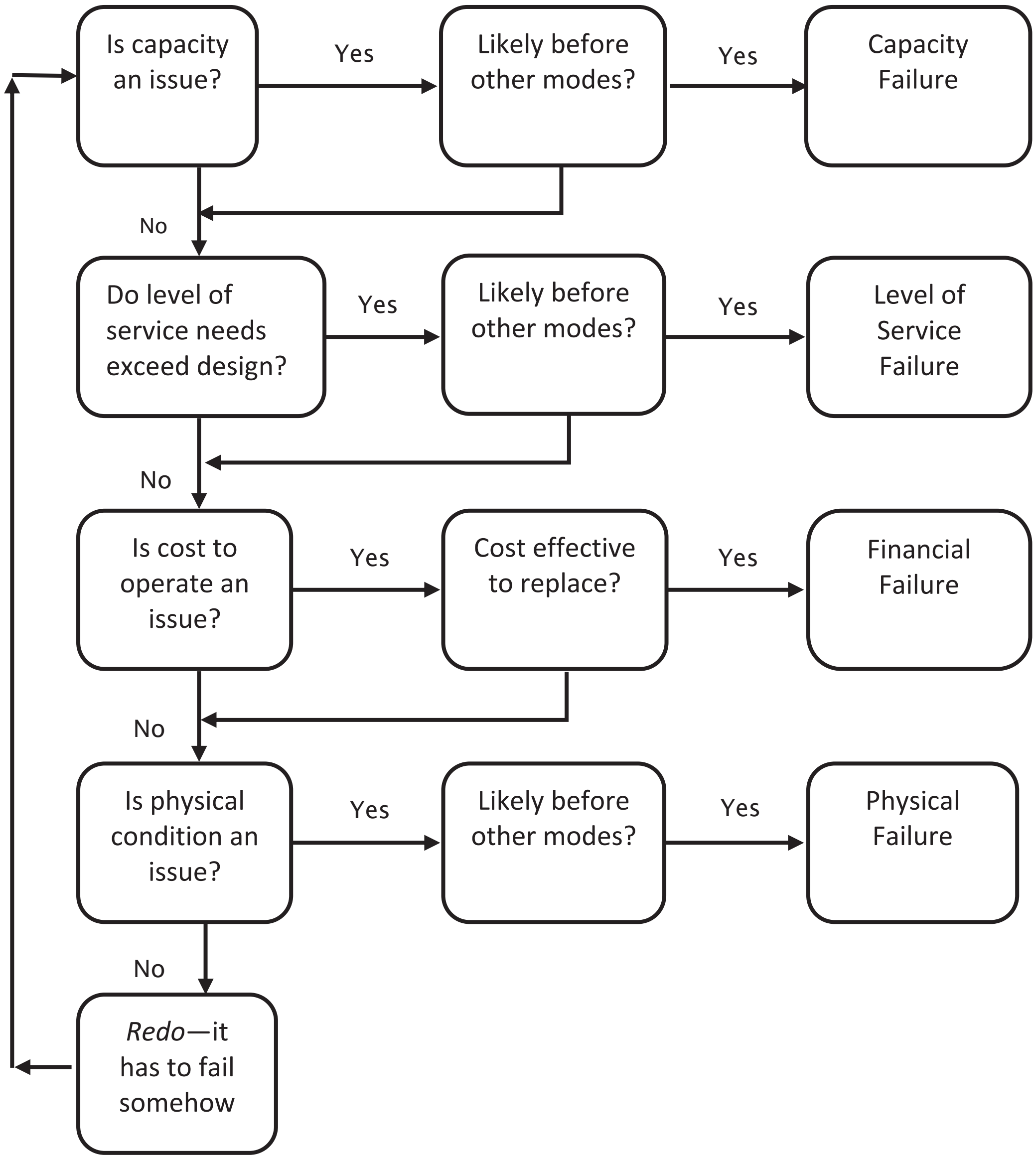


Figure 1: Asset Failure Mode Identification

Previous asset evaluations done for CAWD have focused primarily on physical mortality as a means to identify whether an asset needs to be replaced, rehabilitated or repaired. However, as presented above, assets are also subject to other failure modes including financial efficiency, level of service and capacity. This memorandum presents examples of assets in which the most imminent failure mode is one of these other failure modes and not physical mortality. Ultimately assets that are deemed to be failing under any of the four failure modes should be considered for inclusion in the 15-year CIP.

## Level of Service Failure Mode

CAWD has developed levels of service goals for the organization which were summarized in Technical Memorandum No. 6. Among these goals are regulatory compliance, asset reliability, maintaining safe working environments, and protecting the plant facilities from flooding. When an asset is unable to meet these requirements regardless of its physical conditions, its failure mode should be categorized as a level of service failure.

### Regulatory/Reliability

Being compliant with regulatory requirements has been identified by CAWD as a fundamental level of service requirement for its operations. Equipment reliability and redundancy has also been identified as a required level of service and could be considered to be closely associated with the regulatory level of service of assets because if an asset or system is not reliable then it could likely cause emergency situations where regulatory requirements may not be met.

Two assets that could be considered failing the required service level in terms of reliability include the existing aeration blowers and bulk storage of sodium bisulfate.

- **Aeration Blowers Reliability:** The United States Environmental Protection Agency (EPA) has established minimum standards of reliability for wastewater treatment systems. These standards dictate that treatment facilities have a sufficient number of blowers such that they are able to meet the maximum design conditions with the largest capacity blower out of service. The existing diffused aeration system was installed in 1992 and included three, 250-hp centrifugal blowers. The aeration system was modified in 1997 and one of the original blowers was replaced with a smaller 150-hp Turblex blower. The smaller blower has had sufficient capacity to meet the plant's aeration demands and has subsequently been the only blower in routine use since its installation. Lack of use of the 250-hp blowers has caused the shafts of these larger blowers to deform such that they vibrate excessively and cannot be run for long periods reliably. The standby blowers are functional however the vibration affects the reliability of these blowers to run properly when needed. Therefore, the standby blowers cannot be considered to provide a reliable level of aeration redundancy intended by the EPA Standards.

  To address this reliability level of service failure, it is recommended that CAWD replace one of the existing 250-hp blowers with a new 150-hp blower to provide a reliable backup blower that is properly sized and redundant to the existing Turblex blower.

- **Sodium Bisulfite Tank Redundancy:** Sodium bisulfite (SBS) is used by CAWD to dechlorinate WWTP effluent in order to meet NPDES discharge limits for total residual chlorine. The existing dechlorination system stores bulk chemical in a single high density polyethylene (HDPE) tank. Bulk storage tanks can fail and for critical systems multiple tanks are typically used to guard against loss of treatment capability if a tank fails. Because CAWD would be unable to meet its NPDES discharge permit limits for total residual chlorine in the event the existing bulk tank failed, lack of a second storage tank is considered a level of service (redundancy) failure.

To address this level of service failure it is recommended that CAWD construct a new chemical containment area and SBS tank adjacent to the existing tank to provide additional SBS storage in the event of a failure of the current single SBS tank.

- **Various Obsolete Electrical Assets:** Obsolete assets are assets that are no longer serviceable because parts are no longer available. Much of the treatment plant electrical equipment is old technology which is no longer supported and spare parts are no longer available. Therefore, it is recommended that planned capital improvement projects include replacement of electrical and controls components to systematically upgrade the current electrical equipment to current standards and current technologies. This would include: motor control centers, breakers, transfer switches, control panels, and programmable logic control equipment.

- **Operations Control Building:** The level of service established for the Operations Control Building is to serve as a central control and monitoring center for the entire WWTP as well as to provide office space for operations staff to conduct business activities involved in operating the WWTP.

  Supervisory control and data acquisition (SCADA) which is used to control and monitor plant operations is accessed via computers at small workstations in the Operations Control Building which are located adjacent to other office workstations. Typically WWTPs have dedicated rooms for SCADA control and monitoring which are separate from other workspaces. Furthermore, SCADA monitoring stations are typically located at large desks with multiple screens which allow multiple operators to view the SCADA screens simultaneously so that operators can work as a team in making process modifications and controlling equipment from the SCADA station. Plant communications tools (i.e. radios and phones) are also normally located around the SCADA screens to allow communication between operators in the field with operators at the control station during control modifications.

  Currently, the Operations Control Building has two small work stations which can be used to monitor SCADA. These work stations are in crowded rooms adjacent to other office work stations making it difficult for multiple operators to view the SCADA screens simultaneously as a team. Furthermore, when Tesco Controls conducts maintenance of the SCADA systems this encroaches on the operations staff ability to maintain interface with SCADA. The crowded layout of the SCADA monitoring computers in the Operations Control Building make it difficult to achieve the level of service of effectively controlling and monitoring plant operations.

To address this level of service deficiency it is recommended to move SCADA control functions to the existing electrical room in the Operations Control Building. The existing electrical/MCC components in this room would need to be abandoned and/or relocated as part of electrical upgrades to make space in the Operations Control Building for an adequate SCADA station. Moving SCADA control into the electrical room would free up more space in the office area to make room for other level of service functions in the Operations Control Building such as serving as the plant library, office area, and meeting area.

### Safety

CAWD has identified safety as one of its strategic levels of service goals to eliminate personal injuries at the WWTP. The asset survey conducted by Kennedy/Jenks in March 2012 identified a number of assets that could be considered either to be failing or in imminent danger of failing to provide an adequate level of service in terms of safety. These include walking-work surface assets, electrical equipment assets, and emergency eyewash/showers.

- **Walking-Work Surfaces:** Walking-work surface assets that are not providing required level of service were identified during the survey. Examples include ladders without safety cages or not designed for permanent use, grating that is not properly supported or in poor condition, and lack of fall protection/guardrail at the end of the walkway to Digester 4 (Sludge Holding Tank).

- **Arc Flash Safety:** CAWD does not currently have an arc flash safety program in place to help protect against the potentially severe consequences of this type of electrical explosion. Electrical equipment such as switchboards, panel boards, control panels and motor control centers that are likely to require examination, or maintenance while energized must be field marked to warn qualified persons of potential electric arc flash hazards. Service equipment must be legibly marked in the field with the maximum available fault current. Establishment of the maximum available fault current and degree of potential arc flash hazard requires completion of an arc flash hazard analysis in accordance with National Fire Protection Association Codes (NFPA 70E).

- **Emergency Showers:** Medical and first aid assets include emergency showers and eyewashes. Existing facilities could be considered to be failing to meet safety level of service requirements. Shortcomings of this particular group of assets include showers within the chlorine area that do not have eyewashes, showers that do not have flow switches that alarm upon use, and corrosion within the plant potable water system (1W) which is creating significant red discoloration of the water which makes it undesirable for use as eyewash water. Portable eyewash stations were installed to meet OSHA requirements for emergency eyewash, but portable systems do not provide as much pressure as hard piped emergency eyewash and therefore it is recommended that CAWD address the cause of the red water to allow use of the hard piped emergency eyewash and showers. Furthermore, flow switches should be added to all eyewash showers to send an alarm to the operations control center to notify staff that an operator may have been exposed to chemical and need assistance.

## Flooding and Storm Water

The CAWD WWTP is located adjacent to the Carmel River and in the Carmel River Flood Plain. The design of the WWTP has the majority of equipment and the top of walls of tanks above elevation 21 feet. This design criterion was developed in the early 1980's and it is unclear if this meets current projections of flood levels. It is recommended therefore that CAWD complete a study to update the design criteria to protect assets and the liquid process from inundation from floods.

The design of the onsite storm drain system is unknown and it has not been determined if runoff is completely contained onsite. It is recommended that CAWD re-evaluate the storm water system onsite to determine if improvements need to be made to keep spills occurring onsite from being discharged to the environment, which would be a NPDES permit violation.

## Capacity Failure Mode

An asset is categorized as having a capacity failure if the demand placed on the asset exceeds its design capacity. Growth and system expansion with associated increases in flow rates and solids loading can result in a capacity failure of wastewater treatment plant assets. For example, the capacity failure would be indicated if an influent pumping station was subject to peak flows in excess of its pumping capacity.

### Digestion System

The Digestion System currently does not have the capacity to provide adequate digestion time with the largest digester out of service (i.e. firm capacity). The Digestion System firm capacity failure is described in detail in Technical Memorandum No. 4.

### Influent Manhole

Hydraulic capacity of the plant has been stressed during high wet weather flow events although the plant has successfully operated through significant wet weather flow events recently and in the past. Further data and information needs to be gathered to determine if there are hydraulic capacity concerns in the Influent Manhole. Staff has recently observed that the Influent Manhole is a bottle neck upstream of the headworks that could be improved to avoid potential spills occurring over the walls of the influent manhole during high wet weather influent flows.

## Financial Efficiency Failure Mode

The failure mode of an asset can be categorized as a financial efficiency failure if there are feasible and less costly alternatives that could replace it. As technology advances, assets may also become financially inefficient simply because alternatives are available that are less costly in terms of labor, energy and material consumption.

Potential examples of assets whose failure mode is financial efficiency have been identified for existing WWTP assets. They include the aeration blower control system, sludge wasting system and microturbines. A potential financial investment in a new septic truck receiving station is also evaluated as a set of assets that could increase the financial efficiency of the WWTP. In each case, CAWD should produce a formal Business Case Evaluation (BCE) prior to selecting the most cost effective alternative solution.

## Aeration Blower Control System

The WWTP's diffused aeration system was originally constructed in 1992 and included the use of three, 250-hp, constant speed, centrifugal blowers. In 1997, energy efficiency improvements were made that included replacement of one blower with a smaller, 150-hp, constant speed, Turblex brand centrifugal blower. Means to monitor and control the dissolved oxygen (DO) concentration within the aeration basins was also provided by adding DO probes and electrically actuated throttling valves on the aeration air drop legs.

The aeration blower system has a high energy demand and therefore even moderate improvements in energy efficiency would result in significant energy savings. By improving the energy efficiency of the aeration system, CAWD would pay less for energy use. Feasible alternatives to improve energy efficiency could include inlet air throttling, or adjustable speed blower operation.

On a recent project for City of West Lafayette, Indiana, K/J found that their wastewater treatment facility could reduce aeration energy use by about 20 to 30 percent by implementing inlet air throttling, or adjustable speed blower operation. This reduction was in comparison to their existing system that had no form of air flow control. Because CAWD currently has made some energy improvements (i.e. blower discharge throttling and installing a more efficient Turblex blower), energy savings would be less than that predicted for the City of West Lafayette but still could be significant.

K/J investigated the configuration of the existing CAWD Turblex blower and found that the blower does not appear to be equipped with inlet guide vanes which are commonly provided as part of Turblex blowers to greatly increase efficiency. Because this blower does not take advantage of inlet guide vanes, it is feasible that worthwhile improvements in energy efficiency can be made. Examples of more financially efficient blower controls are provided in the following theoretical analysis. Determining the amount of energy savings that could actually be achieved at CAWD would require additional detailed analysis. However, for the purposes of this evaluation one could assume a feasible reduction of 10 to 15 percent in energy use. According to plant record information, in 2011 a total of 782,560 kW-hr of electricity was used by the blower system at a cost of $100,042 for that year.

Adjusting airflow to meet oxygen demand via inlet throttling would be more energy efficient in reducing power requirements than the current practice of discharge throttling. Installation of adjustable inlet vanes on the existing Turblex blower with associated controls capable of automatically modulating the inlet airflow could cost in the range of $100,000. Assuming a 10 percent reduction in energy consumption by adding inlet throttling the resulting estimated annual savings would be about $10,000 per year. This results in a payback period of 10 years, which would be less than the average useful life for the new equipment.

The use of adjustable frequency drives (AFDs) could provide even greater increases in energy efficiency but would require a capital investment in new AFD equipment and programming modifications to the existing blower control system. Installation of one AFD with associated controls could cost in the range of $150,000. Assuming a 15 percent reduction in energy use by adding AFDs the resulting estimated annual saving would be about $15,000 per year; again resulting in a payback period of about 10 years. This too would be less than the expected useful life of the new equipment.

Additional analysis would be needed to determine if alternative blower control systems are truly financially feasible. Performance of the existing system, other control options such as peak shaving, and incentive programs could all factor into the analysis. Nonetheless, from initial K/J investigations of blower efficiency, the information gathered thus far indicates that this system may be financially inefficient.

## Sludge Wasting

Excess or waste activated sludge (WAS) is currently removed from the secondary process by means of throttling valves within the return activated sludge piping. This system has been identified as being difficult to control resulting in operational challenges for plant staff. One feasible alternative would be to replace the throttling valves with separate WAS pumps that could be designed to better control the rate and volume of sludge wasted.

In determining whether or not the failure mode of the existing system wasting is in fact a financial efficiency, costs associated with operation of the throttling system would be compared with that of constructing an alternate pumped system. Costs of the existing system could include labor associated with continuously monitoring and adjusting the wasting valves and cost impacts on the solids treatment process (e.g., labor, polymer usage, energy use, etc.). There is currently insufficient data to complete the evaluation of the existing WAS throttling valves financial efficiency, but this system should be flagged as a possible financial inefficiency and with adequate data it could be concluded that investing in pumped sludge wasting would actually reduce costs compared to keeping the existing valve throttling system.

## Microturbines

The WWTP has a digester gas power cogeneration system comprised of two microturbines that generate approximately 770 kW-hr per day (average daily from year 2011 plant data) resulting in an annual offset of CAWD electricity costs in the range of $35,000 per year (assuming $0.12 per KW-hr). The microturbines return waste heat back to the digesters (about 0.30 million British Thermal Units per hour (MMBH)) to supplement digester heating. Natural gas is purchased to further heat the digester sludge, because the waste heat from the microturbines is not sufficient to heat the digesters alone. However, the digester gas which is used in the microturbines to generate energy could be used to heat the digesters directly via the sludge heater/boiler eliminating the need to purchase natural gas. Therefore, the natural gas which is purchased to make up for the digester gas used up in the microturbines is an additional cost to CAWD associated with running a cogeneration system. It is estimated based on 2011 plant data that about 0.15 MMBH (35 therms per day) of heat is purchased from PG&E in the form of natural gas at a cost of approximately $12,000 per year. Therefore, the net yearly financial savings provided by the microturbine cogeneration system is estimated at about $23,000 per year (not including maintenance costs).

There are no other feasible alternatives that would result in a higher financial return than maintaining the current system as it is in its current condition. However, when it comes time to rehabilitate or replace the existing microturbines the cost should be weighed against the annual returns and life cycle extension to determine the level of capital investment that would be acceptable to avoid creating a financial inefficiency. The average useful life of this equipment is estimated to be in the range of 20 years, and when it is time to rehabilitate or replace the microturbines financial efficiency will be a factor. Furthermore, there is not a regulatory driver for CAWD to have a cogeneration system; therefore investments in this system should be primarily based on a balance of financial return and investment.

As an example, the cost of completely replacing the existing microturbine cogeneration system is estimated to be about $500,000. Assuming a continuation of the current yearly cost savings associated with power cogeneration, the payback period for a complete replacement of the microturbine system would be over 21 years. This payback period is not particularly attractive because it is greater than the expected useful life of the investment. Typically payback periods should be considerably less than the life of the asset to be attractive from a financial investment standpoint. For the microturbines, an acceptable payback period should be less than 15 years. The investment dollars over the acceptable payback period should not exceed the yearly net financial return (approximately $23,000 per year) over the payback period. Therefore, for future rehabilitation or repair of the cogeneration system, which would be expected to extend the useful life another 20 years, the payback period should not exceed 15 years and thus the capital expenditures should not exceed $345,000 (i.e. $23,000 x 15 years).

## Septage Receiving Station

The WWTP was designed to operate at an average dry weather flow (ADWF) of 2.43 MGD as part of the 1982 improvements. The 1992 improvements show a tertiary influent capacity of 2.25 MGD. The average flow from 2008 to 2011 was 1.56 MGD. It appears then that the WWTP may have excess treatment capacity and that CAWD is paying to maintain higher capacity assets than are actually being utilized. As such the replacement cost of the assets per MGD of treated water is higher than necessary to treat the actual influent flow. To take financial advantage of the excess capacity CAWD could consider constructing a septage receiving facility in order to increase revenue.

A new septage receiving station at CAWD should be sized based on projections of local demands for septage disposal. Further study into local demands for septage disposal would be required as part of planning the development of a septage receiving station. As an example of scale, the City of Santa Cruz with an average annual wastewater flow rate of 10 MGD, receives about 20,000 gallons of septage per day. This is delivered in 3,000 to 5,000-gallon trucks with five to six deliveries per day. It is not clear if septic waste volumes generated in the Carmel area would reach this amount, nonetheless, with developments southward to Big Sur, and up the Carmel Valley which are not connected to a public sewer system it is conceivable that a septic receiving station at CAWD would be reasonably utilized.

A new septage receiving station would be comprised of an underground tank with connections for septic tank waste disposal vehicles, pumps to pump the septic waste into the headworks, and odor control chemical dosing systems. The construction cost for a new septage receiving station could be in the range of $200,000. Tipping fees could be in the range of $0.06 to $0.16 per gallon. Assuming that the plant received one 3,000-gallon delivery per day, five days per week, at $0.10 per gallon, the annual revenue from septage receiving would be $78,000. The simple payback on investment therefore would be about 3 years. The actual payback period would have to account for increased operating costs associated with the receiving station (e.g., labor, energy, etc.).The estimated useful life of a septic receiving station is over 30 years.

Process implications that should be considered include; increased operating costs for the secondary process system associated with additional aeration demand and increased solids production with associated solids handling costs. Before implementing a plan to develop a septage receiving station CAWD should conduct further studies. For example, if improvements were made to the WWTP’s digestion system, it may be financially more advantageous to feed septage directly into the anaerobic digesters instead of the secondary treatment process. Sending septage directly to digestion would eliminate an increase in energy use that would result if it were treated via the secondary process and would also lead to greater gas production for use by the plant’s microturbines.

## Conclusion

The four failure modes (Financial Efficiency Failure, Level of Service Failure, Capacity Failure, and Physical Mortality Failure) are all occurring at the CAWD WWTP. While physical mortality issues appear to be the most prevalent failure mode for the assets currently, it is important to include assets which are exhibiting other failure modes in the CIP to manage the risk associated with assets not meeting levels of service or required capacity.

Financial efficiency failures should be addressed in terms of investing funds to reduce life-cycle cost, however for prioritizing projects in the CIP financial efficiency failures will likely not have high consequences of failure compared to some of the assets at CAWD which are critical for regulatory compliance and which are showing signs of physical mortality, level of service, or capacity failures. The 15-year CIP Master Plan will be developed in a way that takes into account the four failure modes however physical mortality, level of service and capacity issues will take precedence over financial efficiency failures, primarily to manage high risk assets and also to plan expenditures such that projects may be funded from reserve funds and to limit funding projects from loans or bonds.

29 November 2012

# Technical Memorandum No. 8

To: Ms. Barbara Buikema and Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Reviewed by: Mr. Doug Stewart, P.E., Kennedy/Jenks Consultants

Subject: WWTP Assets Business Risk Evaluations
K/J 1268007*01

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This memorandum presents a preliminary evaluation of business risk for the assets in the Carmel Area Wastewater District (District/CAWD) wastewater treatment plant (WWTP). The business risk information contained herein is considered preliminary as the physical condition data generated thus far has been limited and should continue to improve as CAWD improves asset management practices. Furthermore, the projected extent that an asset failure could result in negative consequences is based on predicted hypothetical scenarios which could be further modeled in subsequent evaluations.

The risk information contained in this technical memorandum is useful in informing which assets pose the most significant risks to CAWD in the event the asset failed today. The focus of the current work is to develop a 15-year Capital Improvement Plan and the risk evaluations contained herein are useful in prioritizing potential asset improvement projects in terms of importance to business risk.

## Probability of Failure and Consequence of Failure

Probability of Failure (PoF) and Consequence of Failure (CoF) form the basis for determining Business Risk Exposure (BRE). The following is a brief description of these terms:

**Probability of Failure (PoF):** PoF is a metric developed to estimate the likelihood that an asset will fail. For this assessment, each asset is given a PoF score based on the physical condition data generated during the asset survey visual observations conducted by Kennedy/Jenks in March 2012, and by Beecher Engineering for the electrical assets. For the most part, PoF was established based on the observed physical condition of the asset and the percent life consumed of the asset. However, in some cases other failures such as level of service failures or capacity failures played a role in the PoF score of the asset. The scores for PoF were developed on a scale of 1 to 10, with 1 being an improbable likelihood of failure and 10 projecting an imminent failure.

**Consequence of Failure (CoF):** CoF is a metric developed to estimate the resulting consequences of an asset failure. For this evaluation a hypothetical sequence of events resulting from asset failure was estimated based on engineering judgment and understanding of the CAWD treatment plant operations. While the actual sequence of events that could unfold in the event of an asset failure is impossible to predict exactly, a plausible outcome of a failure was assumed for each asset. To develop a numerical score for CoF for this assessment, a scoring matrix was developed specifically for the CAWD WWTP assets. Each asset was given a score for CoF for six categories of failure criteria:

- ***Acceptable Downtime*** - The amount of time the asset can be down before a process failure or upset may result.
- ***Safety*** – The resulting impacts to human injury or health in the event the asset failed.
- ***Spill/Odor/Noise*** – The impacts and nuisance to the public in terms of spills, odor or noise caused by the asset failure.
- ***Permit/Environmental*** – The impacts to permit compliance and environmental impacts resulting from the asset failure.
- ***Process Functionality*** – The ability to maintain the functionality of the wastewater treatment process in the event the asset failed.
- ***Cost to Address Failure*** – Financial impacts to fix the asset and/or address the impacts of the asset failure and return the plant to a state of normal operations.

Table 1 shows the matrix developed to score CoF under each category. The total CoF score was a sum of the CoF scores for each category. The CoF scores ranged from 6 to 60; 60 being a significant CoF and 6 being negligible CoF.

Table 1: CoF Scoring Matrix for CAWD WWTP Assets

| CoF SCORE | Acceptable Downtime | Safety | Spill/Odor/ Noise | Permit/ Environmental | Process Functionality | Cost to Address Failure |
|---|---|---|---|---|---|---|
| **1** | Can be out of service indefinitely | No Impact to Safety | No Effect on Spills/Odors/ Noise | No Impact to Environment | No change in Process Functionality | No Cost |
| **3** | Cannot be down a month | Minor Inconvenience | Short Duration, Small qty. Event Onsite: No Complaints | Violate Daily Max Effluent Limitation | Routine Operations to maintain process functionality | In-house Repair Work (less than $1,000) |
| **5** | Cannot be down a week | Minor Injury/Health Risk (Readily Treatable) | Short Duration; Small qty Event Offsite; Small no. of Complaints | Violate Weekly Average Effluent Limitation | Maintaining Process Functionality requires staff divert from other work | Major In-House Repair Work (less than $25,000) |
| **7** | Cannot be down 1 day | Moderate Injury/Health Risk (Short Recovery) | Short Duration; Large qty Event offsite; Aggressive Complaints; No Property Damage | Violate Monthly Average Effluent Limitation or Fail Class B Biosolids | Maintaining Process Functionality Requires Emergency Outside Assistance | Emergency Contractor Needed to Address Failure (less than $500,000) |
| **9** | Cannot be down 8 Hours | Major Injury/Health Risk (Chronic/Long Recovery) or Death | Sustained Event impacting offsite, Media Attention, Minor Property Damage | Minor Environmental Damage, but Ecosystem can Recover | Loss of Process Functionality for less than 1 week | Regulatory Fines and Lawsuits + Emergency Contractor Needed (less than $1 Million) |
| **10** | Cannot be down 1 hour | Substantial Widespread Health Effects or Death | Sustained Event impacting offsite, Media Attention, Extensive Property Damage | Permit Jeopardized Environmental Damage Requires Remediation | Loss of Process Functionality Indefinitely | Regulatory Fines and Lawsuits + Emergency Contractor Needed (greater than $1 Million) |

**Business Risk Exposure (BRE):** BRE is a metric developed to estimate the risk profile of an asset. The BRE is based on a combined perspective of both PoF and CoF. An asset with a high PoF score and a high CoF score would be likely to fail and have a high consequence if it failed, and therefore would be considered a higher risk compared to an asset with a lower PoF and CoF score where failure is unlikely and the impacts of failure would be minimal. This memorandum contains graphs which plot the PoF score and the CoF score of the assets which illustrate where the assets fall in the range of BRE. BRE can be divided into risk categories such as high, medium and low risk. “High Risk”, “Medium Risk” and “Low Risk” are relative and not absolute metrics. The thresholds for each risk category were established for CAWD for this project as shown in the attached BRE graphs.

**A Note Regarding Redundancy:** Redundancy of assets is accounted for in the risk evaluations and is captured as part of the CoF score. As an example of how CoF scores take into account redundant assets; take the example of a pump station with two fully redundant pumps with each pump capable of handling the peak flow demands. If one pump fails, the second pump will turn on and maintain the level of service of the pump station. Therefore, the CoF of the first pump failing is very low because there are no adverse impacts to meeting flow demands if the first pump failed. However, if the second pump failed, the pump station would be unable to meet the flow demands and in this hypothetical example could result in overflows of the pump station wet well. Consequently, the second pump would have high CoF associated with spills and the impacts of a loss of pumping ability. This example illustrates how redundancy of assets was included in the CoF scoring and thus was factored into the BRE.

## Risk Exposure Graphs

Business Risk Exposure plots are provided herein for information in prioritizing the investments into the process areas and assets of the WWTP. To avoid a “fix worst first” approach of repairing assets based only on their condition, BRE graphically illustrates areas of the plant which have a higher risk profile relative to other areas.

Not all the assets have been inspected thoroughly enough to be able to define the PoF. In order to account for these assets, an assumed condition rating and PoF of 6 have been assigned. These assets that do not have condition data are distinguished in the risk exposure graphs from other assets.

The risk exposure for the assets should be used to determine the management strategy for the assets. The focus of the current work is to develop a 15-year capital improvements plan for the WWTP assets and the risk exposure graphs are useful in prioritizing capital improvements. However, capital improvements are one aspect of asset management and there are other risk management strategies which should also be implemented by CAWD depending on the risk profile of the asset. Recommended Risk Management Strategies to be implemented based on risk will be described in subsequent Technical Memorandum No. 9. These Risk Management Strategies include capital improvement strategies, maintenance strategies and non-asset strategies as summarized in Table 2.

### Table 2: Asset Risk Management Strategies

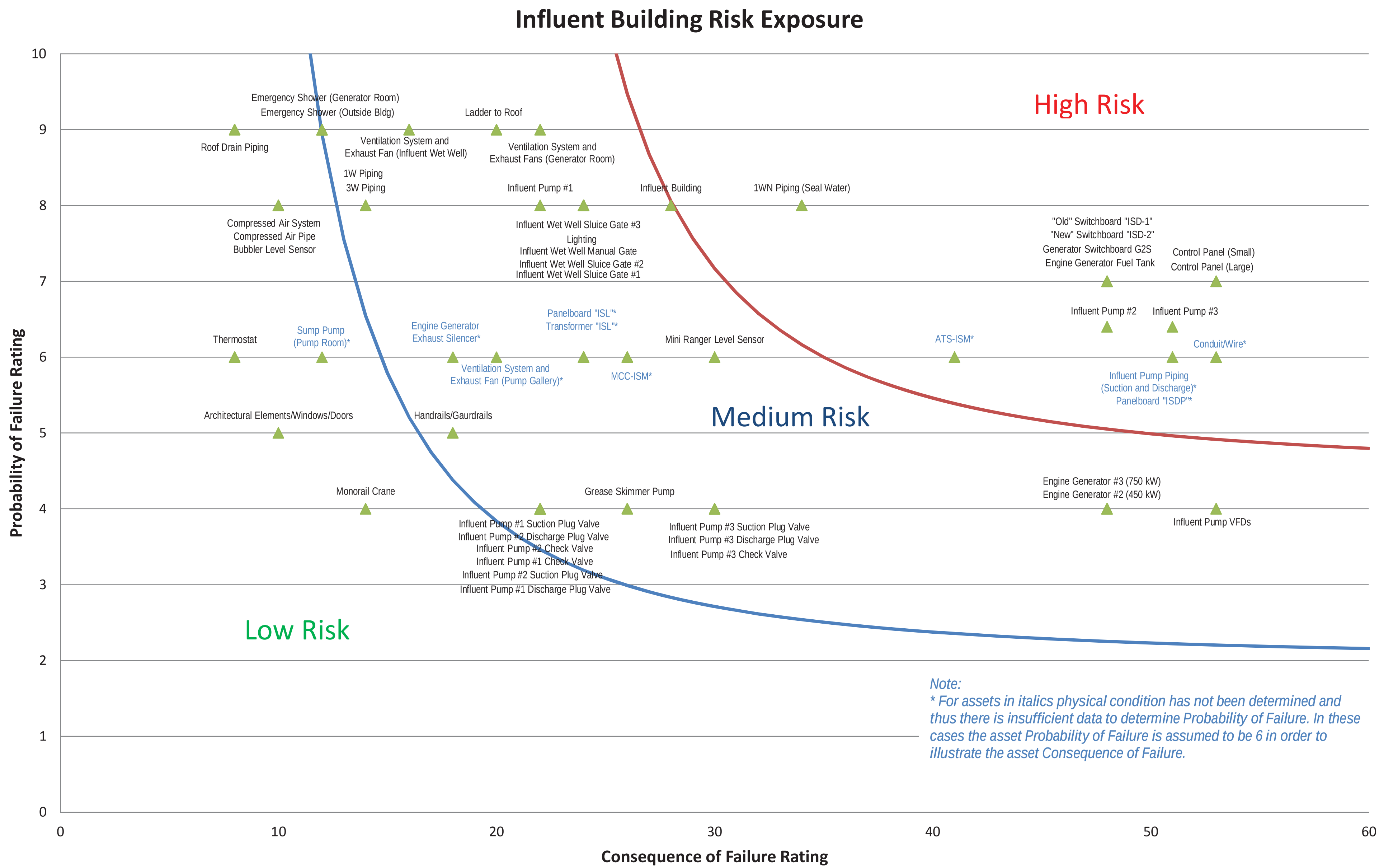
| Capital Improvements Strategies: | Maintenance Strategies: | Non Asset Strategies: |
|---|---|---|
| Plan Rehabilitation/ Replacement (Improve Condition) | Predictive Maintenance (Failure Prediction) and Preventative Maintenance (Maintain Condition) | Take Asset Out of Service |
| Moderate Repair (Improve Condition) | Preventative Maintenance (Maintain Condition) | Strategic Changes to Capacity Requirements or Level of Service |
| Add Portable Backup/Redundancy (Improve Reliability) | Corrective Maintenance (Fix it When it Breaks) | |

## Conclusion

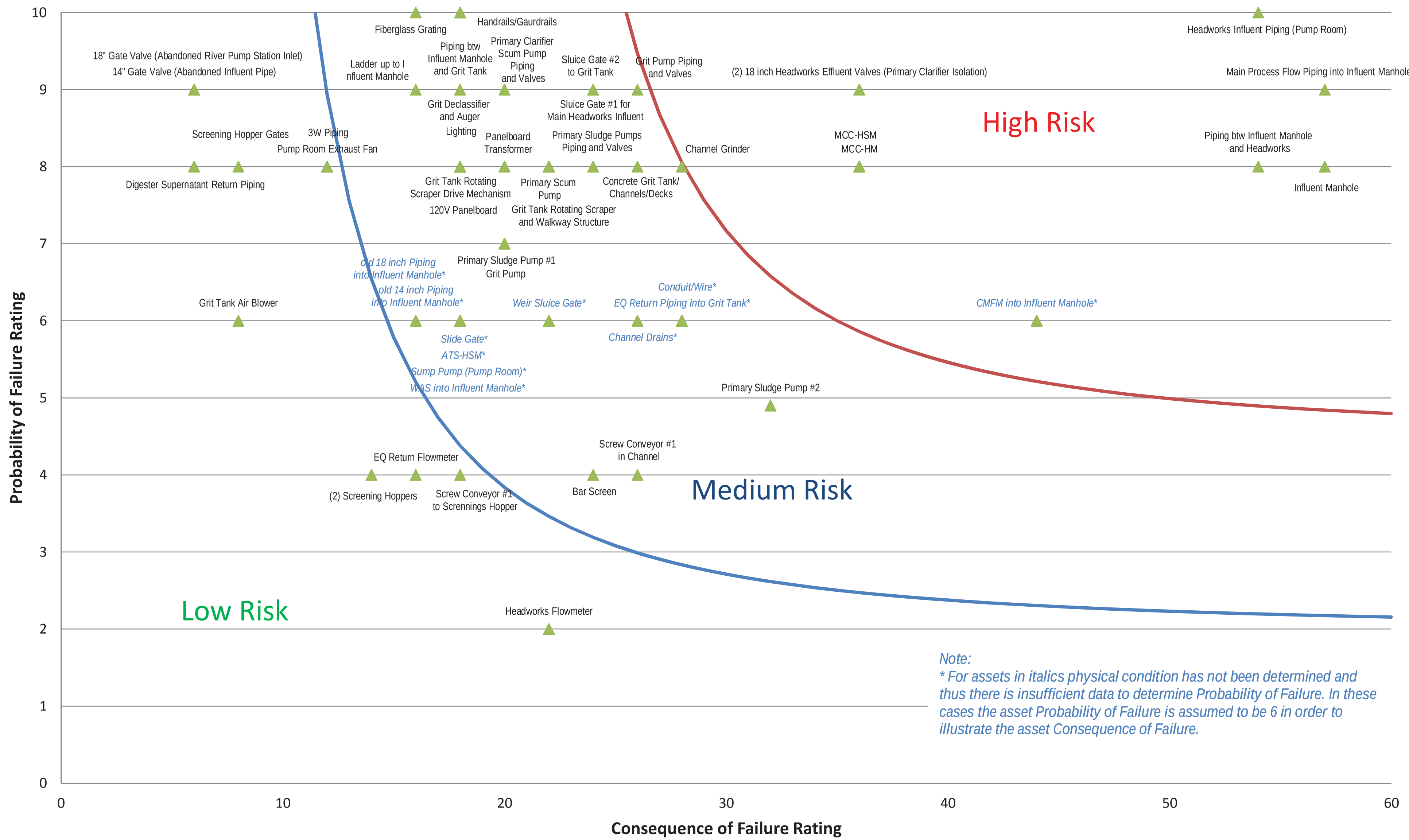
The graphs provided herein provide a snapshot of the current risk profiles associated with each asset and the associated process areas. This information will be used in prioritizing projects in the 15-year CIP plan. Furthermore, this information can be used to focus maintenance practices as will be discussed in Technical Memorandum No. 9. Risk is dynamic and will change as the condition of the assets will change over time. As redundancy may be added to systems the risk profiles will also change. In some cases better condition data may further inform the risk which could result in a lower risk profile. In summary, improving the understanding of the assets and continuing to update the PoF and CoF information is recommended for CAWD to remain informed of risk and be able to effectively manage the assets into the future. In the meantime as information is improved over time, it is recommended that the focus of the risk management strategies and data refinement be on those assets on the upper end of the CoF spectrum as these assets pose the greatest risk to CAWD if they fail.

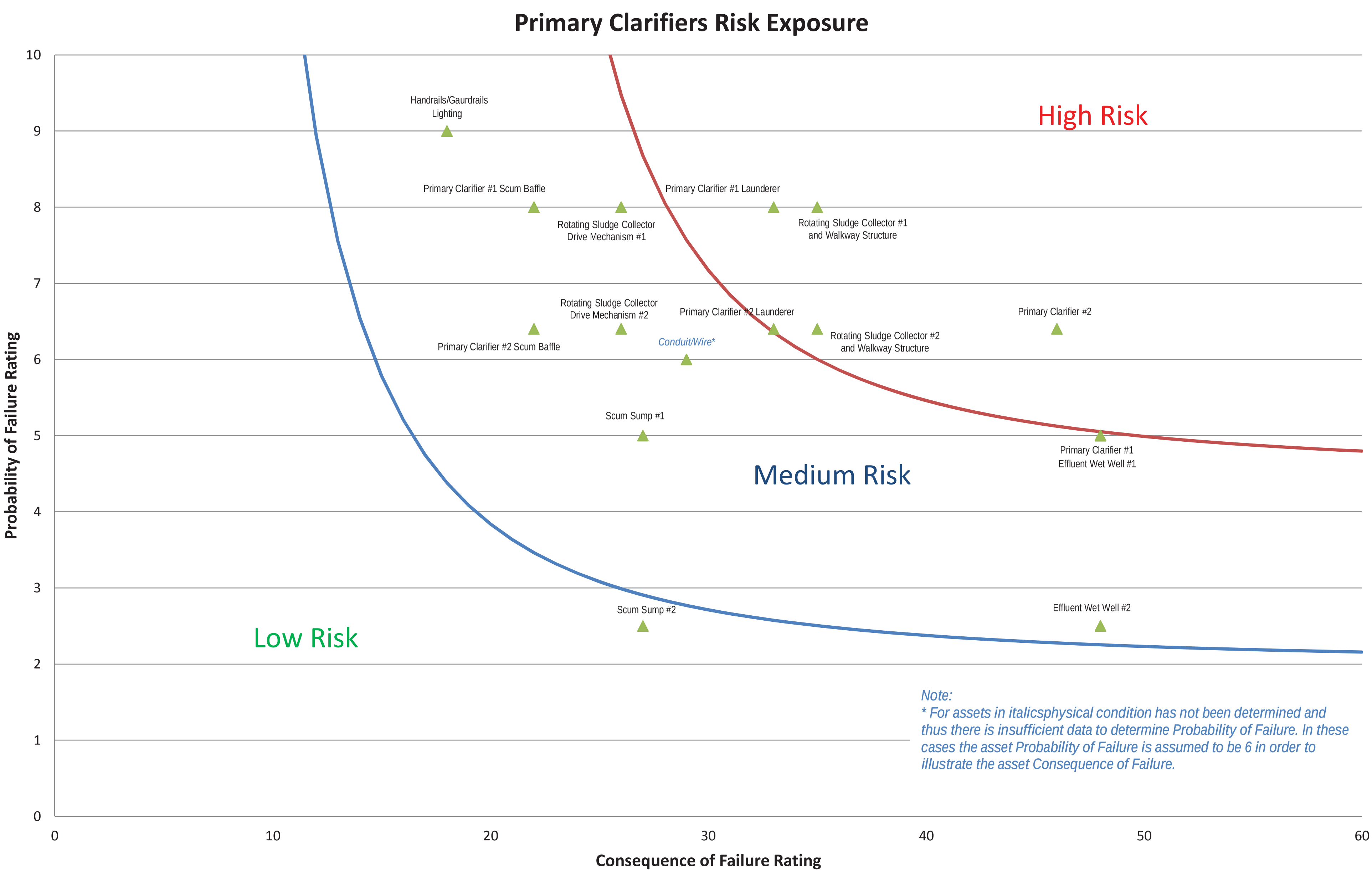
**Enclosures:** Risk Graphs by Process Area

Influent Building Risk Exposure
Influent Manhole/Headworks Risk Exposure
Primary Clarifiers Risk Exposure
Thickener Risk Exposure
EQ/Aeration Risk Exposure
RAS Building Risk Exposure
Secondary Clarifiers Risk Exposure
Chlorine Contact Risk Exposure
Chlor/Dechlor Building Risk Exposure
No. 3 Water System Risk Exposure
No. 1 Water System Risk Exposure
Effluent Building Risk Exposure
Blower Building Risk Exposure
Digester Control Building Risk Exposure
Digesters Risk Exposure
Belt Press Building Risk Exposure
FOG Facility Risk Exposure
Yard Piping Risk Exposure

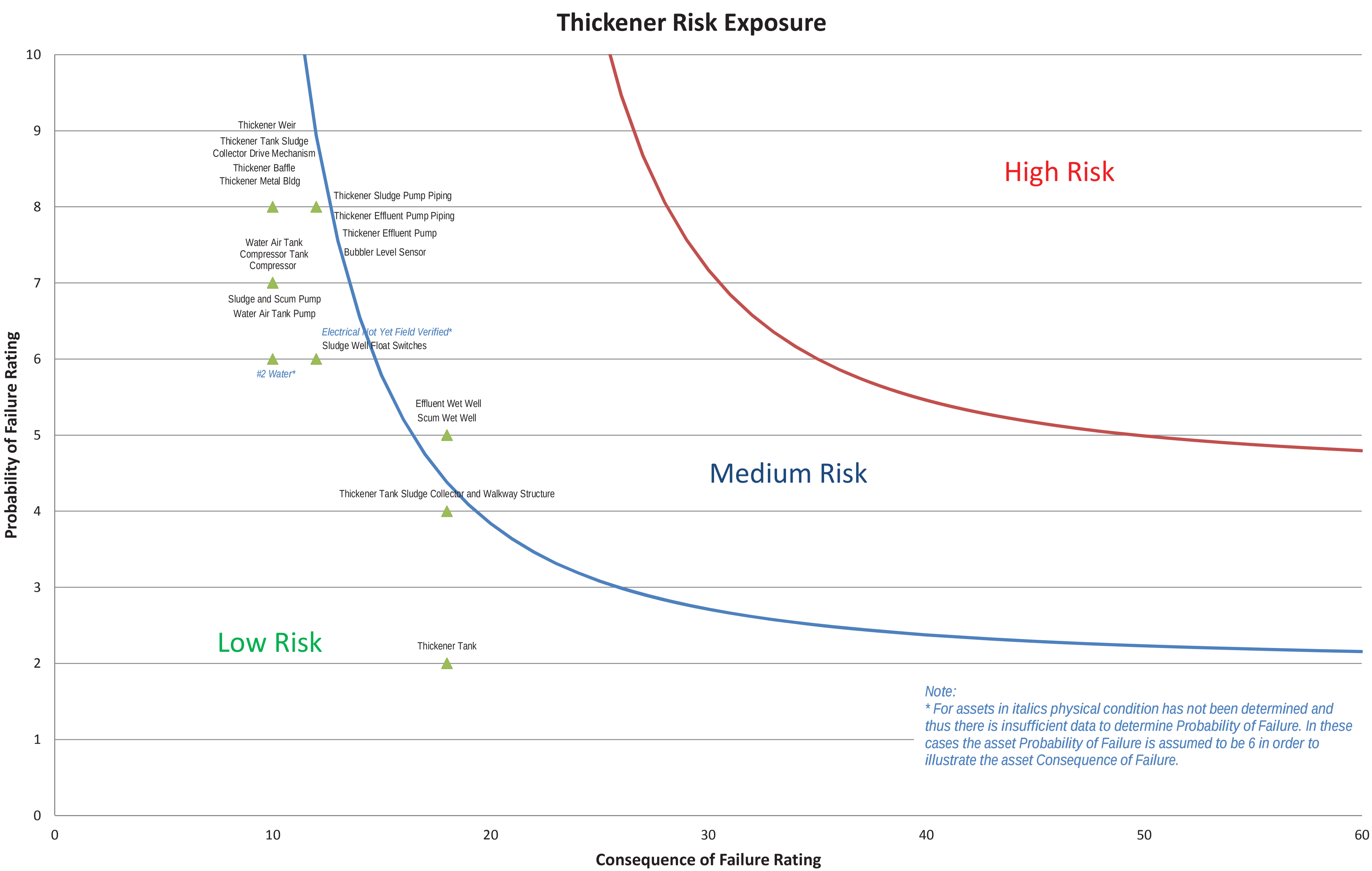

Influent Building Risk Exposure
High Risk
Medium Risk
Low Risk
Probability of Failure Rating
Consequence of Failure Rating
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
Emergency Shower (Generator Room)
Emergency Shower (Outside Bldg)
Roof Drain Piping
Ladder to Roof
Ventilation System and
Exhaust Fan (Influent Wet Well)
Ventilation System and
Exhaust Fans (Generator Room)
1W Piping
3W Piping
Influent Pump #1
Influent Building
1WN Piping (Seal Water)
Compressed Air System
Compressed Air Pipe
Bubbler Level Sensor
Influent Wet Well Sluice Gate #3
Lighting
Influent Wet Well Manual Gate
Influent Wet Well Sluice Gate #2
Influent Wet Well Sluice Gate #1
"Old" Switchboard "ISD-1"
"New" Switchboard "ISD-2"
Generator Switchboard G2S
Engine Generator Fuel Tank
Control Panel (Small)
Control Panel (Large)
Thermostat
Sump Pump
(Pump Room)*
Engine Generator
Exhaust Silencer*
Panelboard "ISL"*
Transformer "ISL"*
Mini Ranger Level Sensor
ATS-ISM*
Influent Pump #2
Influent Pump #3
Conduit/Wire*
Ventilation System and
Exhaust Fan (Pump Gallery)*
MCC-ISM*
Influent Pump Piping
(Suction and Discharge)*
Panelboard "ISDP"*
Architectural Elements/Windows/Doors
Handrails/Gaurdrails
Monorail Crane
Grease Skimmer Pump
Engine Generator #3 (750 kW)
Engine Generator #2 (450 kW)
Influent Pump #1 Suction Plug Valve
Influent Pump #2 Discharge Plug Valve
Influent Pump #2 Check Valve
Influent Pump #1 Check Valve
Influent Pump #2 Suction Plug Valve
Influent Pump #1 Discharge Plug Valve
Influent Pump #3 Suction Plug Valve
Influent Pump #3 Discharge Plug Valve
Influent Pump #3 Check Valve
Influent Pump VFDs
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.

## Influent Manhole/Headworks Risk Exposure

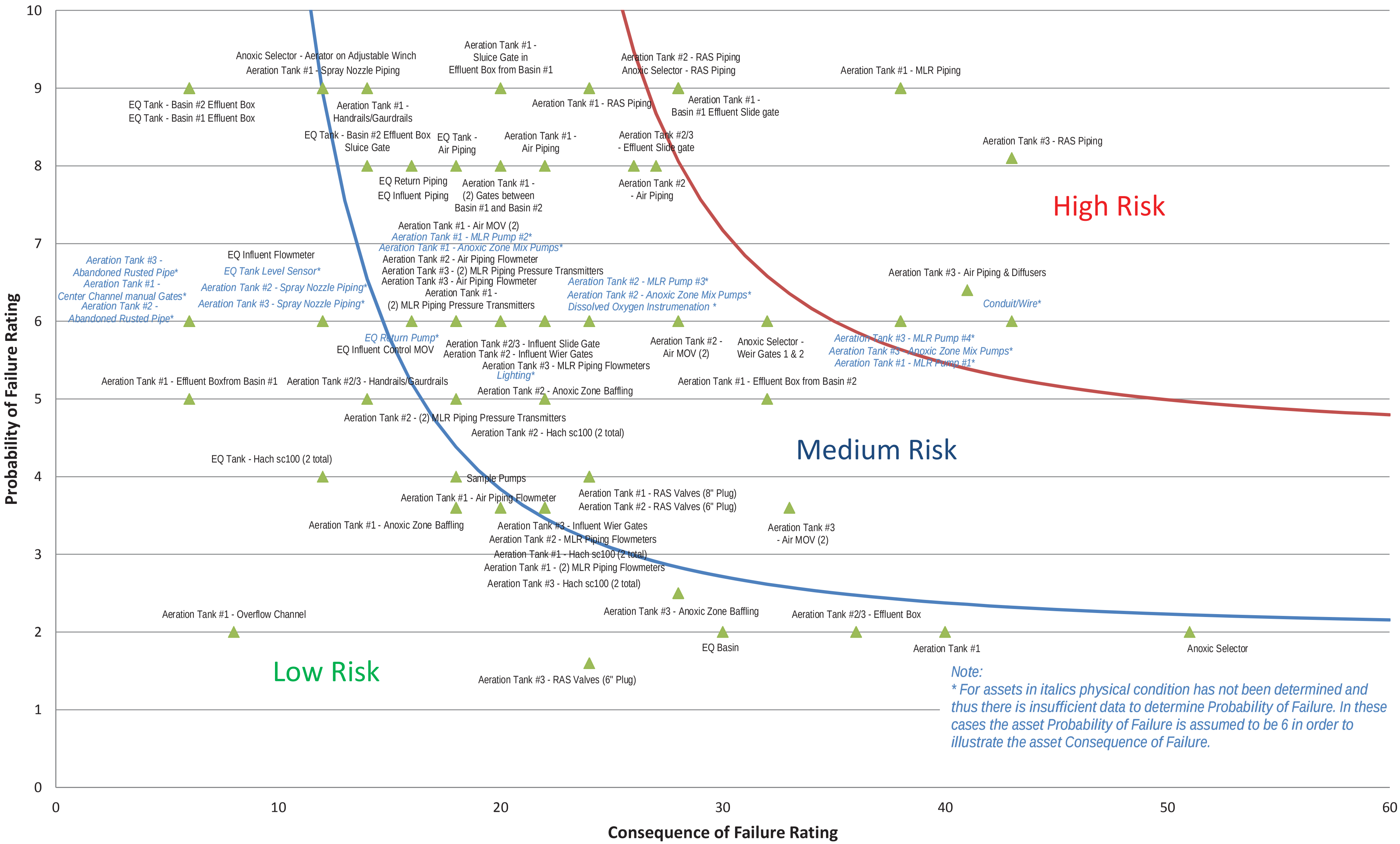


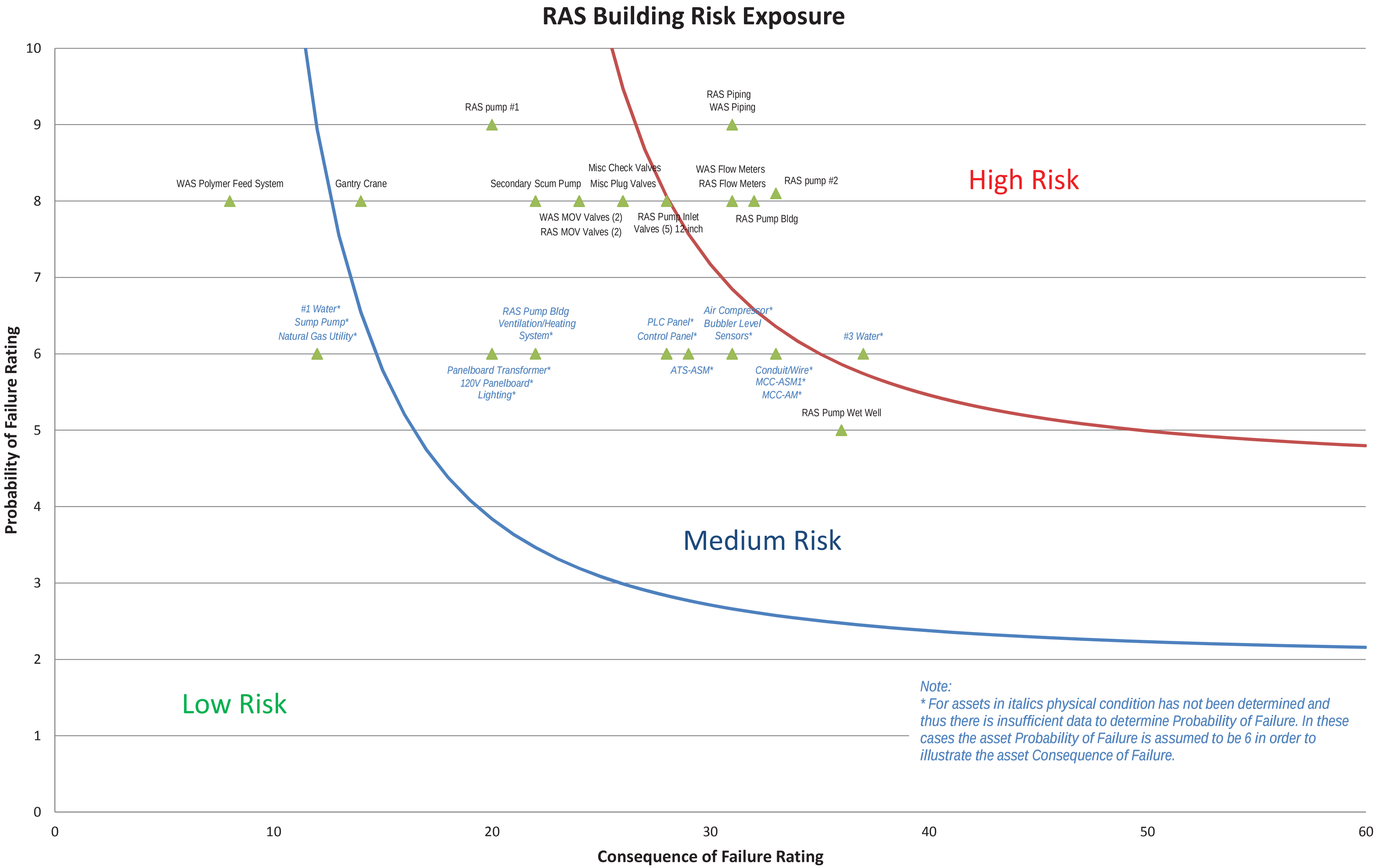


Primary Clarifiers Risk Exposure
Probability of Failure Rating
Consequence of Failure Rating
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
High Risk
Medium Risk
Low Risk
Handrails/Gaurdrails
Lighting
Primary Clarifier #1 Scum Baffle
Rotating Sludge Collector
Drive Mechanism #1
Primary Clarifier #1 Launderer
Rotating Sludge Collector #1
and Walkway Structure
Rotating Sludge Collector
Drive Mechanism #2
Primary Clarifier #2 Scum Baffle
Primary Clarifier #2 Launderer
Conduit/Wire*
Rotating Sludge Collector #2
and Walkway Structure
Primary Clarifier #2
Scum Sump #1
Primary Clarifier #1
Effluent Wet Well #1
Scum Sump #2
Effluent Wet Well #2
Note:
* For assets in italicsphysical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.


Thickener Risk Exposure
Probability of Failure Rating
Consequence of Failure Rating
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
High Risk
Medium Risk
Low Risk
Thickener Weir
Thickener Tank Sludge Collector Drive Mechanism
Thickener Baffle
Thickener Metal Bldg
Thickener Sludge Pump Piping
Thickener Effluent Pump Piping
Thickener Effluent Pump
Bubbler Level Sensor
Water Air Tank
Compressor Tank Compressor
Sludge and Scum Pump
Water Air Tank Pump
Electrical Not Yet Field Verified*
Sludge Well Float Switches
#2 Water*
Effluent Wet Well
Scum Wet Well
Thickener Tank Sludge Collector and Walkway Structure
Thickener Tank
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.

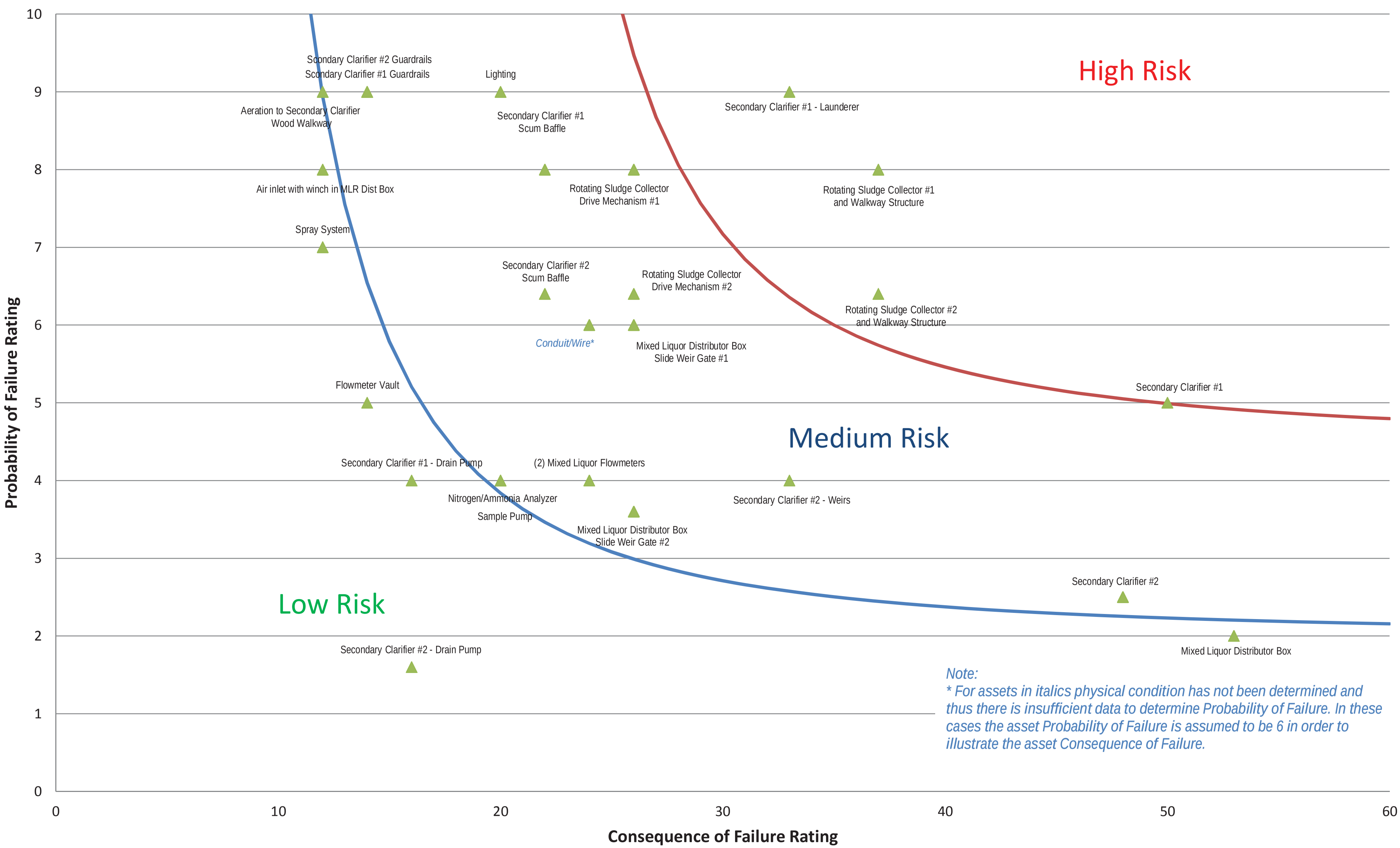
## EQ/Aeration Risk Exposure





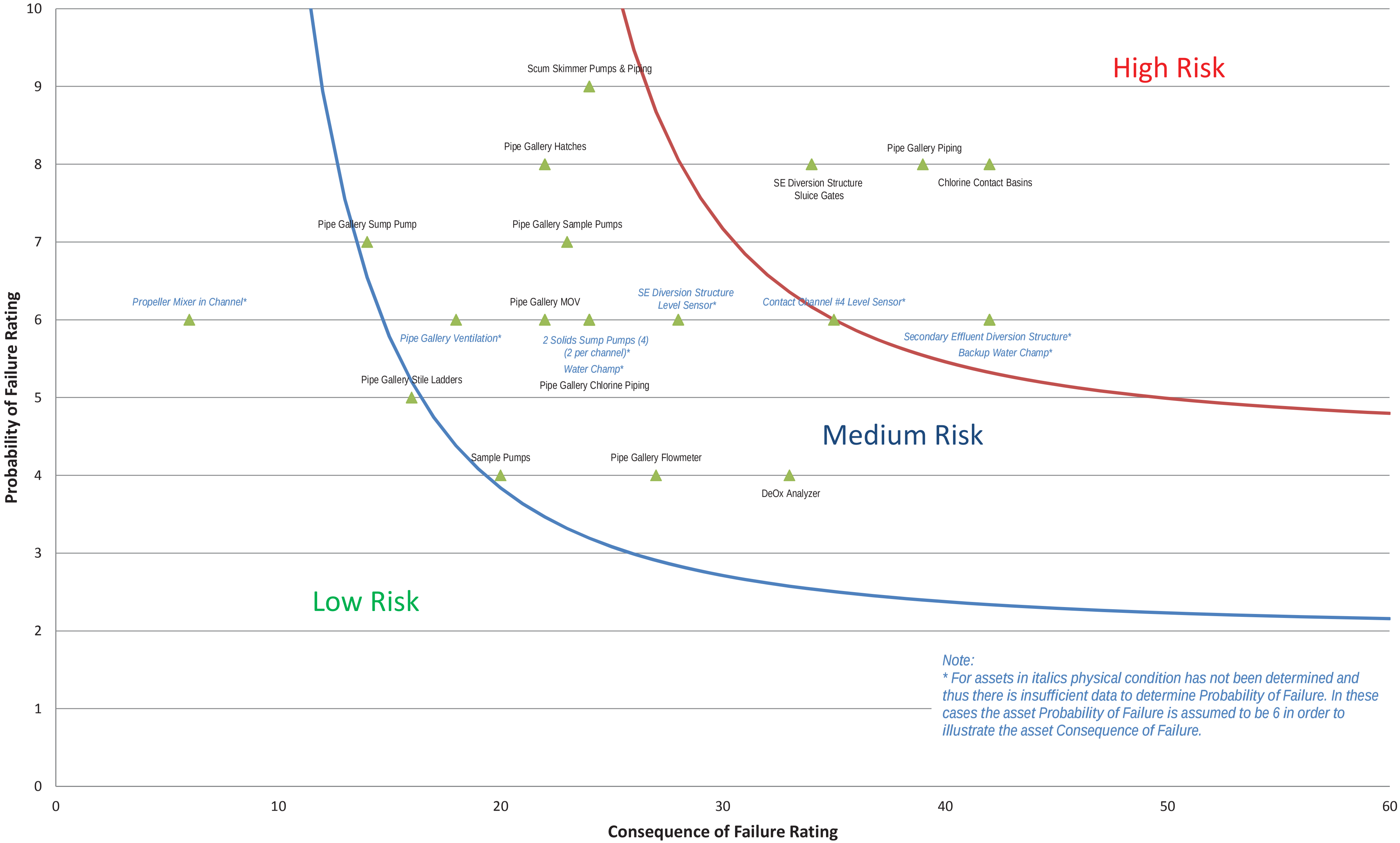

Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.

## Secondary Clarifiers Risk Exposure



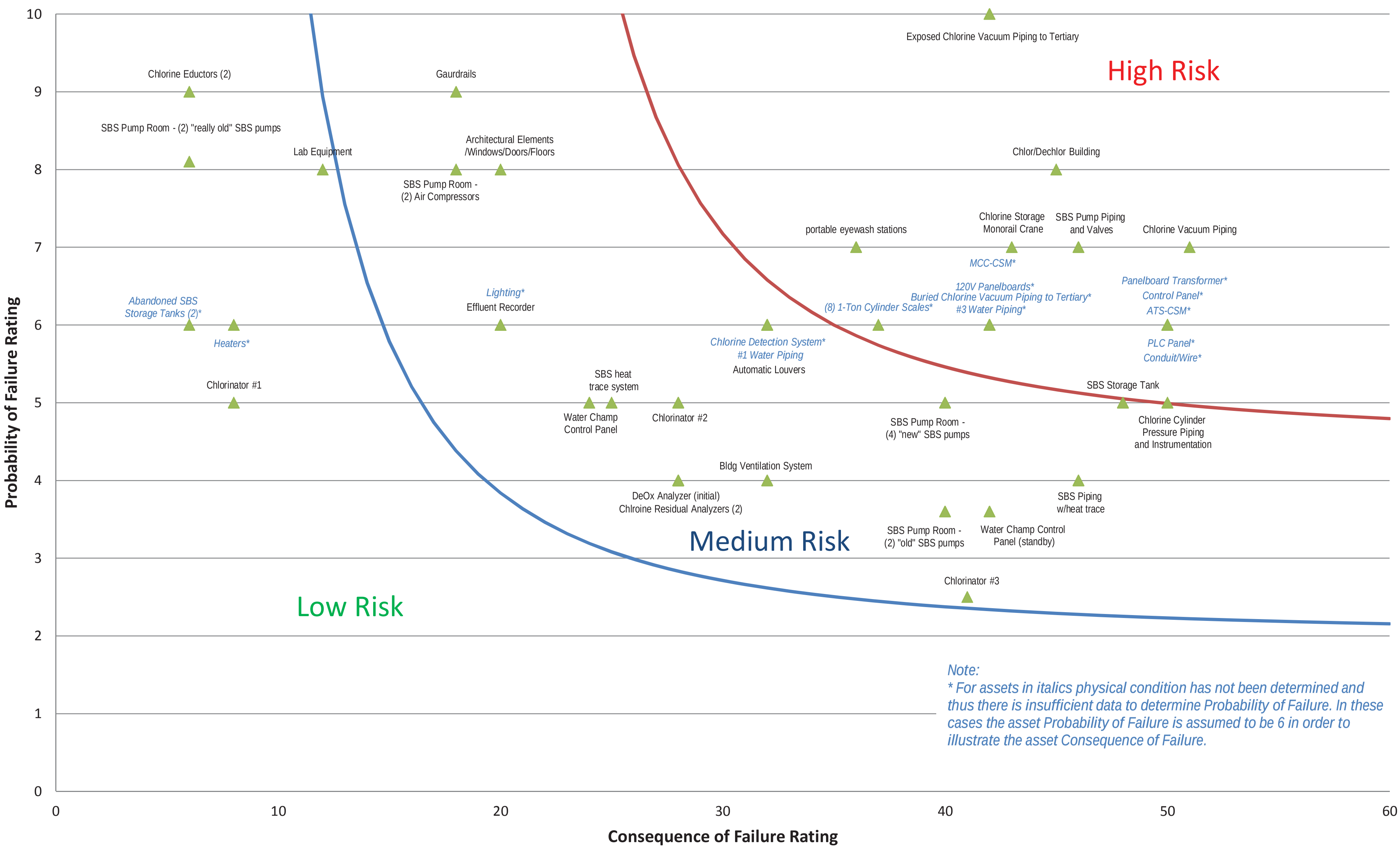

*Note:*
** For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.*

## Chlorine Contact Risk Exposure

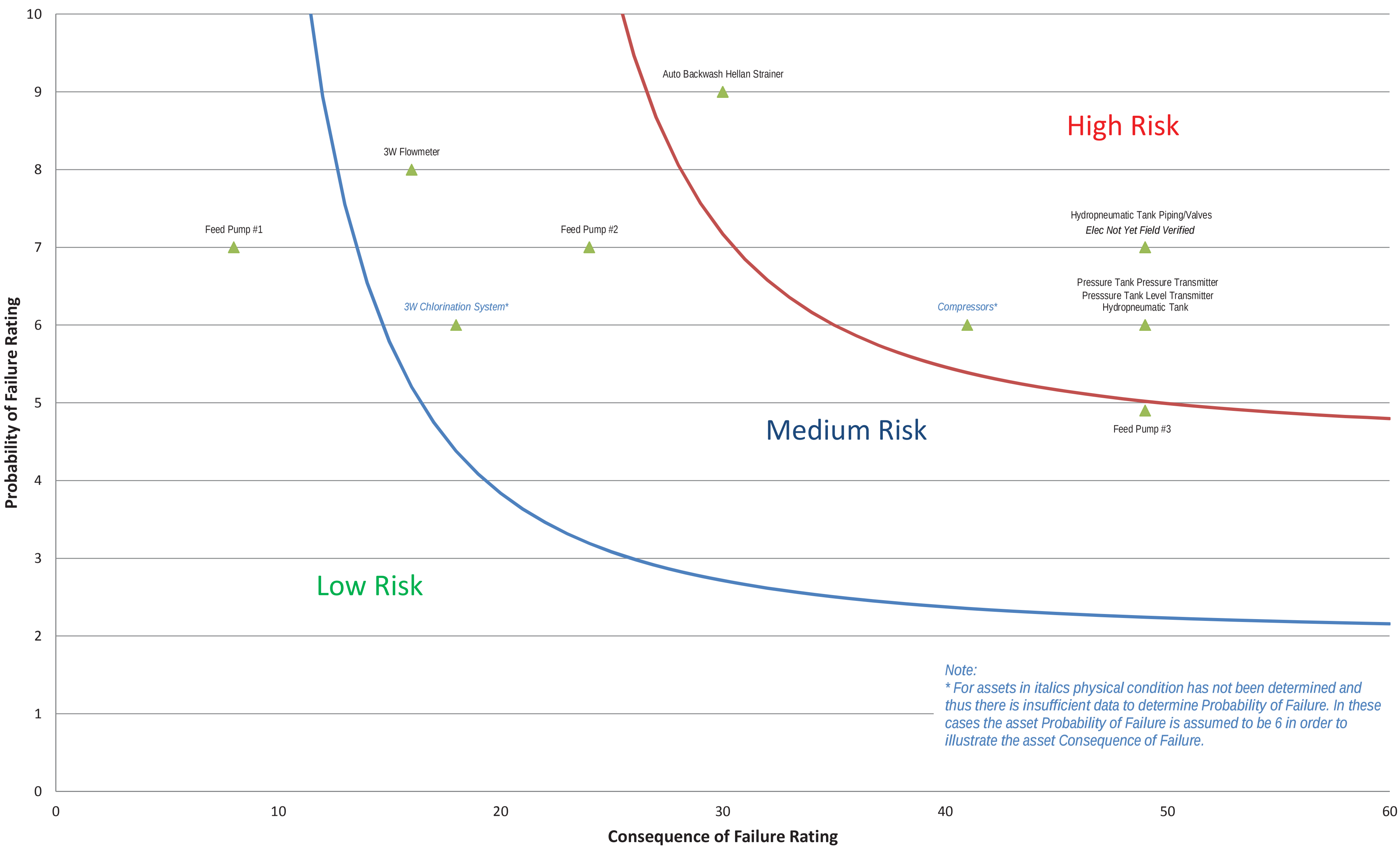



*Note:*
** For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.*

## Chlor/Dechlor Building Risk Exposure

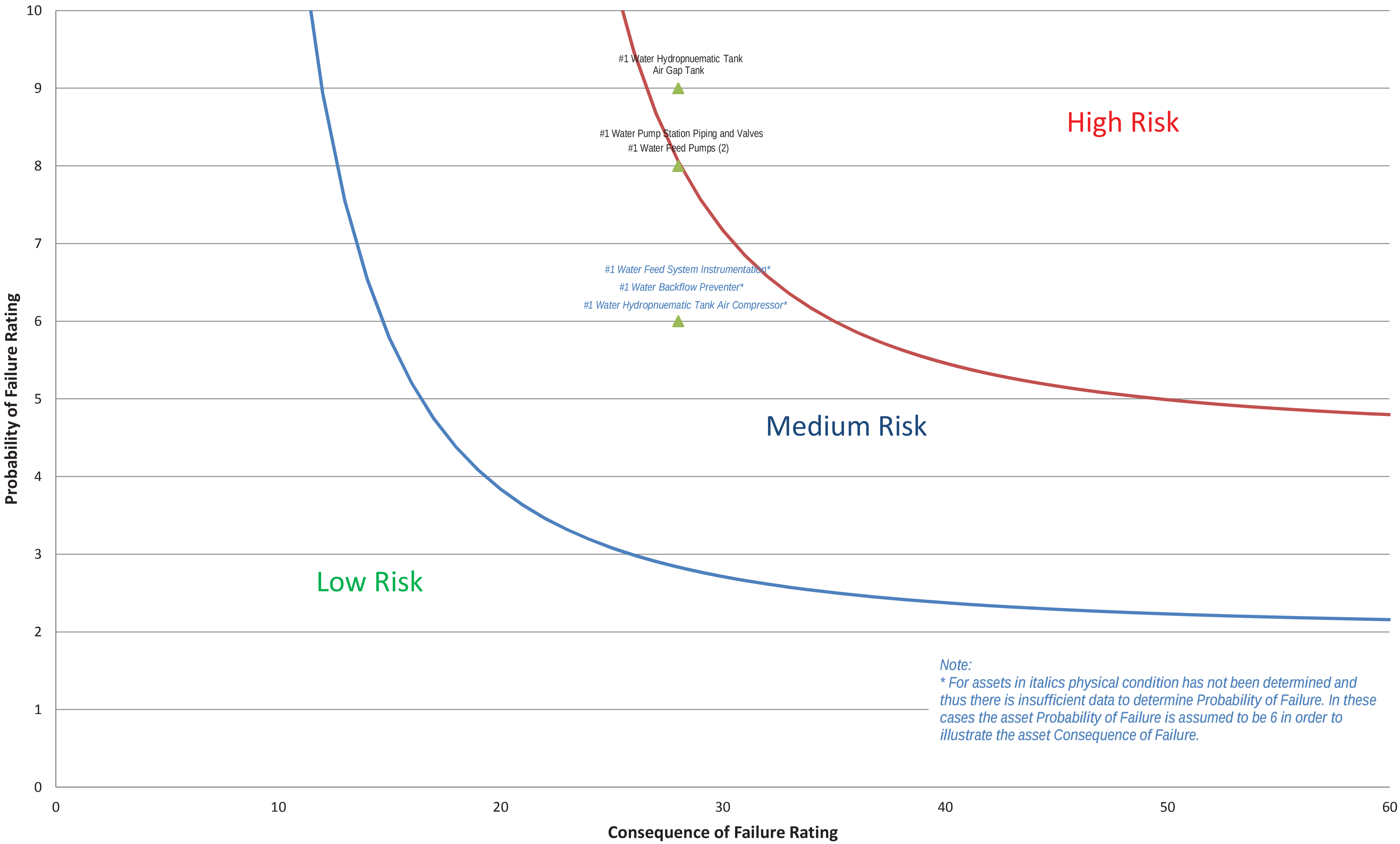


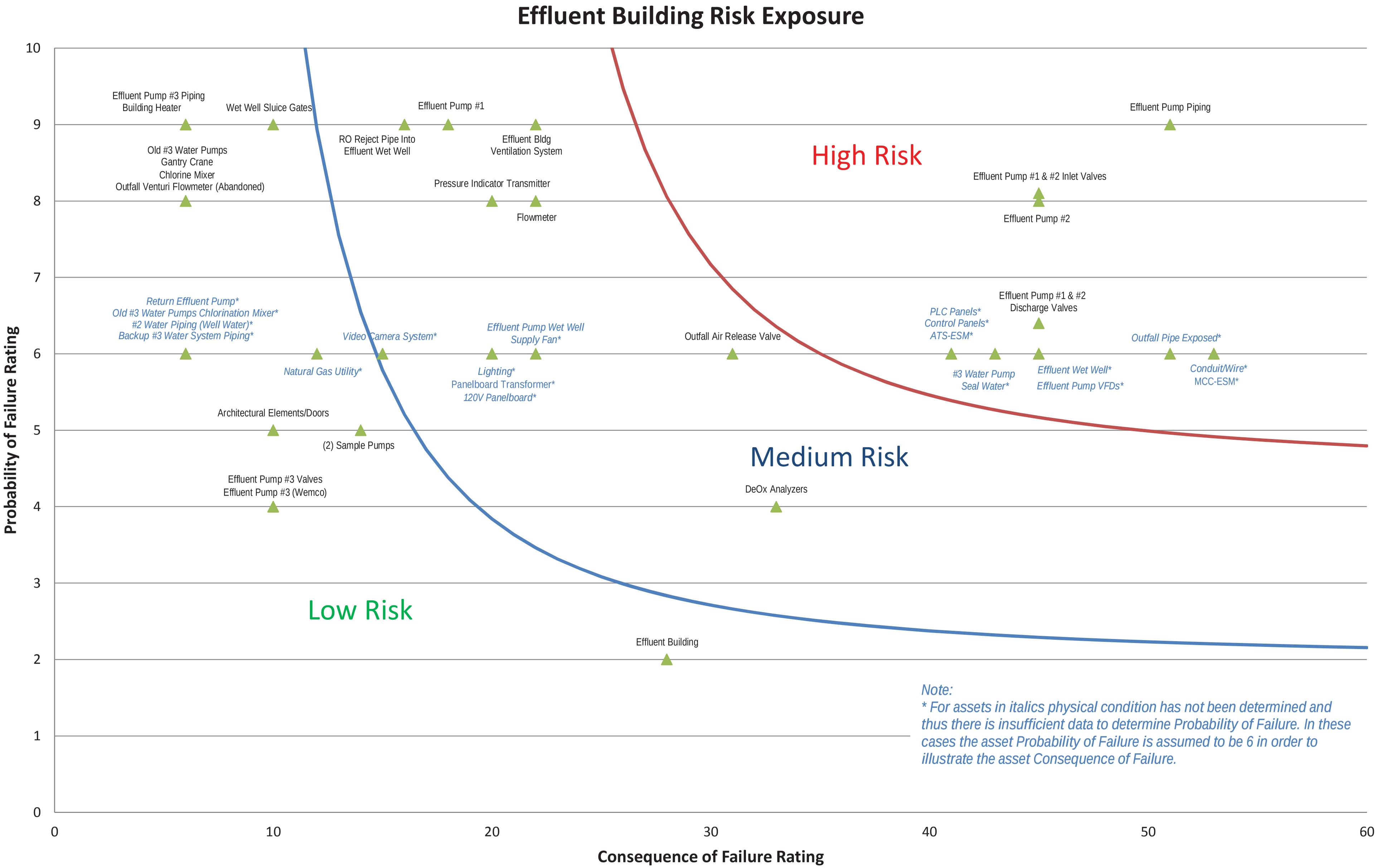
## No. 3 Water System Risk Exposure

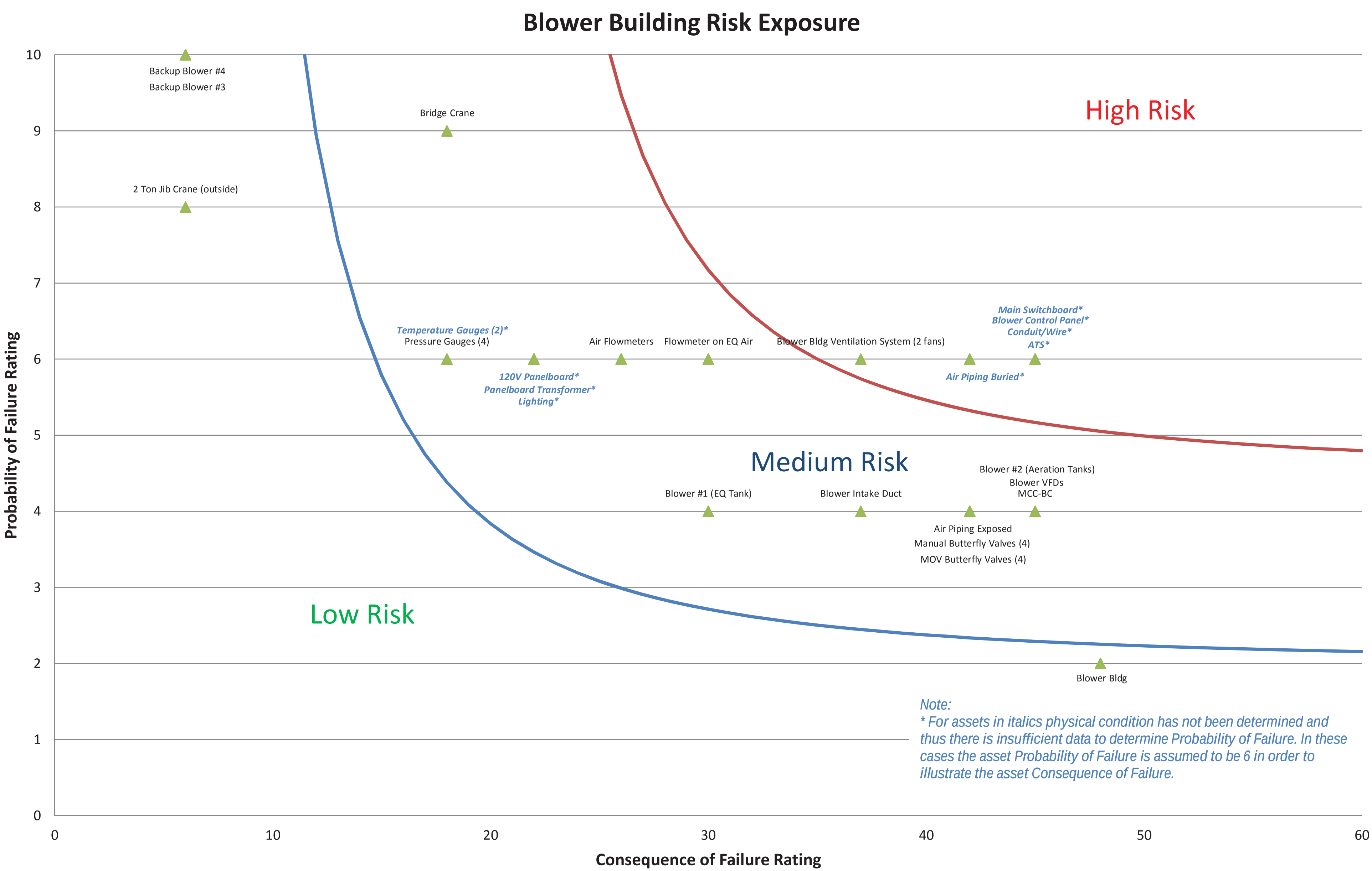



*Note:*
** For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.*

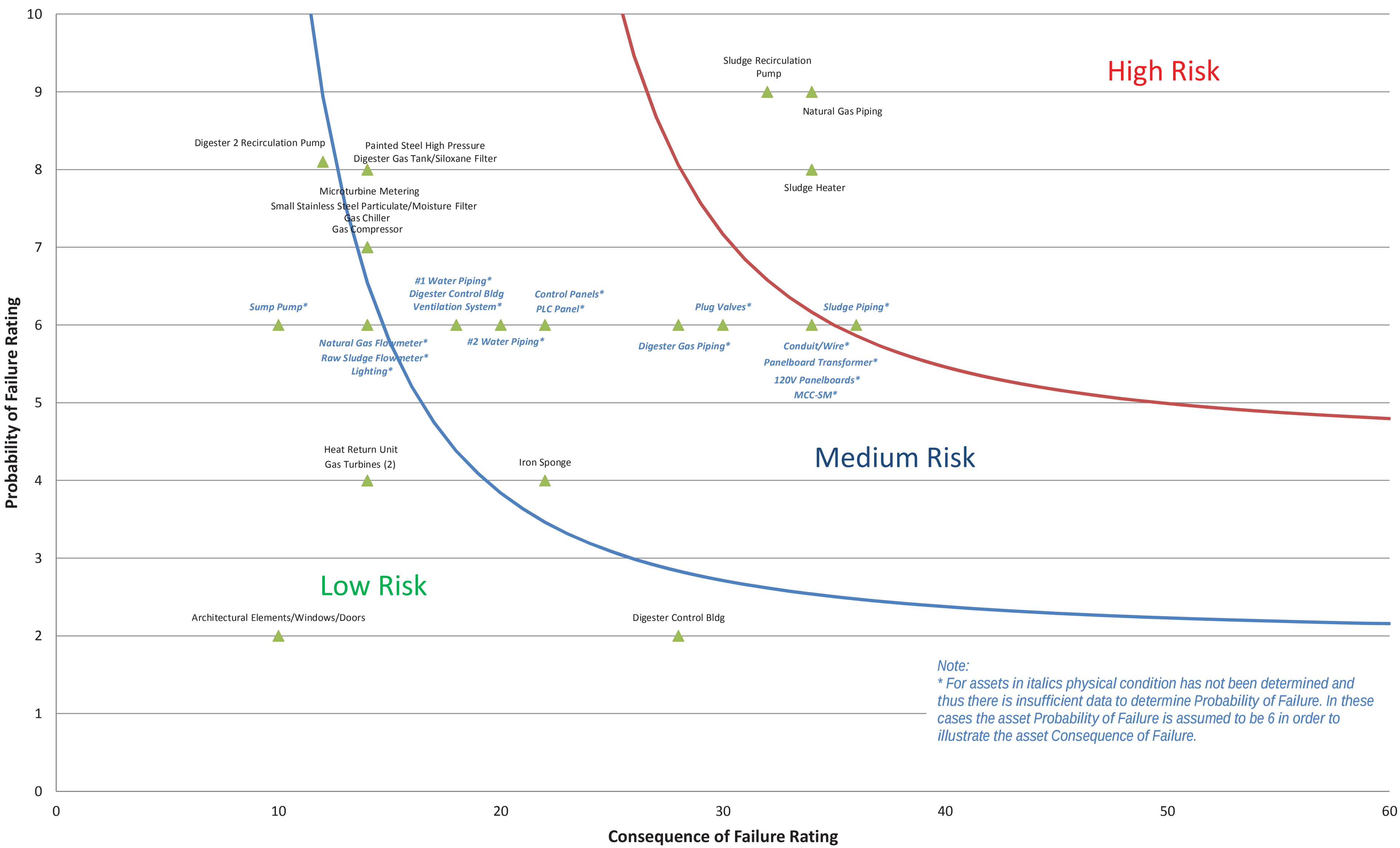
## No. 1 Water System Risk Exposure



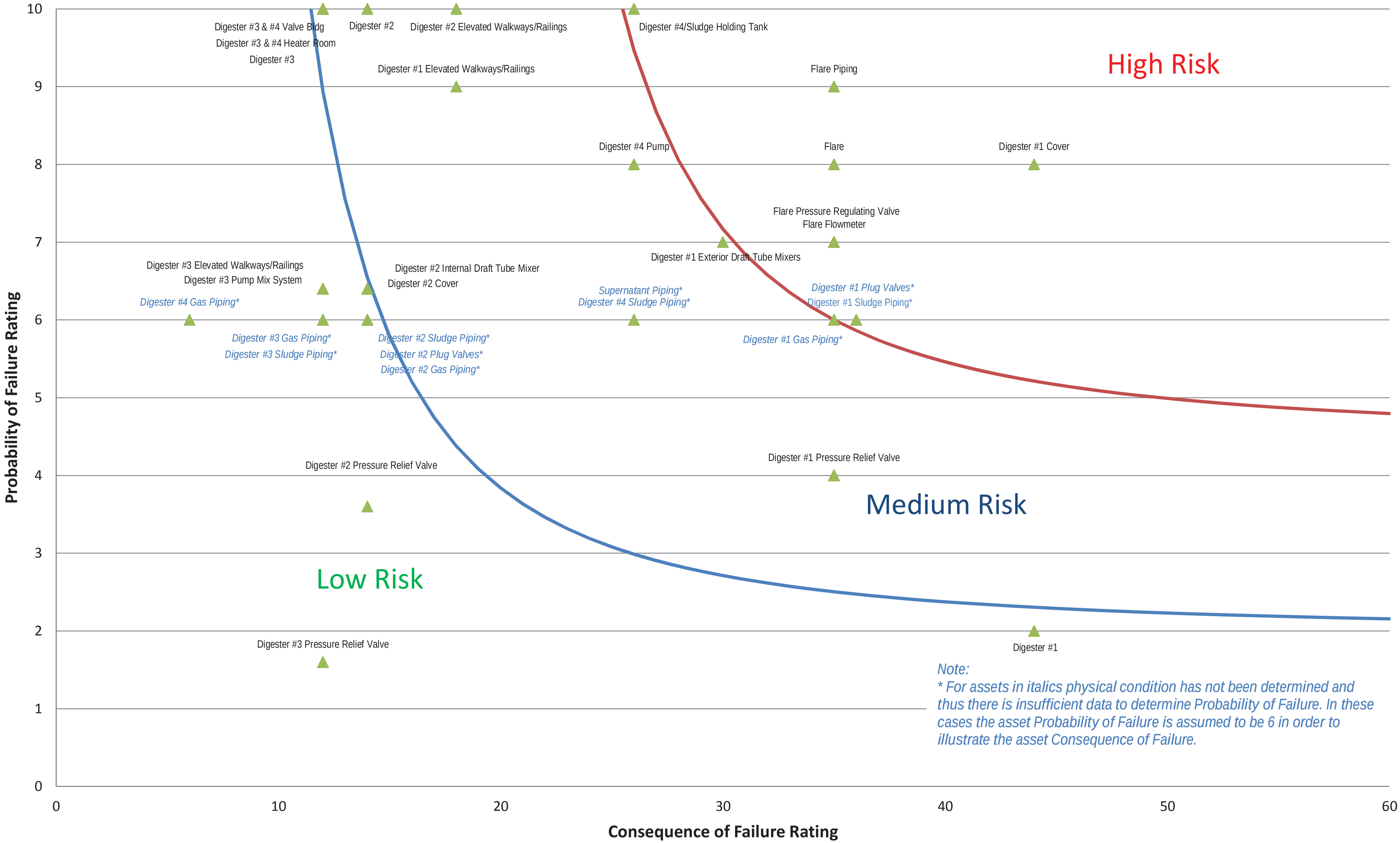

Effluent Building Risk Exposure
Probability of Failure Rating
Consequence of Failure Rating
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
High Risk
Medium Risk
Low Risk
Effluent Pump #3 Piping
Building Heater
Wet Well Sluice Gates
Effluent Pump #1
RO Reject Pipe Into
Effluent Wet Well
Effluent Bldg
Ventilation System
Effluent Pump Piping
Old #3 Water Pumps
Gantry Crane
Chlorine Mixer
Outfall Venturi Flowmeter (Abandoned)
Pressure Indicator Transmitter
Flowmeter
Effluent Pump #1 & #2 Inlet Valves
Effluent Pump #2
Return Effluent Pump*
Old #3 Water Pumps Chlorination Mixer*
#2 Water Piping (Well Water)*
Backup #3 Water System Piping*
Video Camera System*
Effluent Pump Wet Well
Supply Fan*
Outfall Air Release Valve
PLC Panels*
Control Panels*
ATS-ESM*
Effluent Pump #1 & #2
Discharge Valves
Outfall Pipe Exposed*
Natural Gas Utility*
Lighting*
Panelboard Transformer*
120V Panelboard*
#3 Water Pump
Seal Water*
Effluent Wet Well*
Effluent Pump VFDs*
Conduit/Wire*
MCC-ESM*
Architectural Elements/Doors
(2) Sample Pumps
Effluent Pump #3 Valves
Effluent Pump #3 (Wemco)
DeOx Analyzers
Effluent Building
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.


Blower Building Risk Exposure
Probability of Failure Rating
Consequence of Failure Rating
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
High Risk
Medium Risk
Low Risk
Backup Blower #4
Backup Blower #3
Bridge Crane
2 Ton Jib Crane (outside)
Temperature Gauges (2)*
Pressure Gauges (4)
120V Panelboard*
Panelboard Transformer*
Lighting*
Air Flowmeters
Flowmeter on EQ Air
Blower Bldg Ventilation System (2 fans)
Main Switchboard*
Blower Control Panel*
Conduit/Wire*
ATS*
Air Piping Buried*
Blower #1 (EQ Tank)
Blower Intake Duct
Blower #2 (Aeration Tanks)
Blower VFDs
MCC-BC
Air Piping Exposed
Manual Butterfly Valves (4)
MOV Butterfly Valves (4)
Blower Bldg
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.

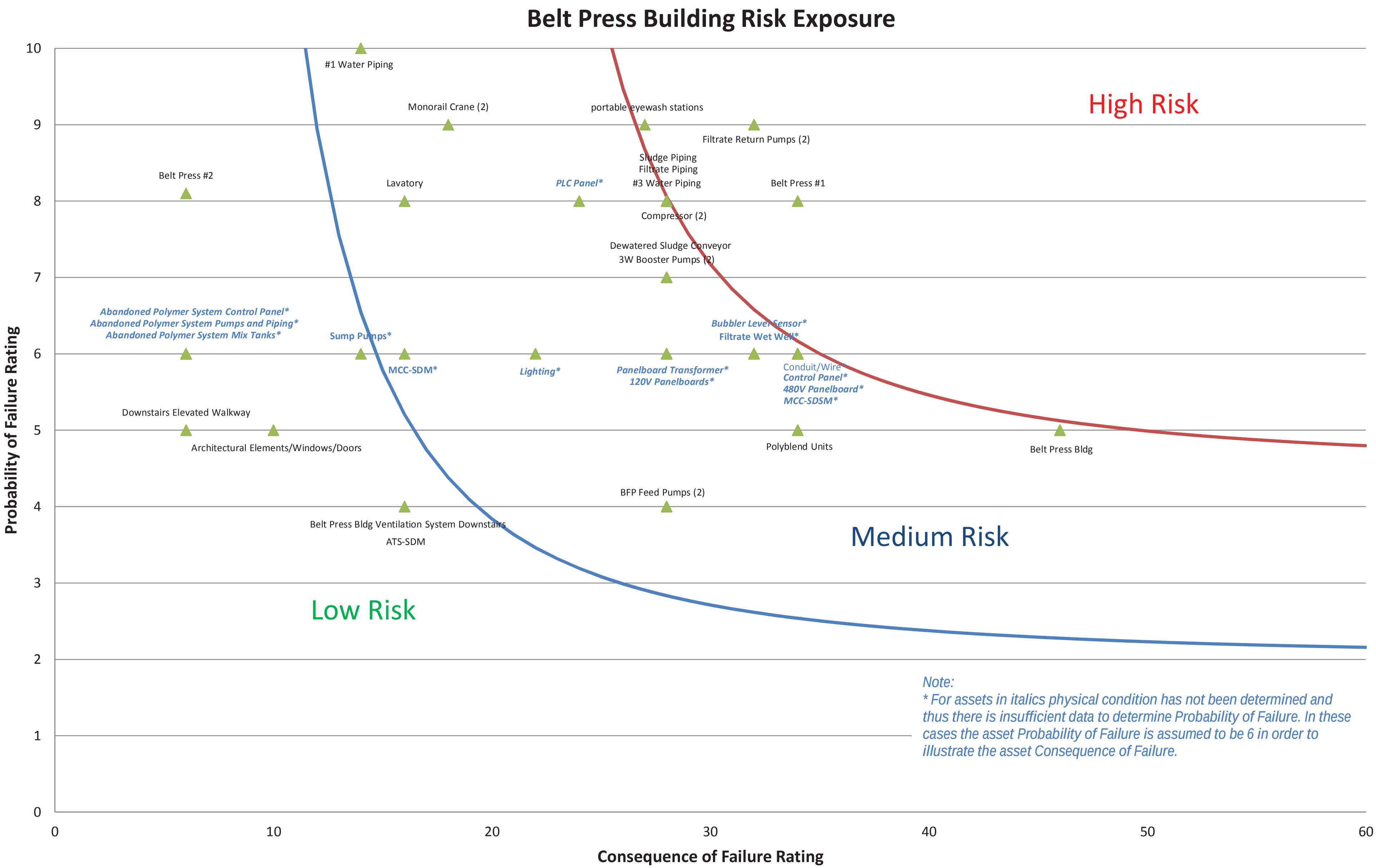
## Digester Control Building Risk Exposure

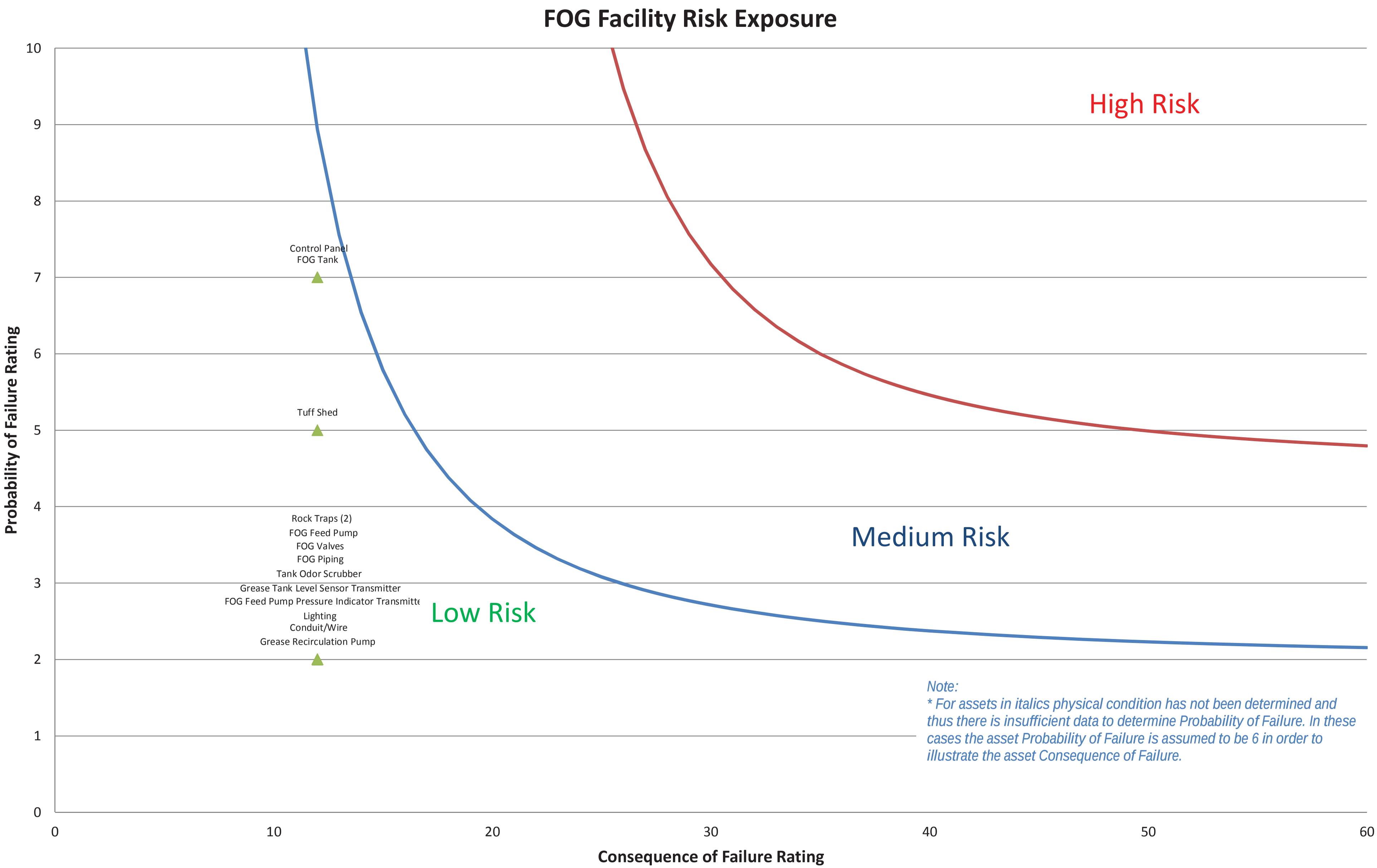


## Digesters Risk Exposure

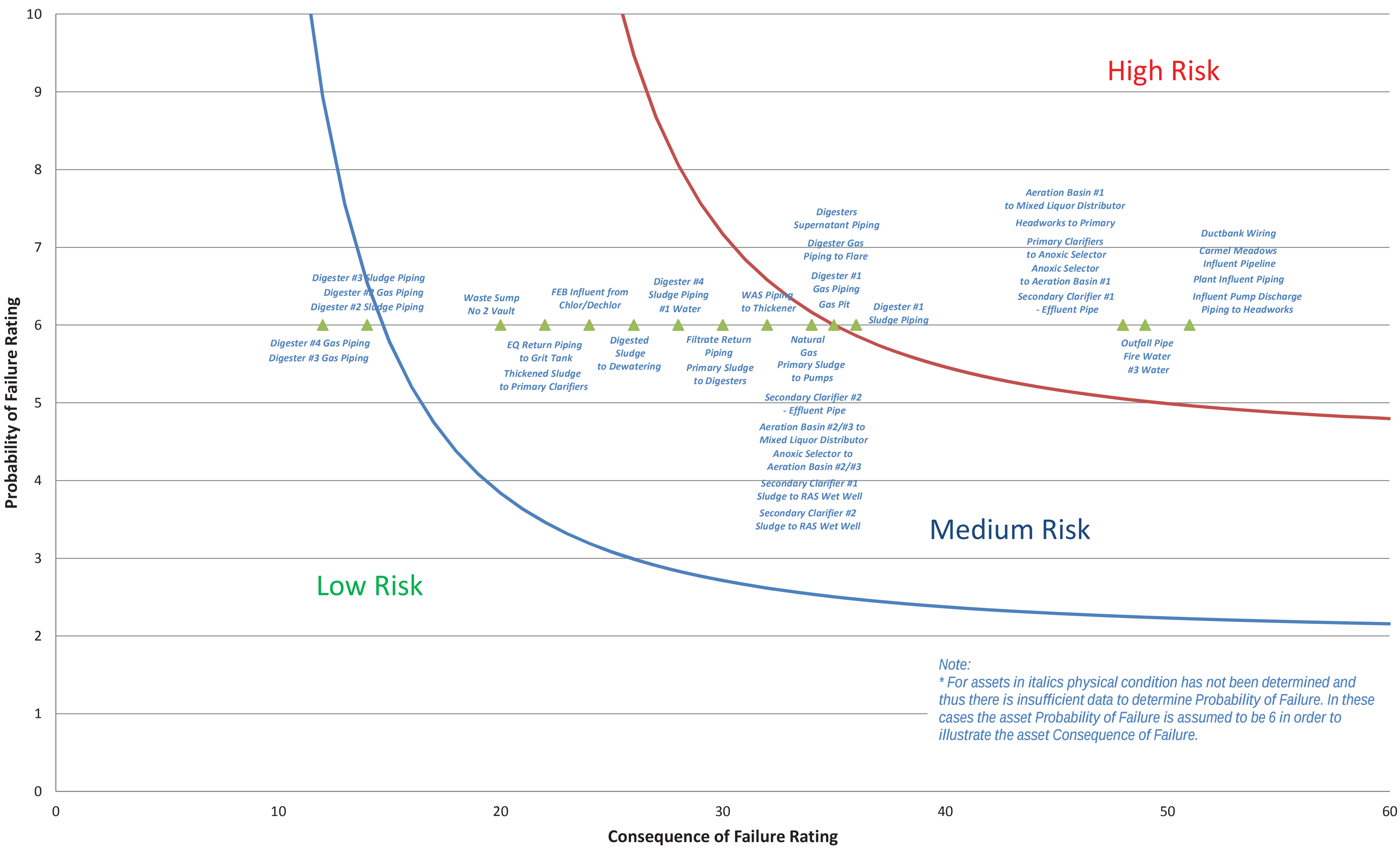



*Note:*
** For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.*


Belt Press Building Risk Exposure
High Risk
Medium Risk
Low Risk
#1 Water Piping
Monorail Crane (2)
portable eyewash stations
Filtrate Return Pumps (2)
Belt Press #2
Lavatory
PLC Panel*
Sludge Piping
Filtrate Piping
#3 Water Piping
Belt Press #1
Compressor (2)
Dewatered Sludge Conveyor
3W Booster Pumps (2)
Abandoned Polymer System Control Panel*
Abandoned Polymer System Pumps and Piping*
Abandoned Polymer System Mix Tanks*
Sump Pumps*
MCC-SDM*
Lighting*
Panelboard Transformer*
120V Panelboards*
Bubbler Level Sensor*
Filtrate Wet Well*
Conduit/Wire*
Control Panel*
480V Panelboard*
MCC-SDSM*
Downstairs Elevated Walkway
Architectural Elements/Windows/Doors
Polyblend Units
Belt Press Bldg
BFP Feed Pumps (2)
Belt Press Bldg Ventilation System Downstairs
ATS-SDM
Probability of Failure Rating
Consequence of Failure Rating
0
1
2
3
4
5
6
7
8
9
10
0
10
20
30
40
50
60
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.


FOG Facility Risk Exposure
Probability of Failure Rating
Consequence of Failure Rating
10
9
8
7
6
5
4
3
2
1
0
0
10
20
30
40
50
60
High Risk
Medium Risk
Low Risk
Control Panel
FOG Tank
Tuff Shed
Rock Traps (2)
FOG Feed Pump
FOG Valves
FOG Piping
Tank Odor Scrubber
Grease Tank Level Sensor Transmitter
FOG Feed Pump Pressure Indicator Transmitte
Lighting
Conduit/Wire
Grease Recirculation Pump
Note:
* For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.

## Yard Piping Risk Exposure




*Note:*
** For assets in italics physical condition has not been determined and thus there is insufficient data to determine Probability of Failure. In these cases the asset Probability of Failure is assumed to be 6 in order to illustrate the asset Consequence of Failure.*

20 December 2012

# Technical Memorandum No. 9

To: Ms. Barbara Buikema and Mr. Jim Pinkevich
Carmel Area Wastewater District

From: Mr. Patrick Treanor, P.E., Kennedy/Jenks Consultants

Reviewed by: Mr. Doug Stewart, P.E., Kennedy/Jenks Consultants

Subject: WWTP Asset Risk Management Strategies
K/J 1268007*01

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This memorandum presents a summary of risk management strategies that may be applied to the assets at the Carmel Area Wastewater District (District/CAWD) wastewater treatment plant (WWTP). These risk management strategies provide a framework and direction to guide the actions to be taken to better manage the risk profile of the assets at the WWTP.

Risk management strategies have been assigned to each asset in the asset registry to serve as a basis for determining budgetary estimates for the capital cost of projects to be included in the 15-year Capital Improvement Plan (CIP). Therefore, the data contained in the asset registry can be used to guide the decision making process for the 15-year CIP projects. The risk management strategies were applied to assets in the asset registry based on the asset business risk exposure (BRE) that was developed and summarized in Technical Memorandum (TM) 8.

## Risk Management Strategies

The risk management strategies presented herein are distinct strategies that can be applied to individual assets based on the particular asset BRE. Table 1 provides an overview of the different asset risk management strategies that were applied to the assets in the asset registry.

### Table 1: Asset Risk Management Strategies

| Capital Improvements Strategies | Maintenance Strategies | Non Asset Strategies |
|---|---|---|
| Plan Rehabilitation/ Replacement (Improve Condition) | Predictive Maintenance (Failure Prediction) and Preventative Maintenance (Maintain Condition) | Take Asset Out of Service |
| Moderate Repair (Improve Condition) | Preventative Maintenance (Maintain Condition) | Strategic Changes to Capacity Requirements or Level of Service (LOS) |
| Add Backup/Redundancy (Improve Reliability) | Corrective Maintenance (Fix it When it Breaks) | |

The following is a brief summary of each of these asset risk management strategies:

## Capital Improvement Risk Management Strategies

Capital improvement strategies would cover most activities which would be included in capital improvements budgets. These strategies encompass constructing new assets to replace assets, repairing existing assets, or purchasing new portable assets to serve as a backup or redundant asset. Capital improvement strategies were assigned to assets with highest Business Risk Exposure (BRE).

- **Plan Rehabilitation/Replacement (Improve Condition):** This strategy encompasses a variety of replacement, rehabilitation or retrofit projects. This strategy is applied to assets in poor condition and in which it would be more desirable to improve the asset condition directly rather than building a backup or redundant asset.

- **Moderate Repair (Improve Condition):** This strategy encompasses asset repairs to improve the condition of the asset without replacing the asset and without major overhaul of the asset. Implementation of this strategy should cost less than rehabilitation/replacement as it should involve a repair of part of the asset (not the entire asset) or it would include minor repairs.

- **Add Backup/Redundancy (Improve Reliability):** This strategy includes purchasing backup equipment to either be installed on a full time basis or to be used as an emergency portable backup that can be installed on short notice in the event of an asset failure. Having backup equipment available can improve the reliability of service delivery by giving operators options and contingencies for maintaining operations under failure conditions.

## Maintenance Risk Management Strategies

Maintenance strategies would cover most activities which would be included in annual maintenance budgets. These strategies set different levels of asset maintenance intensity depending on the BRE of the asset.

- **Predictive Maintenance (Failure Prediction) and Preventative Maintenance (Maintain Condition):** This maintenance strategy includes a high level of proactive condition and performance monitoring, testing, and data gathering, and is reserved for assets which have a high consequence of failure. Assets that fall under this maintenance strategy should undergo much more scrutiny as a part of inspection and maintenance activities. Predictive maintenance is focused on increasing the understanding of the condition of the asset in order to better predict when it will fail. Types of predictive maintenance strategies include: vibration analysis, tactical heat measurements, pump curve testing, monitoring bearing noise levels, oil analysis, etc.

In addition to predictive maintenance this asset strategy also includes preventative maintenance activities that are required to keep the asset in acceptable operating condition. Preventative maintenance is included in this strategy because assets which require predictive maintenance to predict failures also require maintenance to maintain condition.

- **Preventative Maintenance (Maintain Condition):** This maintenance strategy is focused on keeping assets in acceptable operating condition as well as keeping condition data up to date such that if the condition of the asset changes the asset risk management strategy would be reassessed as the BRE changes over time. While gathering condition data is important, the data gathering for this maintenance strategy should be less rigorous than data gathering conducted as part of predictive maintenance.

- **Corrective Maintenance (Fix it When it Breaks):** This strategy is reserved for assets that have low consequence of failure, such that failure of the asset is an acceptable occurrence. Assets with this risk management strategy would not require any predictive maintenance efforts, but would require some routine maintenance.

## Non-Asset Risk Management Strategies

Non-asset risk management strategies take a perspective that looks beyond the asset to strategic level of service and capacity to determine if the same service level can be met with another means than the original asset.

- **Take Asset Out of Service:** For an asset that at one time had a level of service goal or capacity need associated with it, but that prior level of service is no longer needed then that asset may be taken out of service.

- **Strategic Changes to Capacity Requirements or Level of Service (LOS):** For assets that would have a high capital cost to replace or repair it may be less costly to invest in determining if strategic changes to the level of service or capacity could be made. One such example is discussed in TM 4 for the digestion system. In TM 4 an alternative to reduce the digestion system LOS is presented which involves creating an agreement with the local landfill to occasionally accept partially digested dewatered sludge which does not meet Class B requirements. Having the ability to dispose of partially digested dewatered sludge to the landfill changes the level of service and consequences of failure for the digestion system as discussed in TM 4.

## CAWD Asset Risk Management Overview

The BRE of an asset serves as the basis for determining the best risk management strategy. For instance, assets in a "High Risk" category would be managed differently than assets in a "Low Risk" category. In general, risk management strategies were determined by relating BRE to risk management strategies as illustrated in Figure 1. Areas of the BRE graph are delineated with the most likely best management strategy. Four different areas of the graph are shown in Figure 1 as Categories A, B, C & D. As seen in the graph the delineations for the most likely best management strategies overlap and are not firm boundaries. Thus, each asset risk management strategy was assigned specifically for that asset using the delineations in Figure 1 as a guide, but not as a static rule.

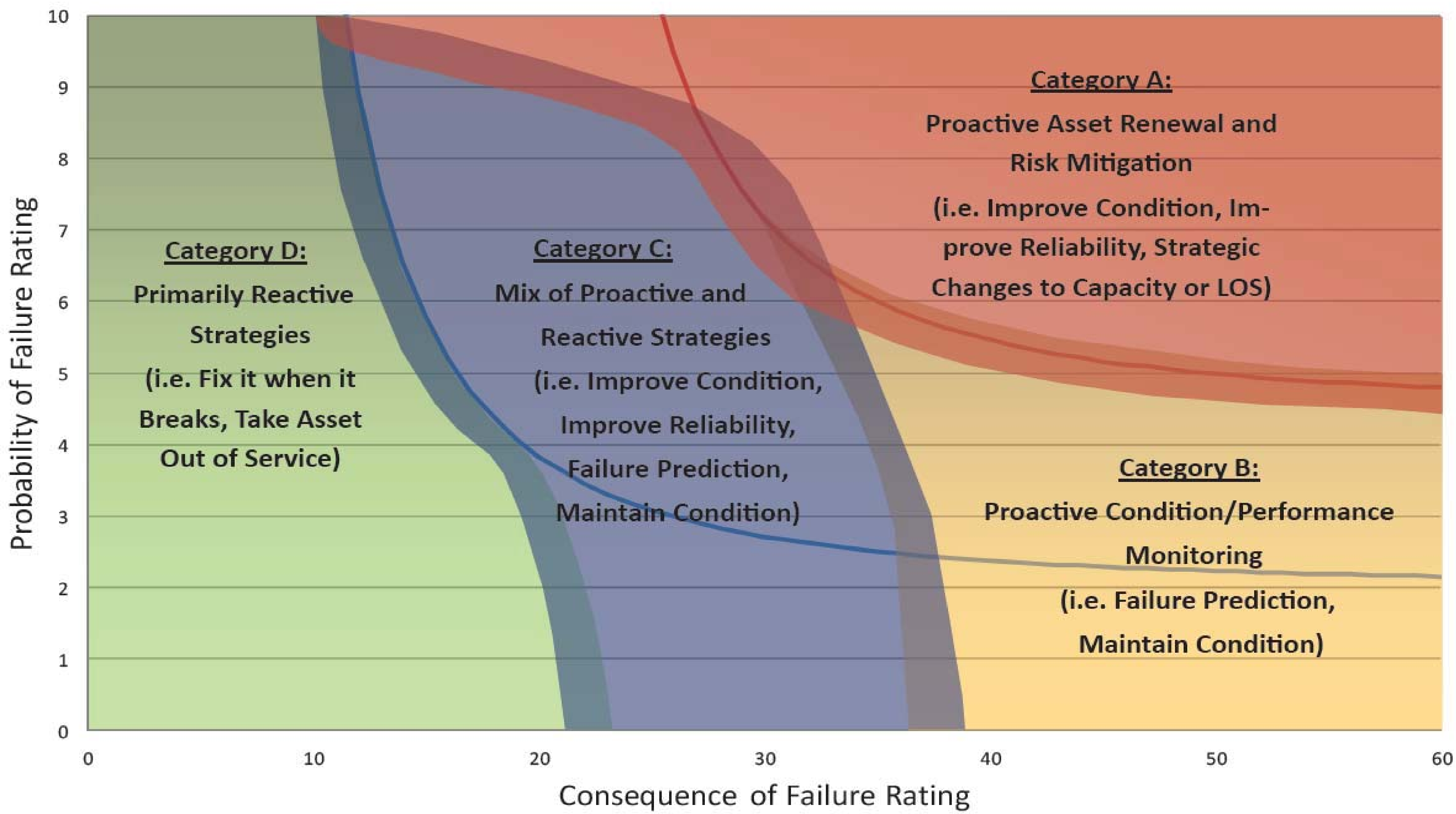


Figure 1: Risk Management Strategies as Related to the BRE Graph

The risk management strategies associated with Categories A, B, C, and D shown in Figure 1 are described below:

- **Category A:** This area of the BRE graph includes all "High Risk" assets as well as assets with "Medium Risk" and high probability of failure (PoF). The risk management strategies assigned for Category A assets were primarily "Capital Improvement Risk Management Strategies" to renew the condition of these assets. The goal of capital improvement risk management for category A assets is to reduce the PoF such that the condition of the asset is acceptable and the asset BRE would then fall into Category B or C. High cost assets with high consequences of Failure (CoF) would be good candidates for investigation into possible strategic changes to capacity and level of service requirements to reduce CoF. By reducing CoF by affecting the level of service requirements the BRE could shift to Category C or D.

- **Category B:** This area of the BRE graph includes assets with high CoF but low PoF, meaning that these assets have untoward consequences of failure yet they are in acceptable condition. Because the condition of these assets is acceptable the focus of risk management would be in making sure the asset condition remains acceptable. Because of the undesirable CoF proactive maintenance and condition monitoring is recommended. Therefore, for assets in Category B the primary risk management strategy assigned was "Predictive Maintenance and Preventative Maintenance".

- **Category C:** This area of the BRE graph includes assets with midrange CoF. The CoF for these assets may or may not be worth risking failure. Therefore, depending on the asset and the projected failure consequences, proactive or reactive strategies could be implemented. Proactive strategies include planning for rehabilitation/replacement/repair, adding backup systems, and predictive maintenance. Reactive strategies include fixing the asset when it breaks, and preventative maintenance. Assets in this category were reviewed by Kennedy/Jenks and a decision was made as to the best management strategy. It is recommended that CAWD staff review the risk management decisions made for these assets to continue to improve the basis for decision making.

- **Category D:** This area of the BRE graph includes assets with low CoF. These are assets that can fail without appreciable consequences. Therefore, the risk management strategies for these assets can be reactive (i.e. fix it when it breaks). In some cases the asset has a low CoF because it is no longer needed to meet LOS requirements. In these cases the asset can be taken out of service.

Figure 2 summarizes the number of assets in the asset registry which were assigned to the various risk management strategies. From the distribution of assets it can be seen that the risk management strategies with the highest occurrence are "Plan Rehabilitation / Replacement", "Predictive Maintenance and Preventative Maintenance", and "Preventative Maintenance".

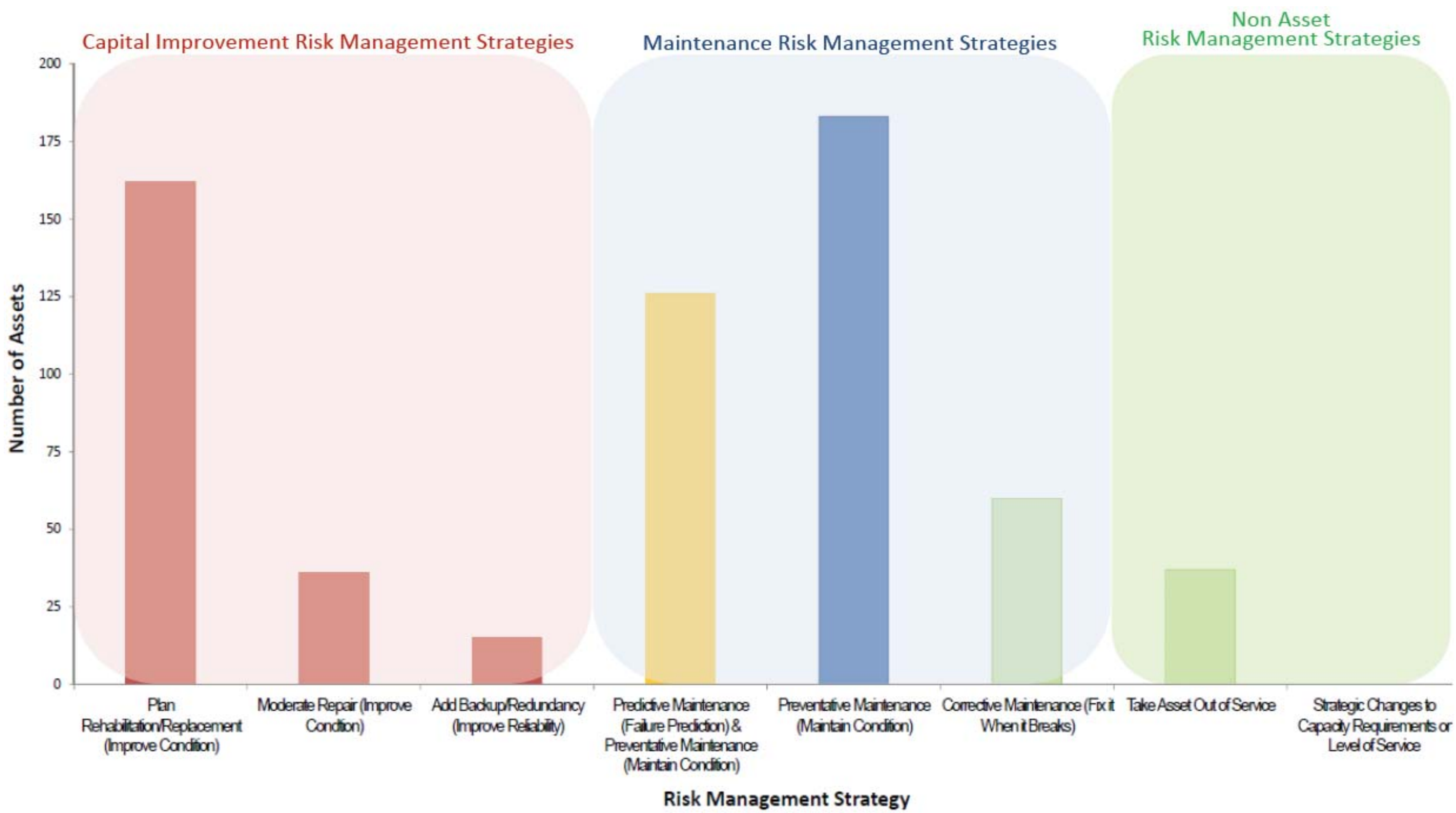


Figure 2: Risk Management Strategies Asset Distribution

## Conclusions and Recommendations

The risk management strategy data developed for the assets and summarized herein is a snapshot in time and is based on data from field observations and consequence of failure predictions using engineering judgment. It is recommended that the risk management strategies developed for the assets in the asset registry be regularly updated by CAWD to keep this information up to date and include new information as it is uncovered. Assets which were not accessible during investigations by Kennedy/Jenks should be inspected (i.e. buried piping, interior of tanks, etc). Many of these assets which were not visible during investigations by Kennedy/Jenks were assigned the risk management strategy “Predictive Maintenance and Preventative Maintenance”. Predictive maintenance activities direct resources to inspecting these assets thoroughly to continue to improve the BRE data to avoid an unforeseen failure of critical assets.

It is recommended that the computer maintenance management system (CMMS) currently being developed by CAWD include the risk management strategy data developed in the asset registry for each of the assets. Having the risk management strategies integrated into CMMS will allow CAWD to generate appropriate work orders. For example, assets that need predictive maintenance would have more extensive work orders versus corrective maintenance assets which would have little to no work orders.

The asset registry contains the risk management data as summarized in this TM. The data developed in the asset registry has assets designated as falling under “Capital Improvement Risk Management Strategies”, “Maintenance Risk Management Strategies” or “Non-Asset Risk Management Strategies”. The assets in the database which have been identified as needing “Capital Improvement Risk Management Strategies” will be a basis for developing the budgets and projects for the 15-year CIP Master Plan.

Kennedy/Jenks Consultants