EAST CAROLINA UNIVERSITY

Health Sciences Campus

HSC Chilled Water System

Utility Condition Assessment

September 16, 2016

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UTILITY CONDITION ASSESSMENT

SECTION 1

OVERVIEW

OVERVIEW

Introduction

Overall, the chilled water generation and distribution systems at the East Carolina University (ECU) Health Sciences Campus (HSC) is in good operating condition. They were originally commissioned for service in 1977 and have since experienced phases of remodel and growth. Most of the equipment has been modified or replaced within the last ten to fifteen years.

The generation system consists of six water-cooled chillers with a maximum cooling capacity of 6,680 tons. Five cooling tower cells generate nearly 7,200 tons of condenser water. Seventeen pumps distribute the chilled water and condenser water within the Central Utility Plant (CUP) and throughout campus via approximately 8,430 linear feet (LF) of pipe installed in the tunnel system and direct-buried. Additional equipment, including water treatment systems, chiller and tower controls, and variable speed drives, support of the primary chilled water generating equipment.

Costs Overview

Current Replacement Value

The current replacement value (CRV) of the chilled water system is approximately $19,182,880. This is an estimate of the cost in current dollars to replace the generation and distribution equipment. It is not a construction estimate or a detailed take-off but rather an estimate of replacement with like equipment. The CUP shell and building equipment and utility tunnel are detailed in their individual reports.

Total Project Costs

The estimated recurring (lifecycle) needs total $5,617,694. Most of these expenditures are to remove and replace the asbestos-cement (transite) piping system from the CUP serving Brody and the surrounding facilities. Additional renewal needs include upgrading the variable speed drives serving the pumps and towers. Nonrecurring project recommendations totaling $24,763,503 primarily concern future capacity concerns, including a recommendation from the RDK Engineers Master Plan to construct a second chiller plant.

Methodology

This document is the result of the assessment of the physical condition and estimated remaining reliable operating life of the chilled water generation and distribution system equipment at ECU-HSC. The estimates for remaining useful life consider safety, reliability, efficiency, and sustainability as the primary operational objectives for capital renewal. These estimates are based on actual equipment age, physical inspections, performance data reviews, personnel interviews, maintenance practices, and operating history.

Visual system assessments and operating records were used as the primary inputs in this nondestructive assessment of the chilled water system. The focus of this report is projected needs of the utility systems over the next ten years. ISES has concluded that estimates extending beyond a ten-year cycle are of questionable value for the purposes of capital investment planning for equipment replacement. The variability of the operating environment, campus load growth, introduction of new and more efficient technologies, and critical or abnormal operating failures precludes any intrinsic value in long-term projections other than for capacity requirements.

The goal was to produce a campuswide report with lifecycle, project and lifecycle renewal recommendations incorporated by ISES engineers into the individual utility system assets in the Asset Management System (AMS). The assessments and estimates are based solely on visual, nondestructive observations, review of existing drawings, previously prepared engineering reports, such as the RDK Engineers Campus Master Plan, interviews with key staff and specific external support companies, such as water treatment representatives, and any available maintenance records and reports.

This methodology for assessing the physical condition of the targeted utility assets was applied to the systems and equipment to arrive at recommendations for asset allocation for critical needs with regard to Deferred Renewal, Corrective Action, and Plant Adaption.

Approach to Lifecycle Calculation

Operating data was reviewed for abnormal excursions, forced outages, and peak load data. This data was evaluated for impact on the equipment's estimated useful life. Information related to forced equipment outages, equipment reliability, and operating performance was reviewed to determine trends that might affect future safety, reliability, and efficiency.

The realization of expected equipment useful life preserves the original capital investment strategy, while accelerated depreciation results in premature expenditure of resources. These observations point out the importance of providing adequate but not excessive resources for utility system asset preservation. Table 1 shows expected useful, reliable equipment life of typical chilled water equipment.

Table 1: Average Equipment Expected Useful Life

COMPONENT	TYPE	USEFUL LIFE (YEARS)
Chiller	Water-cooled, Centrifugal	30
Chiller	Absorption	30
Pump	Horizontal, Split-case, Centrifugal	25
Heat Exchanger	Plate and Frame	40
Thermal Energy Storage	Tank	50
Thermal Energy Storage	Ice Harvester	25
Cooling Tower	Upward draft, Metal Frame	23
Motor Starter	Combination	25
ACM/Transite Water Pipe	Buried Water Line	75
HDPE Pipe	Buried Water Line	50
Steel Water Line	Tunnel Water Line	50

Source Data: ASHRAE, BOMA, Hartford Ins. Co., ISES Database

ISES emphasizes that expected useful life values are averaged forecasts based on equipment that is properly maintained and operated without frequent and/or severe operating excursions. Chronological equipment age is not the primary determinant of service life. In many instances, there is ample evidence of equipment operating well beyond predicted useful life values. This is why it is important to modify these values with actual equipment condition.

In addition, equipment reaching the predicted endpoint of expected useful life does not necessarily cease to function. What does occur is a downward trend toward loss of service reliability and a potential increase in forced outages and maintenance cost requirements.

It is important to note that utility infrastructure assets normally encompass more than just a single piece of equipment and will, in most situations, represent a section or group of materials, i.e. linear footage of installed piping systems or electrical wiring. The majority of these systems will continue to operate reliably and safely beyond the ten-year planning horizon of this assessment. However, beyond the next ten years, it will be necessary to reinspect the systems to ensure that they continue to operate reliably. The items detailed in this report are areas and equipment that are deemed to be at risk for potential failure or deterioration within the next ten years.

For direct-buried piping systems, the established projection of 35 years is also a compilation of published data and direct ISES experience with clients that have installed direct-buried pipe systems. One publication is entitled *Field Investigation of Underground Heat Distribution Systems,* published by the National Academy of Sciences, National Research Council, Washington, D.C. for Task Group 54 of the Federal Construction Agency. This provides a detailed account of the findings of a survey conducted by a Task Force of 12 engineers, each with broad experience in underground piping systems. This Task Force conducted surveys of 41 installations at government facilities and at private steam production facilities in 16 states and the District of Columbia. They evaluated 131 separate system classification types.

A brief summary of the results from this survey showed that 62 percent of the systems had wet insulation; 46 percent showed insulation deterioration; and 75 percent showed wet and/or deteriorated insulation. Wet and/or deteriorated insulation leads to heat/cooling losses greater than design values.

The primary causes of this deterioration include:

- External casing corrosion
- High water table
- Electrolysis (galvanic activity and stray currents in concert with an electrolyte)
- High acid or alkaline soil condition
- Low soil resistivity
- Poor installation
- Improperly installed joints (bad welds, leaking casing joints)
- Pipe defects (pinhole leaks, nonuniform pipe thickness)
- Poor water treatment (internal scale and corrosion)
- Pipe stress (inadequate thrust block settling, heavy surface vehicular traffic, inadequate pipe anchoring)

The consequences of this accelerated deterioration include:

- Premature lifecycle replacement
- Increased energy use and cost
- Loss of usable capacity
- Potential danger to students, faculty and staff

External corrosion was found to be a frequent cause of leakage and was primarily due to too thin or inadequate external coatings. It is very rare for an installation contractor to conduct soil surveys to determine soil resistivity or groundwater elevation and water percolation tests prior to pipe system installation. Whenever metal casings other than cast-iron are used, soil resistivity should be measured to determine the need for cathodic protection. Values less than 2,000 ohms per cubic centimeter require a cathodic protective system. System installations where values of soil resistance are between 2,000 and 10,000 ohms should investigate the application of cathodic protection.

Effects of Maintenance and Operational Practices

The skill and ability of the operating staff can have a significant impact on overall equipment useful life. Accelerated start-ups, emergency shutdowns, overload excursions, air leakage, excessive water leaks, and adherence to balance-of-plant maintenance requirements are critical to the safety, reliability, and efficiency of plant equipment. In addition, proper diagnostic skills can often avoid premature outages or result in the correct decision to remove equipment from service to avoid catastrophic damage.

One method of providing consistency in methods of system/equipment operation is the implementation of Standard Operating Procedures (SOPs). These provide a reference guide for the operating staff for most of the expected operating conditions. They cannot, however, provide 100 percent guidance for all possible events. This is why operator training in the fundamentals of plant operation is so critical. The implementation of SOPs also provides a method of reminding operators about system equipment requirements in plants where there are few, if any, abnormal operating excursions. In this type of operation, skills that have not been exercised recently become difficult to recall under the pressure of rapidly developing events.

The trend in recent years toward planned obsolescence by manufacturers of certain plant systems and equipment alters the strategy for capital replacement as some systems become obsolete. Although the equipment may have many remaining years of safe, reliable, and efficient operation, manufacturers are phasing systems out and not supporting the equipment past a specific phase-out date. For example, digital electronic control systems have an estimated operating life of fifteen years, not because of failure to function but because of the planned lifecycle established by the OEM. One reason for this situation is technological advancements and product development. This also results in a requirement for continuous operator training as equipment is replaced. It is not unusual for newer equipment to have better efficiency and lower operating costs. However, this requires careful analysis by owners to actualize potential savings.

For chilled water generation equipment and distribution piping systems, water treatment is the most salient issue in considering estimated useful life. Internal and external equipment piping scale causes rapid performance deterioration, and corrosion can severely reduce the operating life of systems and equipment. In all cases, proper water treatment normally extends generating equipment useful life as well as balance-of-plant equipment life. We evaluated historical data as well as the current water treatment program for application and execution.

The open loop system currently uses a MIOX Mixed Oxidants SAL-80 delivery system that utilizes a membrane-less electrolytic cell that produces a stand-alone biocide to eliminate microbials and bio-organics from the water system. This service is different from traditional treatment programs that utilize alternating shot dosages of agents such as isothiazolin and bromine. The accumulation of bio-organics, if left untreated, can lead to the formation of Legionella within the cooling towers and condenser water.

The closed loop system uses a two-chemical process of proprietary design for the control of scale, corrosion, and microbial growth within the campus piping system and chillers. The first chemical (CT-402N) is a combination of sodium hydroxide and sodium nitrite with additional organic and inorganic inhibitors. The second chemical (CL-402S) is presumed to be a scale and corrosion inhibitor.

The current system has been successful, as interviews indicated that there is very limited corrosion within the piping system and very minimal scale within the chiller tubes. The chemical injection is being performed by in-house personnel, which is not cost-effective to an organization that is currently limited in available maintenance personnel. It is recommended that the institution start to research additional water treatment options that could include retaining the services of outside contractors who would be directly responsible for the water treatment programs. It would be cost-effective to create a program that includes the main campus water treatment services as well.

UTILITY CONDITION ASSESSMENT

SECTION 2

SYSTEM FINDINGS

SYSTEM FINDINGS

Chillers

Six water-cooled chillers generate a total of 6,680 tons of chilled water for use in approximately fourteen buildings throughout campus. The following table details their type, capacity, and installation year.

Table 2: Chillers Installed at CUP

IDENTIFIER	TYPE	MANUFACTURER	CAPACITY (TONS)	INSTALL DATE
Chiller CH-2	Water-cooled, Centrifugal, Oil-less	Smardt, TurboCor	910	2011
Chiller CH-3	Water-cooled, Centrifugal	Trane, Centravac	910	2003
Chiller CH-4	Water-cooled, Centrifugal	Trane, Centravac	1,400	2013
Chiller CH-5	Water-cooled, Centrifugal	Trane, Centravac	1,400	2013
Chiller CH-6	Water-cooled, Centrifugal	Trane, Centravac	1,060	2005
Chiller CH-7	Water-cooled, Centrifugal	Trane, Centravac	1,000	2005
		Total Capacity:	**6,680**	

All six of the chillers were in proper operating condition at the time of inspection. It was reported that there have been very minimal disruptions of service due to forced outages and that all annual and routine maintenance is being performed. There are no recommendations for the removal and replacement of this equipment at this time.

Cooling Towers

The condenser water is generated by five exterior cooling tower cells. The following table details their type, capacity, and installation year.

Table 3: Cooling Towers Installed at CUP

IDENTIFIER	TYPE	MANUFACTURER	CAPACITY (TONS)	INSTALL DATE
Cooling Tower Cell - 1	Upward Draft	Evapco	1,200	2015
Cooling Tower Cell - 2	Upward Draft	Evapco	1,200	2015
Cooling Tower Cell - 3	Upward Draft	Evapco	1,600	2015
Cooling Tower Cell - 5	Upward Draft, Stainless Steel	Evapco	1,600	2007
Cooling Tower Cell - 6	Upward Draft, Stainless Steel	Evapco	1,600	2007
		Total Capacity:	**7,200**	

The new cooling towers (1, 2 and 3) installed in 2015 are in excellent condition. Each tower fan is equipped with a 150 horsepower (hp) motor and is estimated to be rated for 1,600 tons capacity. With continued diligent maintenance and water treatment, this equipment will remain serviceable beyond the next ten years. The two older towers (5 and 6) are in proper working condition, and very limited scale and corrosion was identified. However, they are undersized. The condenser water common header is almost at maximum available connection points, and there is very limited space for the installation of additional towers at the CUP. To provide a level of redundancy to the condenser water system, it is recommended that towers 5 and 6 be removed and replaced with larger capacity units.

In the "turndown" periods of the year, specifically the cooler months, there is very limited demand for chilled water on campus. However, it is still necessary for one of the tower cells to generate condenser water. The existing towers are not designed to be operated in these turndown months and therefore waste energy while generating such a small amount of condenser water. It is recommended that a smaller cooling tower with variable flow capabilities be installed that can operate in the cooler months at a lower cost than the utility grade towers.

Balance of Plant Chilled Water Equipment

The additional equipment serving the chilled water and condenser water systems includes compressed air equipment, pumps, motor starters, and variable speed drives (VSDs). Seventeen pumps of various sizes were inspected that serve the chilled and condenser water systems. No glaring issues such as unnatural vibration, corrosion or scale accumulation, or insulation damage were observed during the inspection. With continued maintenance, they will remain reliable beyond the scope of this report.

The VSDs connected to the pumps, cooling towers fans, and additional plant equipment are all in proper working condition, and many were installed within the last five years. Most will remain reliable beyond the scope of this assessment. It is recommended that VSD-CWP1, VSD-CHWP4, VSD-CHWP5, VSD-SCHP-2, and VSD-SCHP-3, as they are near the end of their reliable service life.

The chillers are equipped with 5 kV motor starter assemblies and control systems that are currently in good condition. There are no recommendations for this equipment.

The air compressor, air dryer, and associated compressed air storage tank have been included in this assessment and are in excellent condition. There are no recommendations for this equipment.

Chilled Water Distribution

The chilled water distribution system at HSC is primarily installed as two service feeds or loops that consist of approximately 8,430 LF of pipe. The first loop is identified primarily as the Brody Loop, and the second is identified as the Tunnel loop. The following table is an estimate of the pipe that serves the Brody loop:

Table 4: Distribution Pipe to Brody Loop

MATERIALS	LENGTH (LF)	ESTIMATED INSTALL DATE	IDENTIFIER
TRANSITE - 3 INCH	50	1977	CWS - BRODY-MRI
TRANSITE - 3 INCH	50	1977	CWR - BRODY-MRI
TRANSITE - 4 INCH	100	1977	CWS - CUP-BRODY
TRANSITE - 4 INCH	100	1977	CWR - CUP-BRODY
TRANSITE - 6 INCH	140	1977	CWS - BRODY-WARREN
TRANSITE - 6 INCH	140	1977	CWR - BRODY-WARREN
TRANSITE - 10 INCH	480	1980	CWS - CUP-BIOTECH
TRANSITE - 10 INCH	480	1980	CWR - CUP-BIOTECH
TRANSITE - 14 INCH	1150	1977	CWS - CUP-BRODY
TRANSITE - 14 INCH	1150	1977	CWR - CUP-BRODY
TRANSITE - 18 INCH	80	1977	CWS - CUP-BRODY
TRANSITE - 18 INCH	80	1977	CWR - CUP-BRODY
Total Length:	**4,000**		

The direct-buried piping in this loop provides chilled water to Brody, MRI, Warren Life Sciences, and the Biotechnology Building. This system is constructed of asbestos-cement pipe commonly referred to as transite that is nearing 50 years of continuous service. Lifecycle replacement of the piping feeds listed above is recommended. A mark-up has been applied for the removal of the asbestos-containing material, and all new construction should be in accordance with current campus standards.

The following table details the distribution piping identified within the Tunnel loop:

Table 5: Distribution Piping to Tunnel Loop

MATERIALS	LENGTH (LF)	ESTIMATED INSTALL DATE	IDENTIFIER
SCHEDULE 40 STEEL PIPE - 24 INCH	350	2007	CWS - ORIG. TUNNEL
SCHEDULE 40 STEEL PIPE - 24 INCH	350	2007	CWR - ORIG. TUNNEL
SCHEDULE 40 STEEL PIPE - 24 INCH	530	2013	CWS - NEW TUNNEL
SCHEDULE 40 STEEL PIPE - 24 INCH	530	2013	CWR - NEW TUNNEL
PLASTIC HDPE - 12 INCH	50	2007	CWS - HS LIB.
PLASTIC HDPE - 12 INCH	50	2007	CWR - HS LIB.
PLASTIC HDPE - 12 INCH	240	2009	CWS - HEART INST.
PLASTIC HDPE - 12 INCH	240	2009	CWR - HEART INST.
PLASTIC HDPE - 12 INCH	540	2011	CWS - FAM. MED.
PLASTIC HDPE - 12 INCH	540	2011	CWR - FAM. MED.

MATERIALS	LENGTH (LF)	ESTIMATED INSTALL DATE	IDENTIFIER
PLASTIC HDPE - 12 INCH	505	2012	CWS - DENT. MED.
PLASTIC HDPE - 12 INCH	505	2012	CWR - DENT. MED.
Total Length:	**4,430**		

Piping in this loop provides chilled water to the Tunnel, Health Sciences, Heart Institute, Family Medicine, and Dental School. The pipe in the tunnel is seamless, welded schedule 40 carbon-steel and is insulated with mineral wool and wrapped with textile base tape or covering. This piping is in good condition, and there is very limited insulation and wrapping damage. No upgrade is deemed necessary.

In the tunnel system is support equipment for the chilled water piping systems. This includes stanchions, pipe saddles, pipe anchors, and expansion joints. No glaring deficiencies were observed, short of relocating some of the pipe saddles that have shifted over time. Overall, this support equipment is in excellent condition and will remain reliable beyond the next ten years.

The remainder of the pipe in this loop is direct-buried and constructed of high-density polyethylene (HDPE) material. The vast majority of this distribution loop was installed within the last ten years and is in excellent condition. There are no recommendations for these branch feeds at this time.

Included in the distribution system are the unitary isolation valve associated with the chilled water supply and return systems. Most of the valves inspected had no physical deterioration, such as corrosion or scale accumulation. However, there is currently no standardized valve exercise program in place to ensure the reliable operation of this equipment. It is recommended that such a program be developed and implemented. It is also recommended that twenty valves of various sizes be replaced within the next ten years. Most of the valves that will need replacement are presumed to be affiliated with the Brody loop. No specific valves were identified, as this recommendation is considered a placeholder for future capital planning expenditures.

Miscellaneous

Significant resources have been expended to extend the current distribution system throughout campus. Although a capacity study was not part of the scope of this assessment, it is our opinion that there will be a lack of available capacity in the future as the campus grows. Institutional competition requires that universities must continually offer a varying array of course curriculums to attract students. This kind of growth is vital to the continuing success of any institution. For ECU-HSC to continue to be a leader in its disciplinary fields, additional chilled water capacity is needed. In a separate campuswide chilled water system capacity study, RDK Engineers recommended the construction of a second chilled water plant. ISES is in agreement that this is the best course of expansion for future growth. The current CUP has a very limited footprint available for expansion, and it is highly unlikely that the original facility design was engineered for vertical expansion.

SECTION 3

CONDITION ASSESSMENT DEFINITIONS

CONDITION ASSESSMENT DEFINITIONS

The following information is a clarification of the Asset Report using example definitions.

Material and Labor Cost Factors and Additional Markups

The database contains an R. S. Means City Cost Index for material and labor cost factors to adjust the project costs from the national averages to reflect conditions in Greenville. The percentage adjustment of the national average is shown below. Typical general contractor fees (which could include profit, overhead, bonds, and insurance) and professional fees (architect or engineer design fees and in-house design costs) are also included. However, most of the project costs were provided by University personnel, so no mark-ups have been applied.

GLOBAL MARKUP	%
Local Labor Index	51.3
Local Materials Index	100.7
General Contractor Markup	20.0
Professional Fees	16.0

Recurring and Nonrecurring Renewal Costs

Renewal costs are divided into two main categories – recurring and nonrecurring. Recurring costs are cyclical and consist primarily of major repairs to or replacement/rebuilding of systems and components. The tool for projecting the recurring renewal costs is the Lifecycle Component Inventory, which is explained in detail below. Nonrecurring costs typically consist of modifications or repairs necessary to comply with code requirements or to address isolated, nonrecurring deficiencies that could negatively affect the systems and components. For these nonrecurring costs, projects have been developed and include estimated material and labor costs.

Recurring Costs

Asset Component Inventory and Cost Projections

The Asset Component Inventory is a list of major systems and components and is based on industry standard lifecycle expectancies. Each indicated component has the following associated information:

CATEGORY	DEFINITION
Uniformat Code	The standard Uniformat Code that applies to the component
Component Description	This line item describes the individual component
Identifier	Unique identifying information entered for a component as necessary
Quantity	The quantity of the listed component
Units	The unit of measure associated with the quantity
Unit Cost	The cost to replace each individual component unit (this cost is in today's dollars)
Complexity Adjustment	A factor utilize to adjust component replacement costs accordingly when it is anticipated that the actual cost will deviate from the average for that component
Total Cost	Unit cost multiplied by quantity, in today's dollars. Note that this is a one-time renewal/replacement cost
Install Date	Year that the component was or is estimated to have been installed. When this data is not available, it defaults to the year the asset was constructed
Life Expectancy	Average life expectancy for each individual component
Life Expectancy Adjustment	Utilized to adjust the first lifecycle of the component and to express when the next replacement should occur

The component listing forms the basis of the Recurring Component Renewal Schedule, which provides a year-by-year list of projected recurring renewal costs over the next ten years. Each individual component is assigned a replacement year based on lifecycles, and the costs for each item are in future year dollars. For items that are already past the end of their lifecycle, the replacement year is shown as Deferred Renewal.

Recurring Cost Classifications

- Deferred Renewal
  Recurring repairs, generated by the Lifecycle Component Inventory, that are past due for completion but have not yet been accomplished as part of normal maintenance or capital repair efforts. Further deferral of such renewal could impair the proper functioning of the system. Costs estimated for Deferred Renewal should include compliance with applicable codes, even if such compliance requires expenditures beyond those essential to effect the needed repairs.

- Recurring Component Replacement
  Recurring renewal efforts, generated by the Lifecycle Component Inventory, that will be due within

the scope of the assessment. These costs represent regular or normal facility maintenance, repair, or renovation that should be planned in the near future.

Nonrecurring Costs

As previously mentioned, modifications or repairs necessary to comply with code requirements and those that address isolated, nonrecurring deficiencies that could negatively affect the systems and components are not included in the Lifecycle Component Inventory. For each such deficiency, a project with an estimated cost to rectify said deficiency is recommended. These projects each have a unique number and are categorized by system type, priority, and classification, which are defined below. The costs in these projects are also indexed to local conditions and markups applied as the situation dictates.

Project Number

Each project has a unique number consisting of three elements, the asset identification number, system code, and a sequential number assigned by the FCA software. For example, the fourth electrical project identified for asset 0001 would have a project number of 0001EL04:

Example: Project Number 0001EL04		
0001	-	Asset Identification Number
EL	-	System Code (EL represents Electrical)
04	-	The next sequential number for an Electrical project

Project Classification

- Plant Adaption
  Nonrecurring expenditures required to adapt the physical plant to the evolving needs of the institution and to changing codes or standards. These are expenditures beyond normal maintenance. Examples include compliance with changing codes and improvements occasioned by the adoption of modern technology (e.g., the use of personal computer networks).

- Corrective Action
  Nonrecurring expenditures for repairs needed to correct random and unpredictable deficiencies. Such projects are not related to aligning a building with codes or standards. Deficiencies classified as Corrective Action could have an effect on utility safety, or usability.

Priority Class

- Immediate

  Projects in this category require immediate action to:

  a. correct a cited safety hazard
  b. stop accelerated deterioration
  c. and/or return a facility to normal operation

- Critical

  Projects in this category include actions that must be addressed in the short-term:

  a. repairs to prevent further deterioration
  b. improvements to facilities associated with critical accessibility needs
  c. potential safety hazards

- Noncritical

  Projects in this category include:

  a. improvements to facilities associated with noncritical accessibility needs
  b. actions to bring a facility into compliance with current building codes
  c. actions to improve the usability of a facility following an occupancy or use change

Category Code

CATEGORY CODE*	SYSTEM DESCRIPTION
EL1A – EL8A	ELECTRICAL
HV1A – HV8B	HVAC
PL1A – PL5A	PLUMBING

**Refer to the Category Code Report starting on the following page.*

Example: Category Code = EL5A	
EL	System Description
5	Component Description
A	Element Description

Priority Sequence

A Priority Sequence number is automatically assigned to each project to rank the projects in order of relative criticality and show the recommended execution order. This number is calculated based on the Priority Class and identified system of each project.

Example:			
Priority Class	**Category Code**	**Project Number**	**Priority Sequence**
1	HV2C	0001HV04	01
2	PL1D	0001PL02	02
2	EL4C	0001EL03	03

CATEGORY CODE REPORT

ELECTRICAL			
CODE	COMPONENT DESCRIPTION	ELEMENT DESCRIPTION	DEFINITION
EL1A	Incoming Service	Transformer	Main building service transformer.
EL1B	Incoming Service	Disconnects	Main building disconnect and switchgear.
EL1C	Incoming Service	Feeders	Incoming service feeders. Complete incoming service upgrades, including transformers, feeders, and main distribution panels are catalogued here.
EL1D	Incoming Service	Metering	Installation of meters to record consumption and/or demand.
EL2A	Main Distribution Panels	Condition Upgrade	Main distribution upgrade due to deficiencies in condition.
EL2B	Main Distribution Panels	Capacity Upgrade	Main distribution upgrades due to inadequate capacity.
EL3A	Secondary Distribution	Step-Down Transformers	Secondary distribution step-down and isolation transformers.
EL3B	Secondary Distribution	Distribution Network	Includes conduit, conductors, sub-distribution panels, switches, outlets, etc. Complete interior rewiring of a facility is catalogued here.
EL3C	Secondary Distribution	Motor Controllers	Mechanical equipment motor starters and control centers.
EL4A	Devices and Fixtures	Exterior Lighting	Exterior building lighting fixtures, including supply conductors and conduit.
EL4B	Devices and Fixtures	Interior Lighting	Interior lighting fixtures (also system wide emergency lighting), including supply conductors and conduits.
EL4C	Devices and Fixtures	Lighting Controllers	Motion sensors, photocell controllers, lighting contactors, etc.
EL4D	Devices and Fixtures	GFCI Protection	Ground fault protection, including GFCI receptacles and breakers.
EL4E	Devices and Fixtures	Lightning Protection	Lightning arrestation systems including air terminals and grounding conductors.
EL5A	Emergency Power System	Generation/ Distribution	Includes generators, central battery banks, transfer switches, emergency power grid, etc.
EL6A	Systems	UPS/DC Power Supply	Uninterruptible power supply systems and DC motor-generator sets and distribution systems.
EL7A	Infrastructure	Above Ground Transmission	Includes poles, towers, conductors, insulators, fuses, disconnects, etc.
EL7B	Infrastructure	Underground Transmission	Includes direct-buried feeders, duct banks, conduit, manholes, feeders, switches, disconnects, etc.
EL7C	Infrastructure	Substations	Includes incoming feeders, breakers, buses, switchgear, meters, CTs, PTs, battery systems, capacitor banks, and all associated auxiliary equipment.
EL7D	Infrastructure	Distribution Switchgear	Stand-alone sectionalizing switches, distribution switchboards, etc.
EL7F	Infrastructure	Area and Street Lighting	Area and street lighting systems, including stanchions, fixtures, feeders, etc.
EL8A	General	Other	Electrical system components not catalogued elsewhere.

HVAC			
CODE	COMPONENT DESCRIPTION	ELEMENT DESCRIPTION	DEFINITION
HV1A	Heating	Boilers/Stacks/ Controls	Boilers for heating purposes, including their related stacks, flues, and controls.
HV1B	Heating	Radiators/ Convectors	Including cast-iron radiators, fin tube radiators, baseboard radiators, etc.
HV1C	Heating	Furnace	Furnaces and their related controls, flues, etc.

CODE	COMPONENT DESCRIPTION	ELEMENT DESCRIPTION	DEFINITION
HV1D	Heating	Fuel Supply/Storage	Storage and/or distribution of fuel for heating purposes, including tanks and piping networks and related leak detection/monitoring.
HV2A	Cooling	Chillers/ Controls	Chiller units for production of chilled water for cooling purposes, related controls (not including mods for CFC compliance).
HV2B	Cooling	Heat Rejection	Repair/replacement of cooling towers, dry coolers, air-cooling, and heat rejection. Includes connection of once-through system to cooling tower.
HV3A	Heating/Cooling	System Retrofit/ Replace	Replacement or major retrofit of HVAC systems.
HV3B	Heating/Cooling	Water Treatment	Treatment of hot water, chilled water, steam, condenser water, etc.
HV3C	Heating/Cooling	Package/Self-Contained Units	Repair/replacement of self-contained/package type units, including stand-up units, rooftop units, window units, etc; both air conditioners and heat pumps.
HV3D	Heating/Cooling	Conventional Split Systems	Repair, installation, or replacement of conventional split systems, both air conditioners and heat pumps, including independent component replacements of compressors and condensers.
HV4A	Air Moving/ Ventilation	Air Handlers/ Fan Units	Includes air handlers and coils, fan coil units, unit ventilators, filtration upgrades, etc., not including package/self-contained units, split systems, or other specifically categorized systems.
HV4B	Air Moving/ Ventilation	Exhaust Fans	Exhaust fan systems, including fans, range and fume hoods, controls, and related ductwork.
HV4C	Air Moving/ Ventilation	Other Fans	Supply, return, or any other fans not incorporated into a component categorized elsewhere.
HV4D	Air Moving/ Ventilation	Air Distribution Network	Repair, replacement, or cleaning of air distribution network, including ductwork, terminal reheat/cool, VAV units, induction units, power induction units, insulation, dampers, linkages, etc.
HV5A	Steam/Hydronic Distribution	Piping Network	Repair/replacement of piping networks for heating and cooling systems, including pipe, fittings, insulation, related components, etc.
HV5B	Steam/Hydronic Distribution	Pumps	Repair or replacement of pumps used in heating and cooling systems, related control components, etc.
HV5C	Steam/Hydronic Distribution	Heat Exchangers	Including shell-and-tube heat exchangers and plate heat exchangers for heating and cooling.
HV6A	Controls	Complete System Upgrade	Replacement of HVAC control systems.
HV6B	Controls	Modifications/ Repairs	Repair or modification of HVAC control system.
HV6C	Controls	Air Compressors/ Dryers	Repair or modification of control air compressors and dryers.
HV7A	Infrastructure	Steam/Hot Water Generation	Generation of central steam and/or hot water, including boilers and related components.
HV7B	Infrastructure	Steam/Hot Water Distribution	Distribution system for central hot water and/or steam.
HV7C	Infrastructure	Chilled Water Generation	Generation of central chilled water, including chillers and related components.
HV7D	Infrastructure	Chilled Water Distribution	Distribution system for central chilled water.
HV7E	Infrastructure	Tunnels/ Manholes/ Trenches	Repairs, installation, or replacement of utility system access chambers.
HV7F	Infrastructure	Other	HVAC infrastructure issues not specifically categorized elsewhere.
HV8A	General	CFC Compliance	Chiller conversions/replacements for CFC regulatory compliance, monitoring, etc.
HV8B	General	Other	HVAC issues not catalogued elsewhere.

PLUMBING

CODE	COMPONENT DESCRIPTION	ELEMENT DESCRIPTION	DEFINITION
PL1A	Domestic Water	Piping Network	Repair or replacement of domestic water supply piping network, insulation, hangers, etc.

CODE	COMPONENT DESCRIPTION	ELEMENT DESCRIPTION	DEFINITION
PL1B	Domestic Water	Pumps	Domestic water booster pumps, circulating pumps, related controls, etc.
PL1C	Domestic Water	Storage/ Treatment	Equipment or vessels for storage or treatment of domestic water.
PL1D	Domestic Water	Metering	Installation, repair, or replacement of water meters.
PL1E	Domestic Water	Heating	Domestic water heaters, including gas, oil, and electric water heaters, shell-and-tube heat exchangers, tank type, and instantaneous.
PL1F	Domestic Water	Cooling	Central systems for cooling and distributing drinking water.
PL1G	Domestic Water	Fixtures	Plumbing fixtures, including sinks, drinking fountains, water closets, urinals, etc.
PL1H	Domestic Water	Conservation	Alternations made to the water distribution system to conserve water.
PL1I	Domestic Water	Backflow Protection	Backflow protection devices, including backflow preventers, vacuum breakers, etc.
PL2A	Wastewater	Piping Network	Repair or replacement of building wastewater piping network.
PL2B	Wastewater	Pumps	Pump systems used to lift wastewater, including sewage ejectors and other sump systems.
PL3A	Special Systems	Process Gas/Fluids	Generation and/or distribution of process steam, compressed air, natural and LP gas, process water, vacuum, etc.
PL4A	Infrastructure	Potable Water Storage/ Treatment	Storage and treatment of potable water for distribution.
PL4B	Infrastructure	Industrial Water Distribution/ Treatment	Storage and treatment of industrial water for distribution.
PL4C	Infrastructure	Sanitary Water Collection	Sanitary water collection systems and sanitary sewer systems, including combined systems.
PL4D	Infrastructure	Stormwater Collection	Stormwater collection systems and storm sewer systems; storm water only.
PL4E	Infrastructure	Potable Water Distribution	Potable water distribution network.
PL4F	Infrastructure	Wastewater Treatment	Wastewater treatment plants, associated equipment, etc.
PL5A	General	Other	Plumbing issues not categorized elsewhere.

SECTION 4

COST SUMMARIES AND TOTALS

RENEWAL COSTS MATRIX

All dollars shown as Present Value

CATEGORY	NON-RECURRING PROJECT NEEDS			RECURRING COMPONENT REPLACEMENT NEEDS											
	Immediate	Critical	Non-Critical	Deferred Renewal	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	TOTAL
ACCESSIBILITY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
EXTERIOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
INTERIOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
PLUMBING	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
HVAC	0	0	24,763,503	0	0	0	0	0	1,348,540	0	0	0	0	0	$26,112,043
FIRE/LIFE SAFETY	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
ELECTRICAL	0	0	0	46,522	0	0	0	16,299	0	0	0	20,535	0	0	$83,357
SITE	0	0	0	0	0	0	0	0	0	0	3,278,914	0	0	906,883	$4,185,797
VERT. TRANS.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
HEALTH/EQUIP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	$0
SUBTOTAL	$0	$0	$24,763,503	$46,522	$0	$0	$0	$16,299	$1,348,540	$0	$3,278,914	$20,535	$0	$906,883	$30,381,196
TOTAL NON-RECURRING PROJECT NEEDS			$24,763,503	TOTAL RECURRING COMPONENT REPLACEMENT NEEDS										$5,617,694	

CURRENT REPLACEMENT VALUE	$19,182,880
FACILITY CONDITION NEEDS INDEX	1.58
FACILITY CONDITION INDEX	0.00

GSF	TOTAL 10-YEAR FACILITY RENEWAL NEEDS	10-YEAR NEEDS/SF
NA	$30,381,196	NA

FACILITIES RENEWAL PLAN

NON-RECURRING PROJECT COST

All costs shown as Present Value

PROJECT NUMBER	PROJECT TITLE	UNI-FORMAT	PRIORITY CLASS	PROJECT CLASSIFICATION	PROJECT COST
HSCWHV01	REPLACE CHILLED WATER SUPPLY AND RETURN VALVES		3	Corrective Action	74,965
HSCWHV02	INSTALL COOLING TOWER FOR SEASONAL TURNDOWN		3	Plant Adaption	436,766
HSCWHV03	CONSTRUCT SECOND CHILLED WATER PLANT - RDK ENGINEERS		3	Plant Adaption	24,251,772
				TOTAL	**$24,763,503**

FACILITIES RENEWAL PLAN

RECURRING COMPONENT REPLACEMENT COSTS

All costs shown as Present Value

ASSET CODE COMP CODE	COMPONENT	IDENTIFIER	UNI-FORMAT	REPLACEMENT YEAR	REPLACEMENT COST
HSCW VF11	VARIABLE FREQUENCY DRIVE (75-100 HP)	VSD-SCHP-2	D5010	Deferred Renewal	23,261
HSCW VF11	VARIABLE FREQUENCY DRIVE (75-100 HP)	VSD-SCHP-3	D5010	Deferred Renewal	23,261
HSCW VF10	VARIABLE FREQUENCY DRIVE (50-75 HP)	VSD-CWP1	D5010	2019	16,299
HSCW CT08	COOLING TOWER (>701 TONS)	TOW-05	D3030	2020	674,270
HSCW CT08	COOLING TOWER (>701 TONS)	TOW-06	D3030	2020	674,270
HSCW CP42	PLASTIC HDPE - 3 INCH	CWS - BRODY-MRI	G4020	2022	31,766
HSCW CP42	PLASTIC HDPE - 3 INCH	CWR - BRODY-MRI	G4020	2022	31,766
HSCW CP43	PLASTIC HDPE - 4 INCH	CWS - CUP-BRODY	G4020	2022	70,024
HSCW CP43	PLASTIC HDPE - 4 INCH	CWR - CUP-BRODY	G4020	2022	70,024
HSCW CP44	PLASTIC HDPE - 6 INCH	CWS - BRODY-WARREN	G4020	2022	107,143
HSCW CP44	PLASTIC HDPE - 6 INCH	CWR - BRODY-WARREN	G4020	2022	107,143
HSCW CP48	PLASTIC HDPE - 14 INCH	CWS - CUP-BRODY	G4020	2022	1,245,436
HSCW CP48	PLASTIC HDPE - 14 INCH	CWR - CUP-BRODY	G4020	2022	1,245,436
HSCW CP49	PLASTIC HDPE - 18 INCH	CWS - CUP-BRODY	G4020	2022	185,087
HSCW CP49	PLASTIC HDPE - 18 INCH	CWR - CUP-BRODY	G4020	2022	185,087
HSCW VF08	VARIABLE FREQUENCY DRIVE (30-40 HP)	VSD-CHWP4	D5010	2023	10,268
HSCW VF08	VARIABLE FREQUENCY DRIVE (30-40 HP)	VSD-CHWP5	D5010	2023	10,268
HSCW CP46	PLASTIC HDPE - 10 INCH	CWS - CUP-BIOTECH	G4020	2025	453,442
HSCW CP46	PLASTIC HDPE - 10 INCH	CWR - CUP-BIOTECH	G4020	2025	453,442
				TOTAL	**$5,617,694**

UTILITY CONDITION ASSESSMENT

SECTION 5

PROJECT DETAILS

All costs shown as Present Value

REPLACE CHILLED WATER SUPPLY AND RETURN VALVES

Project Number:	HSCWHV01	**Category Code:**	HV7D
Priority Sequence:	1		
Priority Class:	Non-Critical	**System:**	HVAC
Project Class:	Corrective Action	**Component:**	INFRASTRUCTURE
Date Basis:	8/29/2016	**Element:**	CHILLED WATER DIST.

Code Application:	**Subclass/Savings:**	**Project Location:**
Not Applicable	Not Applicable	Undefined: Floor(s) S

Description

The chilled water supply and return valves in the main chilled water distribution feed to Brody, Biotech, MRI, etc., have been in service for nearly 40 years and have been subject to minimal operation and exercise. It is recommended that approximately 20 valves of various sizes be replaced within the next ten years. No specific valves were identified due to a lack of valve inventory, so this recommendation is a placeholder for future capital needs.

All costs shown as Present Value

Project Cost Estimate

Task Description	Unit	Qnty	Material Unit Cost	Total Material Cost	Labor Unit Cost	Total Labor Cost	Total Cost
Remove and replace chilled water system valves, including demo	EA	20	$2,500	$50,000	$850	$17,000	$67,000
Base Material/Labor Costs				**$50,000**		**$17,000**	
Indexed Material/Labor Costs				**$50,350**		**$12,121**	**$62,471**
General Contractor Mark Up at 20.0%							**$12,494**
Original Construction Cost							**$74,965**
Date of Original Estimate: 8/29/2016						**Inflation**	**$0**
Current Year Construction Cost							**$74,965**
No Professional Fees Required							**$0**
TOTAL PROJECT COST							**$74,965**

All costs shown as Present Value

INSTALL COOLING TOWER FOR SEASONAL TURNDOWN

Project Number:	HSCWHV02	**Category Code:**	HV7C
Priority Sequence:	2		
Priority Class:	Non-Critical	**System:**	HVAC
Project Class:	Plant Adaption	**Component:**	INFRASTRUCTURE
Date Basis:	8/29/2016	**Element:**	CHILLED WATER GENERATION

Code Application:	**Subclass/Savings:**	**Project Location:**
Not Applicable	Not Applicable	Item Only: Floor(s) S

Description

Install a new cooling tower to be utilized during the seasonal turndown periods of the year. The current system is oversized for the demand during the cooler months. The new installation would allow the operators to have better control over the supply and demand and ultimately reduce energy consumption with the tighter control functions.

All costs shown as Present Value

Project Cost Estimate

Task Description	Unit	Qnty	Material Unit Cost	Total Material Cost	Labor Unit Cost	Total Labor Cost	Total Cost
Install seasonal cooling tower	TON	1,500	$177	$265,260	$43.62	$65,430	$330,690
			Base Material/Labor Costs	**$265,260**		**$65,430**	
			Indexed Material/Labor Costs	**$267,117**		**$46,652**	**$313,768**
						General Contractor Mark Up at 20.0%	**$62,754**
						Original Construction Cost	**$376,522**
Date of Original Estimate:	8/29/2016					**Inflation**	**$0**
						Current Year Construction Cost	**$376,522**
						Professional Fees at 16.0%	**$60,244**
						TOTAL PROJECT COST	**$436,766**

All costs shown as Present Value

CONSTRUCT SECOND CHILLED WATER PLANT - RDK ENGINEERS

Project Number:	HSCWHV03	**Category Code:**	HV7C
Priority Sequence:	3		
Priority Class:	Non-Critical	**System:**	HVAC
Project Class:	Plant Adaption	**Component:**	INFRASTRUCTURE
Date Basis:	8/30/2016	**Element:**	CHILLED WATER GENERATION

Code Application:	**Subclass/Savings:**	**Project Location:**
Not Applicable	Not Applicable	Undefined: Floor(s) S

Description

RDK Engineers performed a campuswide capacity study for the chilled water system, and one of their recommendations was to construct a second chilled water plant to accommodate future campus growth. The current plant is nearing full load capacity, and available expansion space is very limited. It is recommended that an additional chiller plant be constructed and that the capacity be designed to provide additional redundancy as well as future growth capacity.

All costs shown as Present Value

Project Cost Estimate

Task Description	Unit	Qnty	Material Unit Cost	Total Material Cost	Labor Unit Cost	Total Labor Cost	Total Cost
Construct additional chilled water plant, including chillers, cooling towers, distribution pipe, electrical expansion, controls, pumps, site remediation	LOT	1	$15,000,000	$15,000,000	$3,250,000	$3,250,000	$18,250,000
Base Material/Labor Costs				**$15,000,000**		**$3,250,000**	
Indexed Material/Labor Costs				**$15,105,000**		**$2,317,250**	**$17,422,250**
General Contractor Mark Up at 20.0%							**$3,484,450**
Original Construction Cost							**$20,906,700**
Date of Original Estimate: 8/30/2016						**Inflation**	**$0**
Current Year Construction Cost							**$20,906,700**
Professional Fees at 16.0%							**$3,345,072**
TOTAL PROJECT COST							**$24,251,772**

SECTION 6

SYSTEM PHOTOLOGS

HSCW001e 4/18/2016
Refrigerant monitoring system
CUP, first floor

HSCW002e 4/18/2016
Variable frequency drives for chilled water pumps
CUP, first floor

HSCW003e 4/18/2016
2,000 GPM pump CHP-7 with 25 hp motor
CUP, first floor

HSCW004e 4/18/2016
Variable frequency drives for chilled water pumps
CUP, first floor

HSCW005e 4/18/2016
2,400 GPM pump CHP-3 with 40 hp motor
CUP, first floor

HSCW006e 4/18/2016
5,000 GPM pump SCHP-4 with 100 hp motor
CUP, first floor

HSCW007e 4/18/2016
5,000 GPM pump SCHP-1 with 100 hp motor
CUP, first floor

HSCW008e 4/18/2016
Trane centrifugal water-cooled chiller CH-3 rated for 1,000 tons
CUP, first floor

HSCW009e 4/18/2016
5,000 GPM pump SCHP-2 with 100 hp motor
CUP, first floor

HSCW010e 4/18/2016
5,000 GPM pump SCHP-3 with 100 hp motor
CUP, first floor

HSCW011e 4/18/2016
SMARDT Turbocor oil-free chiller CH-2 rated for 900 tons
CUP, first floor

HSCW012e 4/18/2016
Oil-free compressor for CH-2
CUP, first floor

HSCW013e 4/18/2016

CH-3 motor starter rated for 5 kV

CUP, first floor

HSCW014e 4/18/2016

Sand filter system

CUP, first floor

HSCW015e 4/18/2016

Chilled water system crossover bridge

CUP, first floor

HSCW016e 4/18/2016

Variable frequency drives for chilled water pumps

CUP, first floor

HSCW017e 4/18/2016

Trane centrifugal water-cooled chiller CH-4 rated for 1,400 tons

CUP, first floor

HSCW018e 4/18/2016

CH-4 motor starter rated for 5 kV

CUP, first floor

HSCW019e 4/18/2016
2,400 GPM pump CHP-4 with 40 hp motor
CUP, first floor

HSCW020e 4/18/2016
2,400 GPM pump CHP-5 with 40 hp motor
CUP, first floor

HSCW021e 4/18/2016
Trane centrifugal water-cooled chiller CH-5 rated for 1,400 tons
CUP, first floor

HSCW022e 4/18/2016
CH-5 motor starter rated for 5 kV
CUP, first floor

HSCW023e 4/18/2016
6 inch domestic water backflow preventer
CUP, first floor

HSCW024e 4/18/2016
Fire pump controller
CUP, first floor

HSCW025e 4/18/2016

Fire pump and associated jockey pump

CUP, first floor

HSCW026e 4/18/2016

Booster pump control equipment

CUP, first floor

HSCW027e 4/18/2016

Booster pumps with 15 hp motors

CUP, first floor

HSCW028e 4/18/2016

Air compressor, air dryer and air storage tank

CUP, first floor

HSCW029e 4/18/2016

Variable frequency drives for chilled water pumps

CUP, first floor

HSCW030e 4/18/2016

2,400 GPM pump CHP-6 with 40 hp motor

CUP, first floor

HSCW031e 4/18/2016
2,400 GPM pump CHP-7 with 40 hp motor
CUP, first floor

HSCW032e 4/18/2016
Trane centrifugal water-cooled chiller CH-6 rated for 1,000 ton
CUP, first floor

HSCW033e 4/18/2016
Trane centrifugal water-cooled chiller CH-7 rated for 1,000 ton
CUP, first floor

HSCW034e 4/18/2016
Chilled water supply and return pipe
CUP, first floor

HSCW035e 4/18/2016
Vacuum breaker cabinet MSGA TX-11
CUP, room 131

HSCW036e 4/18/2016
Vacuum breaker for Chiller 5
CUP, room 131

HSCW037e 4/18/2016
Battery charger and battery bank
CUP, room 131

HSCW038e 4/18/2016
Rear access to switchgear MSGA
CUP, room 131

HSCW039e 4/18/2016
Automatic transfer switch ATS-EQ
CUP, room 133

HSCW040e 4/18/2016
Low-voltage switchgear MSBA
CUP, room 133

HSCW041e 4/18/2016
Low-voltage switchgear MSBB
CUP, room 133

HSCW042e 4/18/2016
Variable frequency drives for cooling tower fans
CUP, first floor

HSCW043e 4/18/2016

Variable frequency drives for pumps and cooling tower fan

CUP, first floor

HSCW044e 4/18/2016

Six condenser water pumps

CUP, first floor

HSCW045e 4/18/2016

Condenser water common header

CUP, first floor

HSCW046e 4/18/2016

Cooling tower and condenser water treatment equipment

CUP, first floor

HSCW047e 4/18/2016

Older cooling towers

CUP exterior

HSCW048e 4/18/2016

Condenser water common header

CUP exterior

HSCW049e 4/18/2016
Rooftop exhaust fans
CUP roof

HSCW050e 4/18/2016
Rooftop exhaust fans
CUP roof

HSCW051e 4/18/2016
Three updated cooling tower cells
CUP roof

HSCW052e 4/18/2016
Cooling tower fan motor
CUP roof

HSCW053e 4/18/2016
Chilled water pipe, valves and support equipment
Original utility tunnel

HSCW054e 4/18/2016
Pipe saddle
Original utility tunnel

HSCW055e 4/18/2016

Utility pipe and tunnel overview

Original utility tunnel

HSCW056e 4/18/2016

Pipe stanchion

Original utility tunnel

HSCW057e 4/18/2016

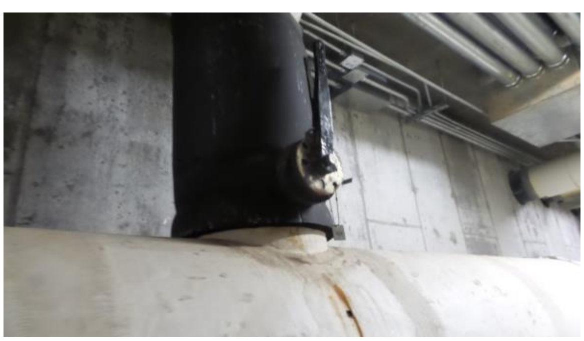
Pipe stanchion with stainless steel footer

Original utility tunnel

HSCW058e 4/18/2016

Isolation valve

Original utility tunnel



HSCW059e 4/18/2016

Isolation valve

Original utility tunnel

HSCW060e 4/18/2016

Isolation valves

Original utility tunnel

HSCW061e 4/18/2016
High voltage conduit
Original utility tunnel

HSCW062e 4/18/2016
Isolation valves
Original utility tunnel

HSCW063e 4/18/2016
Pipe saddle
Utility tunnel extension

HSCW064e 4/18/2016
Pipe saddle and wall anchor
Utility tunnel extension

HSCW065e 4/18/2016
Evidence of pipe movement
Utility tunnel extension 630 foot

HSCW066e 4/18/2016
Pipe guide, anchor, stanchion and saddle
Utility tunnel extension 770 foot

HSCW067e 4/18/2016
Corroded junction box
Utility tunnel extension 800 foot

HSCW068e 4/18/2016
Chilled water supply and return to Dental
Utility tunnel extension

HSCW069e 4/18/2016
Corroded junction box
Utility tunnel extension 850 foot