



# S1 Cooling Towers Upgrades Detailed Audit Proposal UW Medical Center

SEATTLE, WA

JANUARY 16 2020

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**PRELIMINARY DESIGN DEVELOPMENT 2012**



January 16, 2020

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**Subject: Detailed Audit PROPOSAL FOR UNIVERSITY OF WASHINGTON MEDICAL CENTER  
– S1 COOLING TOWERS**

McKinstry Essention (McKinstry) is pleased to present this Preliminary Assessment and Detailed Audit (DA) Proposal for the University of Washington Medical Center (UWMC). UWMC is interested in improving the mechanical infrastructure of their existing facilities while reducing utility costs, operating costs, and improving reliability and efficiency. The S1 Cooing Towers are critical to the operations at the UWMC and are beyond their useful life, less efficient. The water quality and clogging issues in recent months has required extensive repairs. The UWMC will also be losing its Dept of Ecology Permit to use Lake Water to help provide cooling to the facility. Running the three chillers will not be possible with existing cooling towers.

To mitigate these issues in a timely manner the UWMC would like to replace the existing cooling towers and take the opportunity for system efficiency improvements. In lieu of providing a “like for like” refurbishment, UWMC would like to replace the equipment with new equipment that will maximize the existing space footprint and provide a lower life cycle cost for their facility. This audit is being completed through the Energy Services Master Agreement that McKinstry has with the University of Washington.

RCMs:

- Upgrade S1 Cooling Towers and Operations

Target Facilities to be Studied:

- University of Washington Medical Center – S1 Cooling Towers, 1959 NE Pacific, Seattle, WA 98105

Detailed Audit Tasks:

Detailed Audit tasks include but are not limited to:

- Evaluate the condenser water capacity / loads for the existing cooling towers at Montlake and S1
- Collaborate with UWMC (in particular Henry Liem and Rob Parisot) to establish current system operation through review of existing trends, setting new trends, review maintenance and repair logs.
- Study existing condenser piping between the Montlake and S1 Cooling Towers. Investigate interconnection of Montlake and new S1 cooling towers utilizing the existing equalizing line.
- Identify cooling tower designs to best meet the location and operation requirements like acoustics, tower plume, water quality.
- Review the new energy code (2018 WSEC and 2018 SEC) to identify changes and confirm compliance
- Maximize the tower capacity that can fit inside the existing S1 mechanical yard.
- Evaluate pro's and con's of a fluid cooler versus a cooling tower replacement option.
- Determine Architectural and Structural impact to the existing S1 mechanical yard.
- Include a heat exchanger so that Lake Water can still be utilized in an emergency scenario.
- Building on the chilled water master plan of 2012 and update from 2018 develop a more detailed S1 chiller replacement plan as follows:

- Evaluate the S1 chiller room and determine maximum chiller capacity that can be installed within the existing footprint.
  - Based on the capacity available from the new S1 towers and Montlake Towers, evaluate if a chiller can be added to EA or another Mechanical space so that additional chiller capacity can be made available for Pacific Tower.
- Design development to approximately 30% so that GMAX budget and performance guarantees can be developed.

*Note: UWMC have confirmed that the preference of Upper campus is that the Med Center does not utilize campus chilled water.*

#### Construction Scope of Work:

Refer to the attached Preliminary scope of work. This will be refined and expanded to ROM and GMAX scopes of work during the detailed audit.

#### Proposed M&V Plan: The proposed International Performance Measurement and Verification Plan is as follows:

Energy efficiency will be improved in the following ways:

- Reduced water consumption through improved performance, reduced leaks/spills, better water quality. Associated reduction in chemical treatment.
- Implementation of condenser water temperature reset for the SA cooling towers. This will allow the cooling tower fan speed to slow down when OAT is not suitable to produce colder condenser water. This will provide electric energy savings.
- Simultaneous Use with existing SA Towers: At lower cooling loads, the existing SA cooling towers and new cooling towers can be used simultaneously, thereby delaying start of fan operation. Utilizing of existing equalizing lines with new units will also be investigated.

#### Baseline Data

- Evaluate existing tower manufacturers data
- DDC sequence review and trending (Optimization opportunities and simultaneous use of SA Towers)

#### Post Installation

- Manufacturers Data and make-up water meter logging
- DDC trending and fan KW measurements from DDC system

#### Maintenance/Repair/Capital Savings:

The proposed upgrades will replace old components/systems with new components/systems which will reduce maintenance and repair costs. These costs will be included in the cost effectiveness evaluation of the RCMs.

#### Requested Information:

For effective execution of this proposal we ask that the University of Washington Medical Center provide access to the following:

- Historical utility bills for the last 24 months.
- All mechanical, electrical, architectural, structural and building controls drawings.
- Access to Building Automation System (BAS).
- All operational and maintenance manuals, balancing records, & specifications.
- Operational records related to the cost of maintaining specific equipment.
- Information with regards to any on-going maintenance contracts.

- Access to individuals that have relevant information pertaining to the day-to-day operation of energy using systems on site.

#### Criteria for Implementation

Reference the attached Project Cost Effectiveness Worksheet.

#### Tasks and Milestones:

McKinstry is prepared to begin work immediately upon notice to proceed.

Formal progress review meetings will be conducted regularly throughout the study phase. The goal of these review meetings is to focus engineering efforts, budgeting, and savings assessment.

Assuming a start by February 13<sup>th</sup>, 2020 a Conservation Services Proposal (CSP) will be ready by July 3<sup>rd</sup>, 2020. (See attached schedule).

**Proposed Management Approach:** McKinstry will be utilizing in house staff to perform the majority of the audit. Exceptions include utilizing specialty vendors to analyze specific pieces of equipment.

McKinstry staff proposed to develop the study are as follows:

Gerard Galvin, Project Director  
Heramb Amonkar, Energy Engineer  
Bryan Morris P.E., Mechanical Engineer  
Dan Steinert P.E., Senior Electrical Engineer  
Jeff Goodwin P.E., Senior Structural Engineer  
Marla Corey-Loiola, Estimator  
Dave Robinaugh, Senior Construction Manager

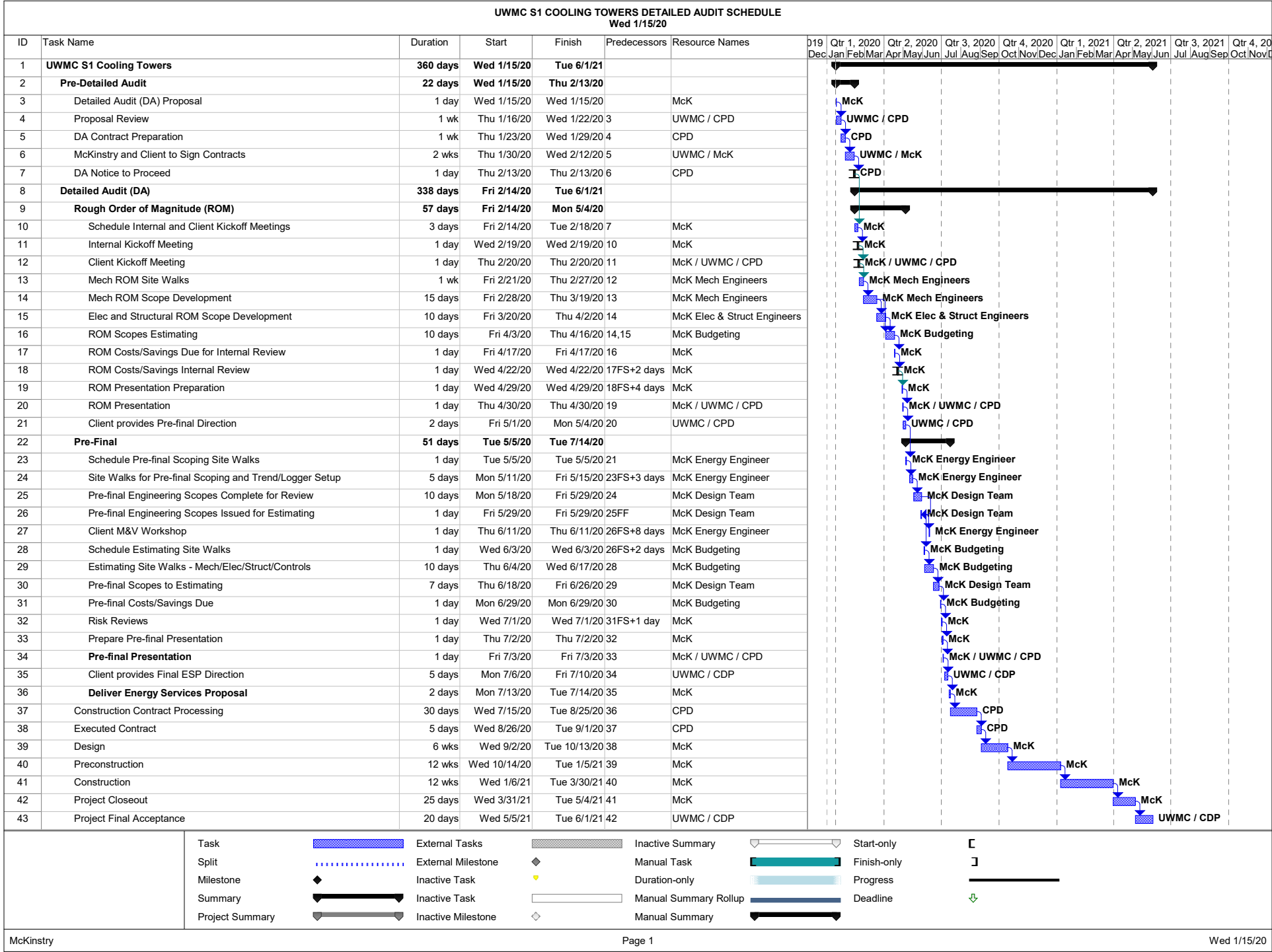
**Conservation Services Proposal and Detailed Audit Fee:** McKinstry will complete the Detailed Audit and subsequent Conservation Service Proposal for a fee of **\$86,400.00**.

**Owner Responsibilities:** In addition to the items described in section 2.6 of the Energy Services Master Agreement, we request a good faith survey for the areas where work will be conducted.

We look forward to work with UWMC to achieve the goal of reducing energy consumption and the consumption of other natural resources while improving facility capital infrastructure, optimizing functionality, and reducing maintenance and operating costs.

Thank You

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206.510.4863



Contractor used the following assumptions when proposing Resource Conservation Measures to determine if a RCM is cost effective.

1. Cost Assumptions for Resources - All economics will be run using the following resource prices for

- Electricity
  - i. \$/KwH
  - ii. Peak Load Premium
- Gas
  - i. \$/Therm
- Power Plant Steam
  - i. \$/klbs
- Water
  - i. Supply \$/CCF
  - ii. Wastewater \$/CCF
- Chilled Water
  - i. \$/ton-hr
- Waste Disposal
  - i. \$/ton
- Fuel Oil
  - i. \$/gal
- Propane
  - i. \$/gal
- Other – define in proposal

2. Cost of Financing

- Owner Financing Interest Rate % (usually last COP issue plus ¼%)
- Term  years
- Percent of Savings that may be applied to repay loan
- Contractor Construction Period Interest (See Section 5.6.11 of Master Agreement)

3. Payback Period when discounted at the cost of public borrowing (check one):

- a. ☐ Yes ☒ No      Revenue Generating: Payback term less than 7 years

- b. ☐ Yes ☒ No Life of University Loan: Payback term less than life of loan
- c. ☐ Yes ☒ No Life of Equipment: Payback for individual RCMs less than life of equipment.
- d. ☒ Yes ☐ No Other (Specify):

- Net Present Value Analysis over 20 years. Compare the cost of doing the project as proposed vs operating the system as currently operating with refurbishments or with equipment replacement “like for like” at current energy code efficiencies.
  - Cost Effective as defined by RCW 39.35C.010(3).
    - Cost Effective means that the present value to the state agency reasonably expected to be saved or produced by the measure or piece of equipment over its useful life, including any compensation from a utility, is greater than the net present value of the costs of implementing, maintaining and operating the measure or piece of equipment when discounted at the cost of public borrowing.
  - Equipment Service Life for fans is 20 years from ASHRE Handbook 2003 Applications, table 3.

4. Owner Operating and Capital Cost Saving Assumptions

- Under no circumstances will proposed project have a payback less than Cost Effective as defined by RCW 39.35C.10 (3). Specify Equipment Life .
- Reductions in Operating Costs may be considered on a project by project basis provided their inclusion is identified in advance of issuing the work order.  
Specify:
- Reduced or Avoided Owner Capital Costs may be considered on a project by project basis provided their inclusion is identified in advance of issuing the work order.  
Specify:   
Avoided Owner Capital Costs may be included in the project savings only at the time (now or the future) when equipment has past its useful life as defined in the latest edition of the “Energy Life Cycle Cost Analysis – Guidelines for Public Agencies” published by the Washington General Administration and the University has allocated funds to replace the equipment.



# Preliminary Assessment



## **UWMC S1 Cooling Towers and Lake Water**

**08-29-19**

### **Current Status / Challenges**

- The towers have significant build-up of biological materials and damaged drift eliminators.
- The existing S1 Cooling towers are at the end of their useful life and should be scheduled for replacement.
- The S1 chilled water plant currently utilizes the S1 cooling towers and Lake Water for heat rejection. The Dept of Ecology has notified UWMC that starting in 2023 Lake Water will no longer be available to the plant
- The Condenser Water system for Pacific and Montlake does not function as a homogeneous unit

### **Solution (Short Term)**

Contract with Fluid-Tek to

- a. Remove the discharge cones (and sound attenuators)
- b. Install new collars at the discharge
- c. Replace Drift Eliminators, and
- d. Clean towers

### **Solutions (Medium-Long term)**

To prepare for eventual failure of the existing towers and the changes in the Lake Water Permit the following plan is recommended:

- Replace the existing cooling towers serving the S1 cooling plant.
- Endeavor to upsize the new towers to provide additional capacity for anticipated future loads. (Max out the size of the existing Mech space and potentially expand.
- Provide a heat exchanger in-line with the cooling towers in the condenser water loop. The cold side of heat exchanger will be connected with the lake water system. (It is planned to use Lake Water only as a backup if the plant fails).
- Performance test the existing Montlake Towers and confirm that they operate optimally. (Additional capacity can potentially be derived from these towers
- Adjust height of new S1 cooling towers out of the well to match height of existing Montlake towers (Interties opportunity).
- Investigate the opportunity to intertie new S1 towers with Montlake towers to maximize capacity, load diversity and system resilience
- Continue to evaluate chilled water loads (trending) and use the opportunity of replacing S1 towers to address the on-going issue of chilled water capacity and balance between S1 plant and EA Plant

### **Schedule**

As replacement work should take place in the Winter months to minimize impact on the hospital, UWMC should start pre-design evaluation work on replacement of the cooling towers this year. This will allow sufficient time for detailed scoping, design, permitting, construction planning and implementation.







# Chilled Water System Capacity Review & S1 Cooling Towers Upgrade UW Medical Center

SEATTLE, WA

AUGUST 29, 2019

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## EXECUTIVE SUMMARY

This report estimates the impact of discontinuing the lake water discharge for chiller condenser heat rejection and possible solutions to make-up for the lost condenser capacity. Chiller S1 CH-1 is a 600 Ton variable speed chiller with open condenser loop that uses lake water. This makes it the most efficient operating UWMC chiller. When the lake water use is discontinued, only two of the three chillers at S1 plant can be operated together at full capacity due to limited cooling tower capacity. This is a reduction of up to 550 tons of chiller capacity for UWMC.

When the chiller capacity is compared with connected chilled water loads (design loads), The EA+SP loop's capacity will be 338 Tons less than the connected loads, while PAC loop's capacity will be 245 tons less than its connected loads. This means, UWMC's chiller capacity will be 583 Tons less than facility's connected cooling loads.

Building Automation System (BAS) trend data (3-day duration) from 2018 was used to calculate operating Tons. However, building operating conditions like temperature set points, occupancy, process loads etc. that drive the cooling load were not known for the trend duration.

The analysis indicates that the operating chilled water loads are much less than the connected loads (design loads). When Outside Air Temperature (OAT) was 88 Deg. F, the trended chilled water load for PAC and EA+SP, peaked at 1,649 Tons. Without the lake water condenser discharge, combined chiller capacity of PAC and EA+SP loops will be reduced to 1,558 Tons, resulting in capacity gap of 91 Tons for these loops. This capacity gap will increase with increase in OAT.

Without the lake water condenser discharge, all chillers will operate near capacity for longer hours during summer, with limited to no downtime for maintenance and repairs. Dependency on the campus loop will be more, frequent, and critical for reliable building operation.

Several solutions are proposed and discussed keeping in mind the limited chiller plant and cooling tower footprint, noise concerns and improving Energy Codes. Creative alternatives for S1 cooling tower upgrades along with strategic focus to gain system wide efficiency should be developed and discussed with AHJ. Changes to operating and control sequences of SA plant and SW chiller should be evaluated to add peak capacity. UWMC should also continue the building energy improvements efforts.

## EXISTING

UWMC runs chiller S1-CHRL1 in S1 mechanical room as lead chiller to serve cooling loads of EA and SP chilled water loop. This chiller has the best operating efficiency among all UWMC water cooled chillers. It uses lake water for condenser heat rejection instead of traditional cooling tower.

In June 2018 WA Ecology/NPDES informed that the category classification of Portage Bay has changed and now has more stringent temperature requirements. Based on lake temperature data available with the department, significant improvement in the temperature of discharge water must be made to meet the new standards for future permits.

Item	Value	Units	Source
Avg Monthly Lake Water Limit	2.4	MGD	UWMC Permit
	100,000	gph	
	1,667	gpm	
Daily Lake Water Limit	3.0	MGD	UWMC Permit
	125,000	gph	
	2,083	gpm	

*Table 1: Lake water discharge limits per the permit*

Further evaluation of the ability to meet the new standards (discharge and background temperature etc.) when using lake water discharge is necessary. However, significant reduction in summer cooling capacity is expected because of the new standards. Timeline for compliance of the new standard is 5 years (from 2018) based on information from UWMC.

Preliminary review of impact on UWMC's cooling system capacity from not using the lake water for condenser heat rejection is presented here. Data from 'UWMC Master Plan Revision 1' dated 03/12/2013 and available sample BAS trends from Summer of 2018 are used for this review.

### ***Known Deficiencies***

The SA chiller plant has a tie-in with the S1 and EA+SP Mech chilled water loop and was designed to draw chilled water from and supply chilled water to S1 and EA+SP loop. The controls shop informed that, during commissioning of the SA chiller plant, this functionality did not work. At present, the SA chiller plant can be postured to draw chilled water from the S1 and EA+SP loop in event of emergency. But the SA chiller plant cannot supply chilled water to the S1 and EA+SP loop.

The tie-in between EA+SP loop and campus chilled water loop is direct and is operated by manually adjusting the isolation valves.

## CHILLED WATER CAPACITY, LOADS AND IMPACT

### CHILLER PLANTS AND CAPACITIES

Chillers				Cooling Towers				Capacity Gap
	Equipment Tag	Evap GPM	Nominal Tons	Equipment Tag	Condenser GPM	Nominal Tons	'Adjusted' Tons	Tons
EA MECH	EA-HRCHLR-1	511	213			HR	HR	
	EA-CHLR2	800	400	CT-EA	1,200	500	500	
S1 <sup>1</sup>	S1-CHLR1	1,150	600	Lake	1,710	713	600	
	S1-CHLR2	1,400	700	S1 CT-1	2,700	750	1,350	
	S1-CHLR3	1,400	700	CT-201A & 201B		1,400		
SW	SW CH-1 (MS)	515	321				HR	
SA <sup>5</sup>	SA CH-1	600	250			HR	HR	
	SA CH-2	600	250	S1 CT-4	1,500	625	400	
	SA CH-3	600	250			HR	HR	
	SA CH-4	600	250	S1 CT-5	1,500	625	400	
EA MECH		1,311	613			500	500	100
S1 Plant		3,950	2,000			2,863	1,950	-50
SW Plant		515	321				HR	-
SA Plant		2,400	1,000			1,250	800	-
EA + S1		5,261	2,613			3,363	2,450	50
UWMC Total		8,176	3,934			4,613	3,250	50

Chiller Plant Capacities : FUTURE without Lake Water								
Chillers				Cooling Towers				
	Equipment Tag	Evap GPM	Nominal Tons	Equipment Tag	Condenser GPM	Nominal Tons	Actual' Tons <sup>1</sup>	
EA MECH	EA-HRCHLR-1	511	213				HR	
	EA-CHLR2	800	400	CT-EA	1,200	500	500	
S1	S1-CHLR1	1,150	600	Lake	X	0	0	
	S1-CHLR2	1,400	700	S1 CT-1	2,700	750	1,350	
	S1-CHLR3	1,400	700	CT-201A & 201B		1,400		
SW	SW CH-1 (MS)	515	321				HR	
SA	SA CH-1	600	250			HR	HR	
	SA CH-2	600	250	S1 CT-4	1,500	625	400	
	SA CH-3	600	250			HR	HR	
	SA CH-4	600	250	S1 CT-5	1,500	625	400	
EA MECH		1,311	613			500	500	100
S1 Plant		3,950	2,000			2,150	1,350	-650
SW Plant		515	321				HR	-
SA Plant		2,400	1,000			1,250	800	-
EA + S1		5,261	2,613			2,650	1,850	-550
UWMC Total		8,176	3,934			3,900	2,650	-550

1

Adjusted Tons derived from Yr 2012 Chilled Water Report from field measurements of the CT performance.

2

Data based on Aug 8-10, 2018 trend data. Design Capacity is 330 Tons, 515 GPM in cooling mode.

3

GPM is sum of AHU and FCU max. flow, per 2012 drawings.

4

Nominal Cooling Load = 500 x GPM x deltaT. Assumed deltaT = 10 F

5

SA has two HR chillers, condenser heat rejected to heating loop, access heat rejected to cooling towers.

6

De-rated based on operating deltaT only. HR chillers considered at nominal Tons, but may operate at less.

Table 2: Chiller and Cooling Tower capacity comparison



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### ***Peak Capacity Scenario***

The lake condenser water loop is connected to the S1 chilled water plant along with (3) existing cooling towers. The lake condenser loop is used for S1-CHLR1 heat rejection only, however the existing piping can allow this chiller to reject heat to the cooling towers as well.

The Year 2012 measurements confirmed the cooling tower combined operating capacity is limited to 1,350 Tons instead of nominal capacity of 2,150 Tons. This permits operation of only two of the three chillers when only the cooling towers are used for heat rejection.

If the lake condenser water loop is not available, the S1 chilled water plant can operate only two chillers and its peak capacity is limited up to 1,350 Tons. Resulting in overall capacity gap of 650 Tons for the UWMC.

*NOTE: The EA Mech and SA chiller plant have Heat Recovery chillers. Peak operating capacity of these chillers will also depend on building heating demand (ability of these chillers to reject condenser heat to the heating loop) and available cooling tower capacity.*

## CHILLED WATER LOOPS AND CONNECTED LOADS

Chilled Water Loops & Connected Loads : EXISTING with Lake Water									
Connected Load <sup>4</sup>				Distribution	Chillers			Capacity Gap	
	Loads	CHW GPM	Calculated Tons	Pump GPM	Loads	Evap GPM	Adjusted Tons	Tons	
EA + SP Loop	EA	1,272	530	1,533	EA-HRCHLR-1	511	213		
	SP Comfort	800	333	800	EA-CHLR2	800	400		
	SP Process	211	88	170					
PAC Loop	PAC Tower Comfort	3,699	1,541	1,150	S1-CHLR1	1,150	600		
	PAC Tower Process	379	158	1,400	S1-CHLR2	1,400	700		
				1,400	S1-CHLR3	1,400	650		
SA Loop	CHW Header <sup>3</sup>	1,929	804		SW CH-1 (MS) <sup>2</sup>	395	154		
				1,380	SA CH-1	600	250		
				1,380	SA CH-2	600	250		
					SA CH-3	600	250		
					SA CH-4	600	250		
EA + SP Loop		2,283	951	3,653		2,461	1,213	262	
PAC Loop		4,078	1,699	2,800		3,195	1,504	-195	
SA Loop		1,929	804	2,760		2,400	1,000	-	
EA+SP+PAC		6,361	2,650			5,656	2,717	67	
UWMC Total		8,290	3,454	9,213		8,056	3,717	67	

Chilled Water Loops & Connected Loads : FUTURE without Lake Water									
Connected Load				Distribution	Chillers				
	Loads	CHW GPM	Calculated Tons	Pump GPM	Loads	Evap GPM	Nominal Tons		
EA + SP Loop	EA	1,272	530	1,533	EA-HRCHLR-1	511	213		
	SP Comfort	800	333	800	EA-CHLR2	800	400		
	SP Process	211	88	170					
PAC Loop	PAC Tower Comfort	3,699	1,541	1,150	S1-CHLR1	1,150	600		
	PAC Tower Process	379	158	1,400	S1-CHLR2	1,400	700		
				1,400	S1-CHLR3	X	X		
SA Loop	CHW Header	1,929	804		SW CH-1 (MS)	395	154		
				1,380	SA CH-1	600	250		
				1,380	SA CH-2	600	250		
					SA CH-3	600	250		
					SA CH-4	600	250		
EA + SP Loop		2,283	951	2,503		1,311	613	-338	
PAC Loop		4,078	1,699	3,950		2,945	1,454	-245	
SA Loop		1,929	804	2,760		2,400	1,000	-	
EA+SP+PAC		6,361	2,650	6,453		4,256	2,067	-583	
UWMC Total		8,290	3,454	9,213		6,656	3,067	-583	

- Adjusted Tons derived from Yr 2012 Chilled Water Report from field measurements of the CT performance.
- Data based on Aug 8-10, 2018 trend data. Design Capacity is 330 Tons, 515 GPM in cooling mode.
- GPM is sum of AHU and FCU max. flow, per 2012 drawings.
- Nominal Cooling Load = 500 x GPM x deltaT. Assumed deltaT = 10 F
- SA has two HR chillers, condenser heat rejected to heating loop, access heat rejected to cooling towers.
- De-rated based on operating deltaT only. HR chillers considered at nominal Tons, but may operate at less.

Table 3: Chiller nominal capacity, loops served and connected loads comparison

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### ***Peak Operating Scenario***

The EA + SP chilled water loop has a nominal cooling load of 951 Tons while nominal chiller capacity of this loop is 613 Tons. The chiller S1-CHLR1 is dedicated to this loop to meet the shortfall (up to 422 Nominal tons).

The PAC chilled water loop has a nominal cooling load of 1,699 tons which is primarily serviced by two chillers at S1 chiller plant (1,350 Tons, measured) and supplemented by SW chiller. In peak demand periods, campus chilled water is used to meet the cooling load.

If lake condenser loop is not available and if the S1 chiller plant is dedicated to PAC tower, on a cooling design temperature day, the EA + SP loop will have cooling shortfall of up to 422 Tons, while PAC Tower's shortfall will be up to 252 tons. Total capacity shortfall of up to 590 Tons at UWMC.

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## 2018 SUMMER OPERATION – SAMPLE DATA

- This analysis uses available 3-day period trend data of Chilled Water Plants (08/08/18 Wed - 08/10/18 Fri).
- Connected load (Tons) calculated using 10 Deg. F temperature drop across the chilled water coils.
- Operating loads are presented for OAT = 88 Deg. F, as this was the highest trended outside air-dry bulb temperature for the trend period. Relative Humidity is not evaluated in this analysis.
- Values in following tables are maximum of the trended data at respective Outside Air Temperature (OAT).
- Building operating conditions like space cooling set points, occupant load, process load, renovations, equipment shutdowns or overrides etc. for this period are not known.

Operating Loads, OAT = 88 Deg. F : EXISTING with Lake Water							
Trended Flows & Loads				Chillers			Capacity Gap
	Loads	Trended GPM	Trended Tons		Operating CHW Delta T	De-rated Plant Capacity Tons	Tons
EA + SP Loop	EA <sup>6</sup>	698	699	EA-HRCHLR-1	7.00	0.70	429
	SP Comfort	716		EA-CHLR2			
	SP Process						
PAC Loop	PAC Tower Comfort	2,213	737	S1-CHLR1	14.10	1.41	600
	PAC Tower Process	165	60	S1-CHLR2	7.50	0.75	1,013
		395	153	S1-CHLR3			
SA Loop <sup>6</sup>	CHW Header	1,745	625	SW CH-1 (MS) <sup>2</sup>	9.10	0.91	154
				SA CH-1	8.60	0.86	860
				SA CH-2			
			SA CH-3				
				SA CH-4			
EA + SP Loop		1,414	699				1,029
PAC Loop		2,773	950				1,167
SA Loop		1,745	625				860
EA+SP+PAC		4,187	1,649				2,196
UWMC Total		5,932	2,274				-

330
217
-
547
-

Operating Loads, OAT = 88 Deg. F : FUTURE without Lake Water							
Trended Flows & Loads				Chillers			Capacity Gap
		Trended GPM	Trended Tons		Operating CHW Delta T	De-rated Plant Capacity Tons	Tons
EA + SP Loop	EA	698	699	EA-HRCHLR-1	7.00	0.70	429
SP Comfort	716	EA-CHLR2					
SP Process							
PAC Loop	PAC Tower Comfort	2,213	737	S1-CHLR1	7.50	0.75	975
PAC Tower Process	165	60	S1-CHLR2				
	395	153	S1-CHLR3				
SA Loop	CHW Header	1,745	625	SW CH-1 (MS)<sup>2</sup>	9.10	0.91	154
			SA CH-1	8.60	0.86	860	
			SA CH-2				
			SA CH-3				
				SA CH-4			
EA + SP Loop		1,414	699				429
PAC Loop		2,378	950				1,129
SA Loop		1,745	625				-
EA+SP+PAC		3,792	1,649				1,558
UWMC Total		5,537	2,274				-

-270
179
-
-91
-

- 1 Adjusted Tons derived from Yr 2012 Chilled Water Report from field measurements of the CT performance.
- 2 Data based on Aug 8-10, 2018 trend data. Design Capacity is 330 Tons, 515 GPM in cooling mode.
- 3 GPM is sum of AHU and FCU max. flow, per 2012 drawings.
- 4 Nominal Cooling Load = 500 x GPM x deltaT. Assumed deltaT = 10 F
- 5 SA has two HR chillers, condenser heat rejected to heating loop, access heat rejected to cooling towers.
- 6 De-rated based on operating deltaT only. HR chillers considered at nominal Tons, but may operate at less.

Table 4: Operating loads and estimated capacities comparison

### Peak Operating Scenario

The average trended cooling loads at 88 Deg F OAT are presented in above table. These loads are much lower than the calculated connected loads in Table 3. However, the operating delta-T for the loops and chiller plants is also low compared to designed conditions. Due to this the cooling capacity is limited by the distribution flow. The de-rated plant cooling capacity is estimated in above table and used to estimate the capacity gap.

OAT (DEG F)	EA+SP LOOP LOAD (TONS)	PAC LOOP LOAD (TONS)	SA LOOP LOAD (TONS)	EA+SP+PAC LOAD (TONS)	UWMC TOTAL LOAD (TONS)
77	562	899	440	1,461	1,901
80	596	934	475	1,530	2,005
84	620	977	550	1,598	2,148
88	699	950	625	1,648	2,273

Table 5 : Trended highest cooling loads of each chilled water loop at OAT = 88 Deg. F

OAT (DEG F)	S1- CHRL1 SUPPLY TONS	EA MECH PLANT TOTAL SUPPLY TONS	S1-CHRL1&2 TO PAC SUPPLY TONS (CALCULATED)	SW CH-1 (MS) CHILLER SUPPLY TONS	SA PLANT SUPPLY TONS
77	426	201	713	150	440
80	440	202	742	153	475
84	437	231	778	153	550
88	464	298	737	153	625

Table 6: highest cooling load of each chiller plant at OAT = 88 Deg. F

In existing scenario, the PAC loop is almost at capacity. The EA+SP loop has some spare capacity, but this spare capacity can reduce based on the heat recovery and loading of the heat recovery chiller. Without the S1-CHLR1, the EA+SP loop will have a significant capacity gap. The de-rated cooling capacity of EA Mech Chiller is 429 Tons. With 561 Tons of cooling load at 77 Deg F OAT (Table 5), the EA+SP loop will suffer capacity gap for most of the cooling season.

### SA Loop

500 Tons of the 1,000 Ton total capacity is provided by Heat Recovery (HR) chillers. Based on operating delta-T, the plant capacity is de-rated 860 tons. As the ability to load the HR is limited by building heating load and cooling tower availability to take the access condenser heat, the peak operating capacity of the SA chiller plant is expected to be less than 860 tons. For this reason, the capacity gap of this plant is not calculated.

Cooling Towers CT-4 and CT-5 were designed for 85 Deg. F leaving water temperature and currently operates to maintain 75 Deg F leaving water temperature. The trend data indicated that, at OAT = 88 Deg. F, the cooling tower fans were running at 94% speed with cooling tower range of 9.5 Deg. F. The building cooling load was 599

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Tons. This suggests that, with current operating set points, the towers are almost at their capacity. More capacity could be available by changing the cooling tower set points.

Considering the independent operation of this plant and the trended cooling load and, the capacity gap is not an immediate concern.

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## CHALLENGES

### 1. S1 Cooling Tower locations and Sound Level requirements

The S1 cooling tower farm consists of three towers in a louvered enclosure. The sound level requirements are stringent, and the sound attenuation adversely impacts the cooling tower performance. The year 2012 measurements and analysis concluded the operating capacity to be much lower than the nominal capacity. Also, the area footprint available for the towers is limited. Together, these limit the total heat rejection capacity that can be provided to the S1 chilled water plant. The SA cooling towers may also have similar limitation, but further study is required validate this.

### 2. Seattle Energy Code Update – 2012 to 2015

*(WSEC 2018 anticipated effective date – July 2020)*

The 2015 code update calls for higher efficiency equipment. For a chilled water plant, this often results in chiller with lower condenser water temperature. To meet this, the cooling tower with improved performance is required, which results in larger footprint. Working in the available footprint will need reducing cooling tower capacity to meet the performance.

## SOLUTIONS AND FURTHER INVESTIGATION

### 1. Explore SA (Montlake) Cooling Towers for Spare Capacity

a. These cooling towers are in proximity of S1 cooling towers. Trends suggest these towers operating near capacity. If physical improvements and operating sequence/ set point optimization can be identified to provide sufficient spare capacity (relative to SA cooling load), they can be inter-connected with the S1 condenser loop. This will 'increase' the heat rejection capacity of S1 chiller plant, allowing to install larger chillers. A feasibility study is suggested.

### 2. Replace and Upsize S1 Cooling Towers

a. This should be evaluated taking in consideration the challenges discussed in previous section.  
b. Perform data driven design and sizing. Implement cooling season trend study for the chiller plant and buildings to establish flow and load (Tons) profiles. Determine performance of individual chillers and cooling towers.  
c. Discuss code compliance exception with the AHJ on basis of alternate design. This design could include additional energy savings strategies for other parts of the system or other systems at UWMC.

### 3. Improve Chilled Water Loop Delta T

a. Replace chilled water valves of larger AHUs with Pressure Independent Control Valves (PICV).



- 
4. Replace and Upsize S1-CHLR3
    - a. This is constant speed chillers and oldest of the S1 chiller. A new VSD chiller will provide efficient and reliable operation. Upsizing should be performed in accordance to upsizing of S1 cooling towers discussed above.
  5. Install SP Heat Recovery Chiller
    - a. A new heat recovery chiller in the SP building will add cooling capacity without the need for cooling towers. Excess condenser heat will be rejected to existing AHU exhaust coils. This measure was previously developed.
  6. Automate campus chilled water loop switchover
    - a. The EA+SP loop has inter-tie with campus loop and is operate with manual isolation valves. With reduced capacity this will be used more frequently than before. Install control valves to modulate the flow from campus loop based on chilled water demand. Re-piping the existing tie-in and utilize a heat exchange to isolate the two loops could avoid pressure and temperature issues.
  7. Replace and Upsize EA chiller EA-CH2
    - a. The cooling tower for EA Mech, installed in year 2005 was the largest physical size tower that could be installed in the EA Exhaust tunnel. The tower was selected for 80 Deg. F/ 70 Deg. F entering and leaving condenser water temperature at 65 F wet bulb temperature. Operating at higher condenser water temperature shall increase the heat rejection capacity, thereby allowing a chiller larger than existing 400 Tons.
    - b. Chiller SW CH-1 (MultiStack) condenser exhaust coils reject heat to the EA exhaust tunnel in comfort cooling mode. This interactive effect should be considered to optimize operation of both chillers.
  8. Equipment and Building retrofit to reduce peak cooling loads
    - a. UWMC has actively identified and implemented energy efficiency measures like lighting upgrades, heat recovery, controls optimization to reduce campus energy use. This effort should be continued with added focus on peak cooling demand reduction.

# SUPPORTING DATA

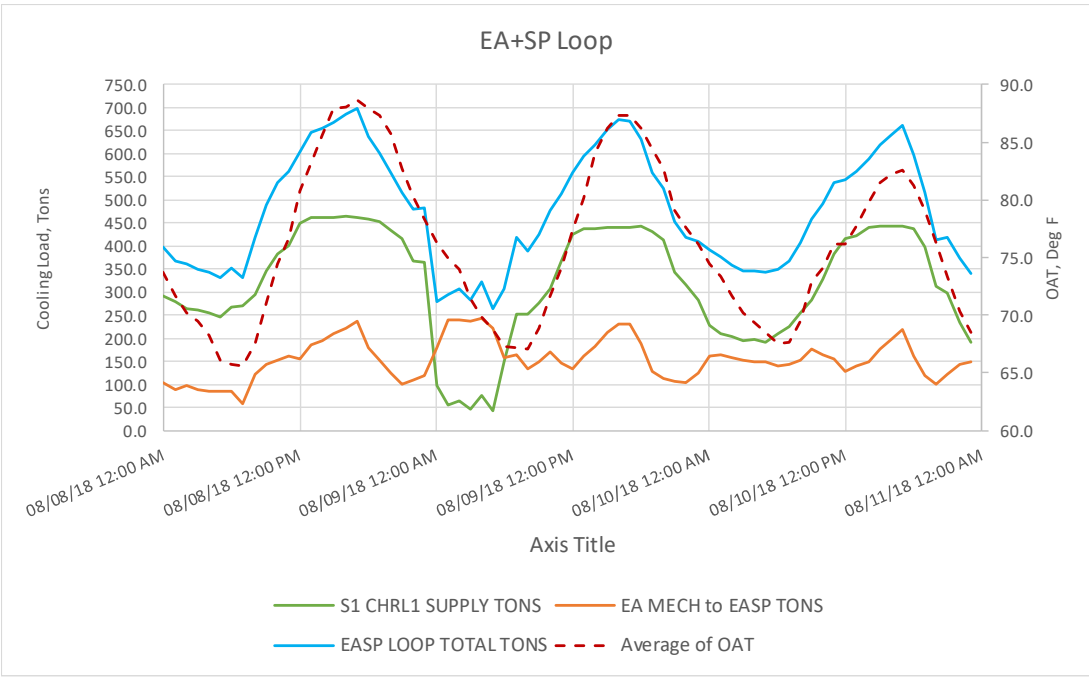


Figure 1: Cooling load profile of EA + SP chilled water loop and supply from connected plant.

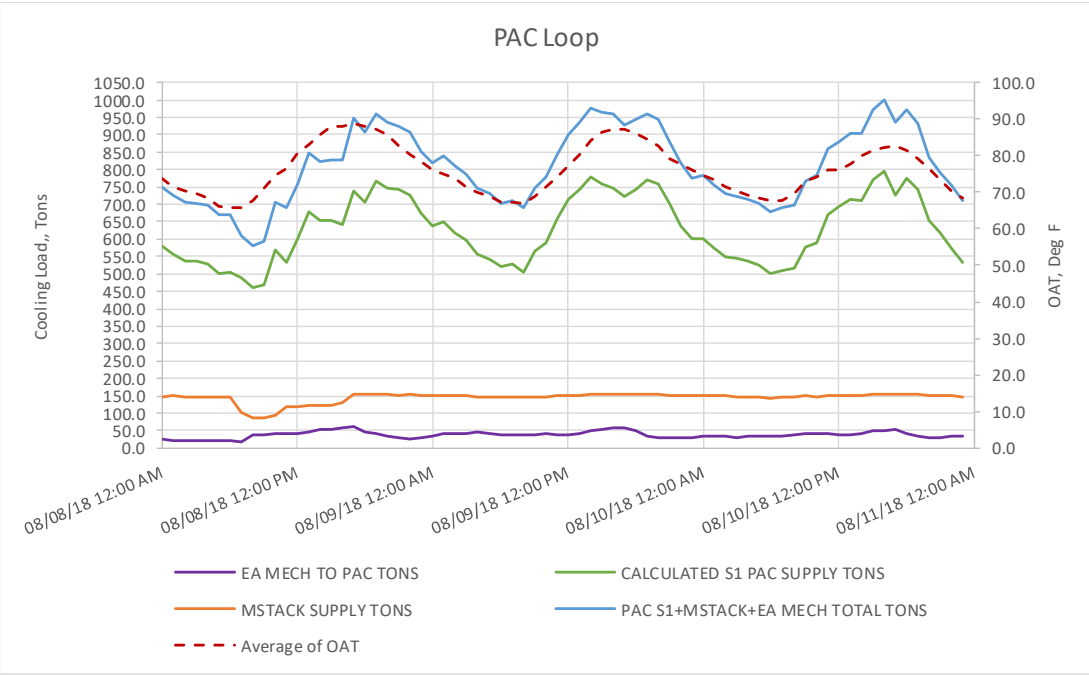


Figure 2 : Cooling load profile PAC chilled water loop and supply from connected chillers.

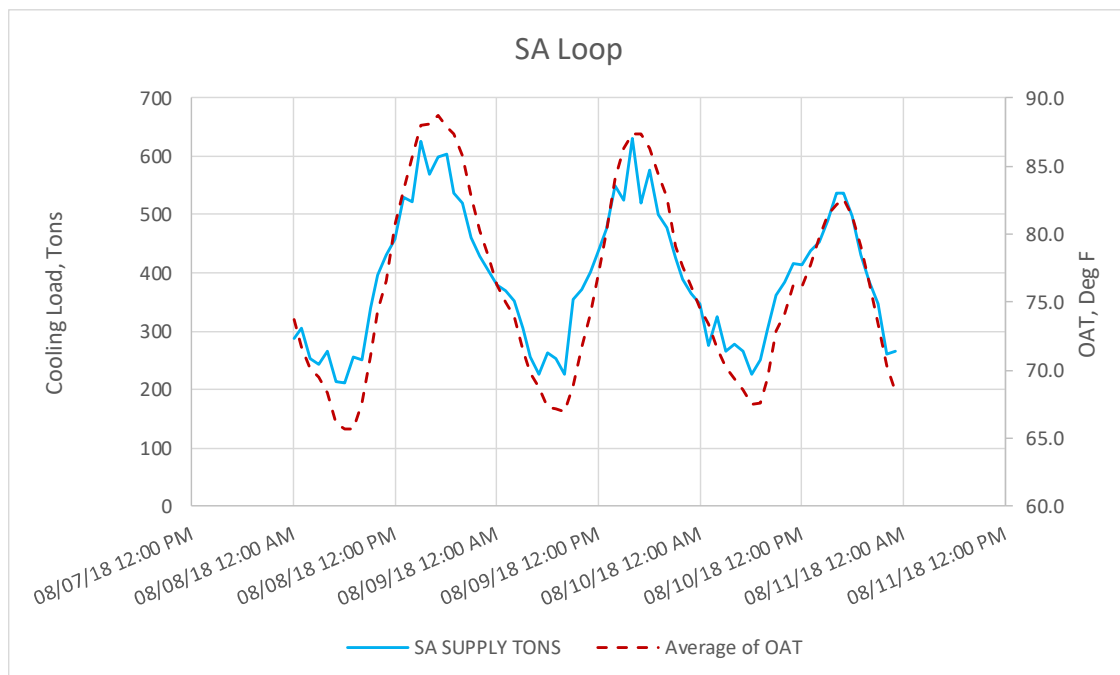


Figure 3 : Cooling load profile SA chilled water loop

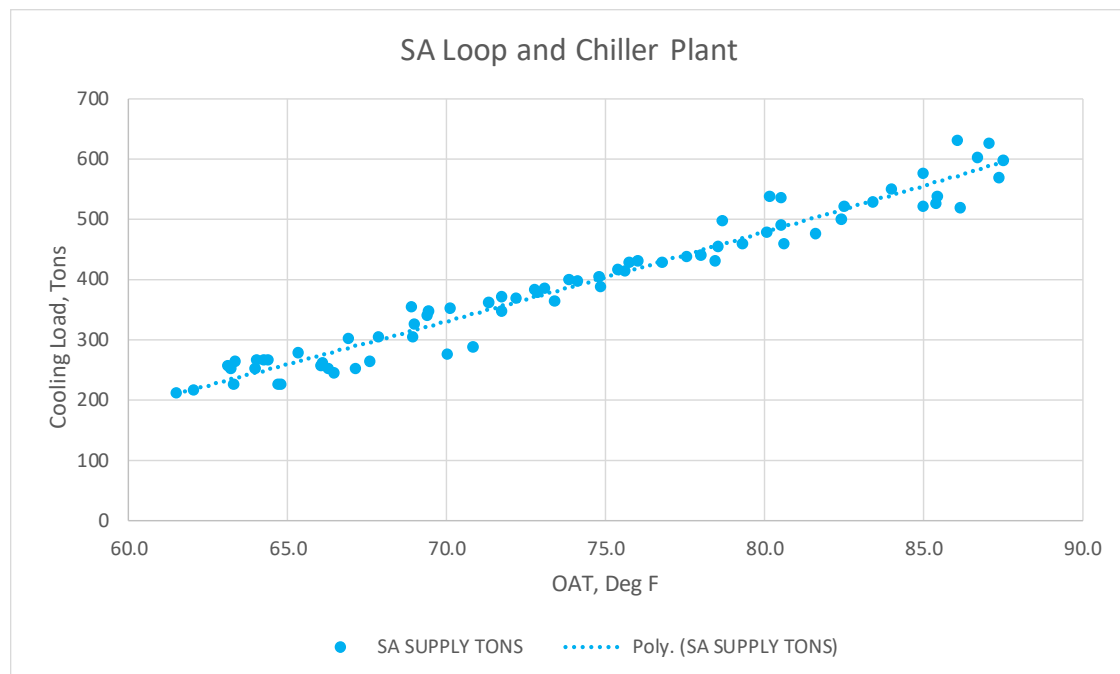


Figure 4 : SA Chiller Plant load profile wrt OAT.

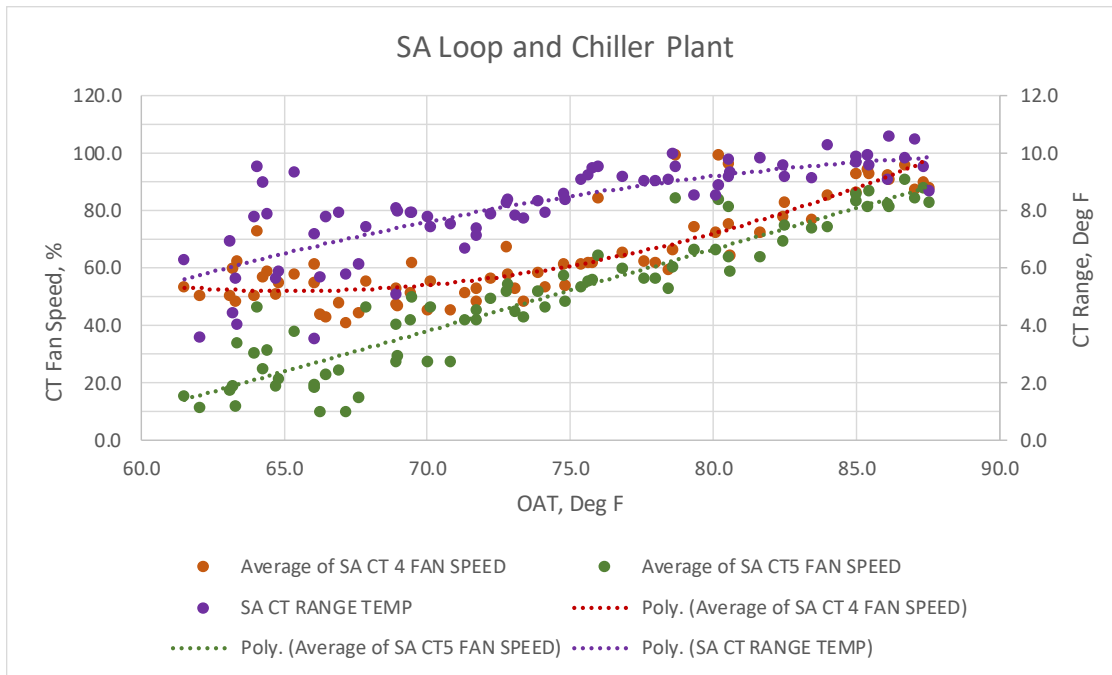


Figure 5 : SA cooling tower's fan speed and range at current operating set points (CWL = 75 Deg. F Approx).

# Detailed Scope of Work

## **FIM ID # 19532 02 Replace S-1 Towers for Future Load University of Washington Med Center**

### **GENERAL**

Replace the existing cooling towers serving the S1 cooling plant. Upsize the plant for additional capacity. Provide a heat exchanger inline with the cooling towers in the condenser water loop. The cold side of heat exchanger shall be connected with the lake water system. The warm side of the heat exchanger shall be connected to the condenser water loop. The lake water shall post cool water from cooling towers before entering the chillers. The cooling towers shall be connected together with an equalization line. The condenser water system shall also be connected to the existing cooling tower serving the new addition. Remove the existing louvers for the side of the building adjacent to the new mechanical space. Replace the existing condenser water pumps with pumps sized for the future capacity. Consider replacing the roof in conjunction with the towers.

### **SCOPE OF WORK INCLUDES**

1. Mechanical – See Sketches
2. Controls
3. Electrical
4. Structural
5. Architectural
6. Acoustical
7. Specialty
8. Design
9. Commissioning
10. Demolition and Removal
11. Training
12. Allotments
13. Measurements & Verification Scope
14. Questions and Answers (To **ask** a question, click on the RFI button in the header. Feel free to combine multiple questions into one to reduce E-mail traffic. To **answer** a question, click on the question and then type ctrl+shift+A.)

### **EXCLUSIONS**

1. Hazardous material abatement.
2. If existing equipment is reused, repairs to existing equipment are not included unless specifically noted in the scope of work above.
3. Unless stated otherwise in Table 3.2, we reserve the right to adjust energy savings if we find insufficient outside air quantities or inoperable equipment during design, construction, or commissioning. We will notify the owner before increasing outside air quantities or correcting inoperable equipment.
4. An acoustical analysis has not been performed.
5. This FIM assumes FIM-19328 (S1 Chiller 3 Replacement) has already been implemented.
6. Assumes EA/SP plant serves the Pac Tower load during construction.
7. Design approach based on 2009 Seattle code interpretations.
8. S1 cooling towers will be installed at a different height than the Montlake cooling towers. This scope includes switch over valves so the Montlake chillers can be served off the S1 cooling towers and the S1 chillers can be served off the Montlake cooling towers. However the Montlake cooling towers and S1 cooling towers cannot operate in parallel using an equalizing line.



## **UWMC S1 Cooling Towers and Lake Water**

**08-29-19**

### **Current Status / Challenges**

- The towers have significant build-up of biological materials and damaged drift eliminators.
- The existing S1 Cooling towers are at the end of their useful life and should be scheduled for replacement.
- The S1 chilled water plant currently utilizes the S1 cooling towers and Lake Water for heat rejection. The Dept of Ecology has notified UWMC that starting in 2023 Lake Water will no longer be available to the plant
- The Condenser Water system for Pacific and Montlake does not function as a homogeneous unit

### **Solution (Short Term)**

Contract with Fluid-Tek to

- a. Remove the discharge cones (and sound attenuators)
- b. Install new collars at the discharge
- c. Replace Drift Eliminators, and
- d. Clean towers

### **Solutions (Medium-Long term)**

To prepare for eventual failure of the existing towers and the changes in the Lake Water Permit the following plan is recommended:

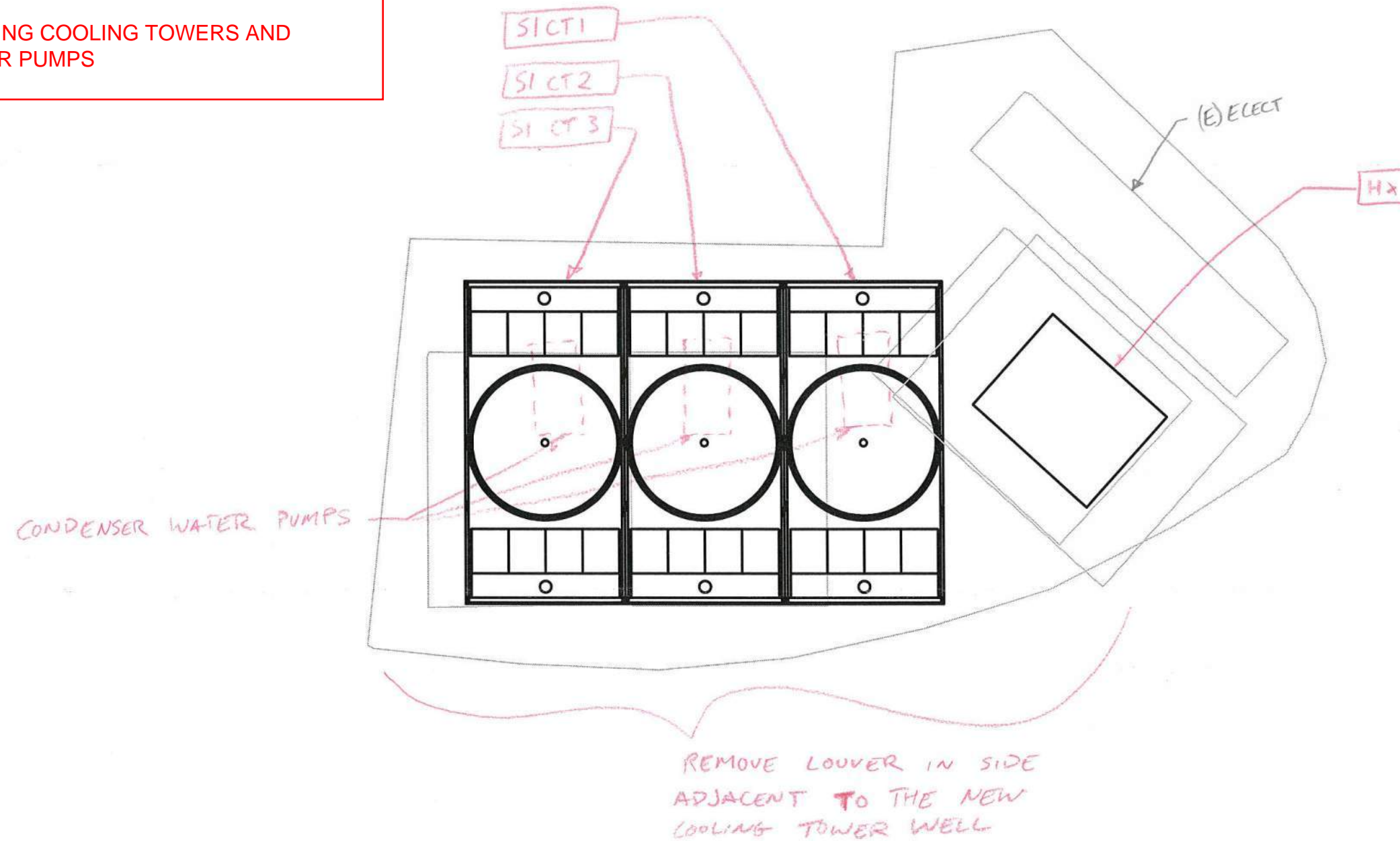
- Replace the existing cooling towers serving the S1 cooling plant.
- Endeavor to upsize the new towers to provide additional capacity for anticipated future loads. (Max out the size of the existing Mech space and potentially expand.
- Provide a heat exchanger in-line with the cooling towers in the condenser water loop. The cold side of heat exchanger will be connected with the lake water system. (It is planned to use Lake Water only as a backup if the plant fails).
- Performance test the existing Montlake Towers and confirm that they operate optimally. (Additional capacity can potentially be derived from these towers
- Adjust height of new S1 cooling towers out of the well to match height of existing Montlake towers (Interties opportunity).
- Investigate the opportunity to intertie new S1 towers with Montlake towers to maximize capacity, load diversity and system resilience
- Continue to evaluate chilled water loads (trending) and use the opportunity of replacing S1 towers to address the on-going issue of chilled water capacity and balance between S1 plant and EA Plant

### **Schedule**

As replacement work should take place in the Winter months to minimize impact on the hospital, UWMC should start pre-design evaluation work on replacement of the cooling towers this year. This will allow sufficient time for detailed scoping, design, permitting, construction planning and implementation.

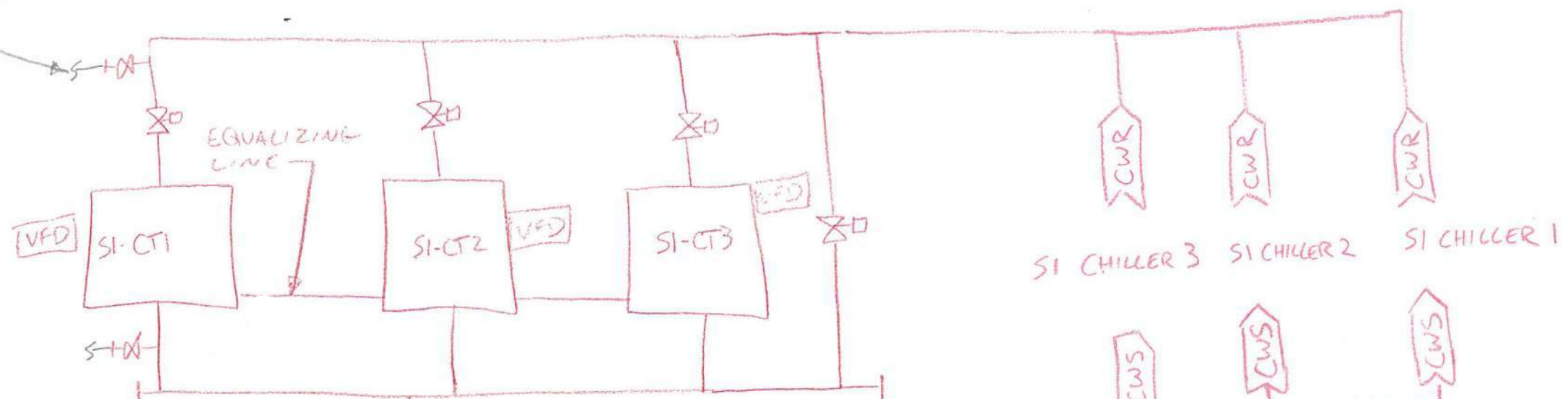
NOTES TO ESTIMATOR-

1. MOUNT COOLING TOWERS 7FT AFF. PROVIDE STRUCTURE TO SUPPORT.
2. LOCATE CONDENSER WATER PUMPS BELOW COOLING TOWERS.
3. PROVIDE CATWALK TO ACCESS TOWERS
4. PROVIDE CONTROLS MODIFICATIONS FOR COOLING PLANT.
5. PROVIDE MAKE-UP WATER FOR TOWERS.
6. PROVIDE INDIRECT DRAIN. CONNECT TO EXISTING LINE.
7. DEMOLISH EXISTING COOLING TOWERS AND CONDENSER WATER PUMPS

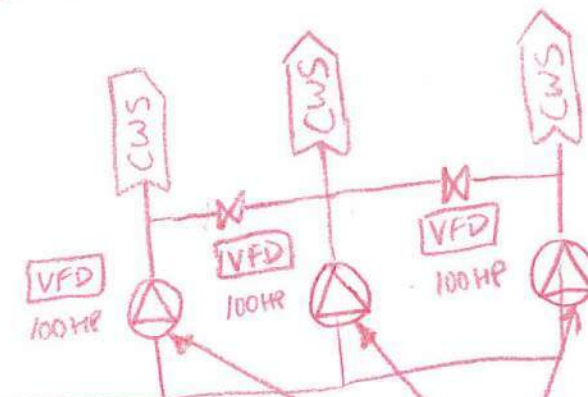


SCALE:  $\frac{1}{8}'' = 1'0''$

CONNECT TO EXISTING  
TOWER (TYP)

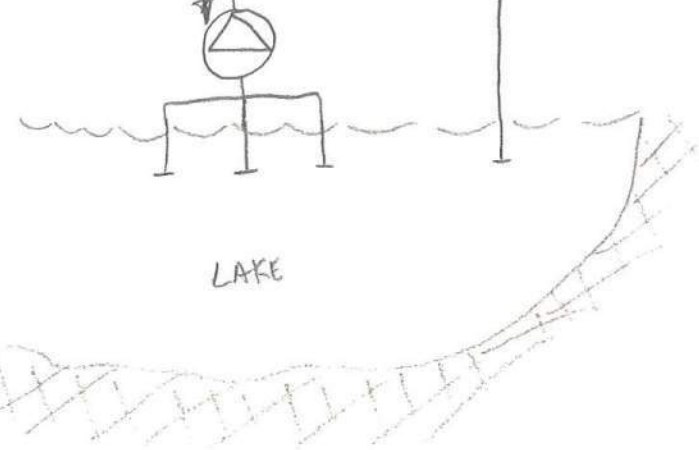


10"  
HX  
16"  
(10,800,000 BTU/H)



CONDENSER WATER  
PUMPS

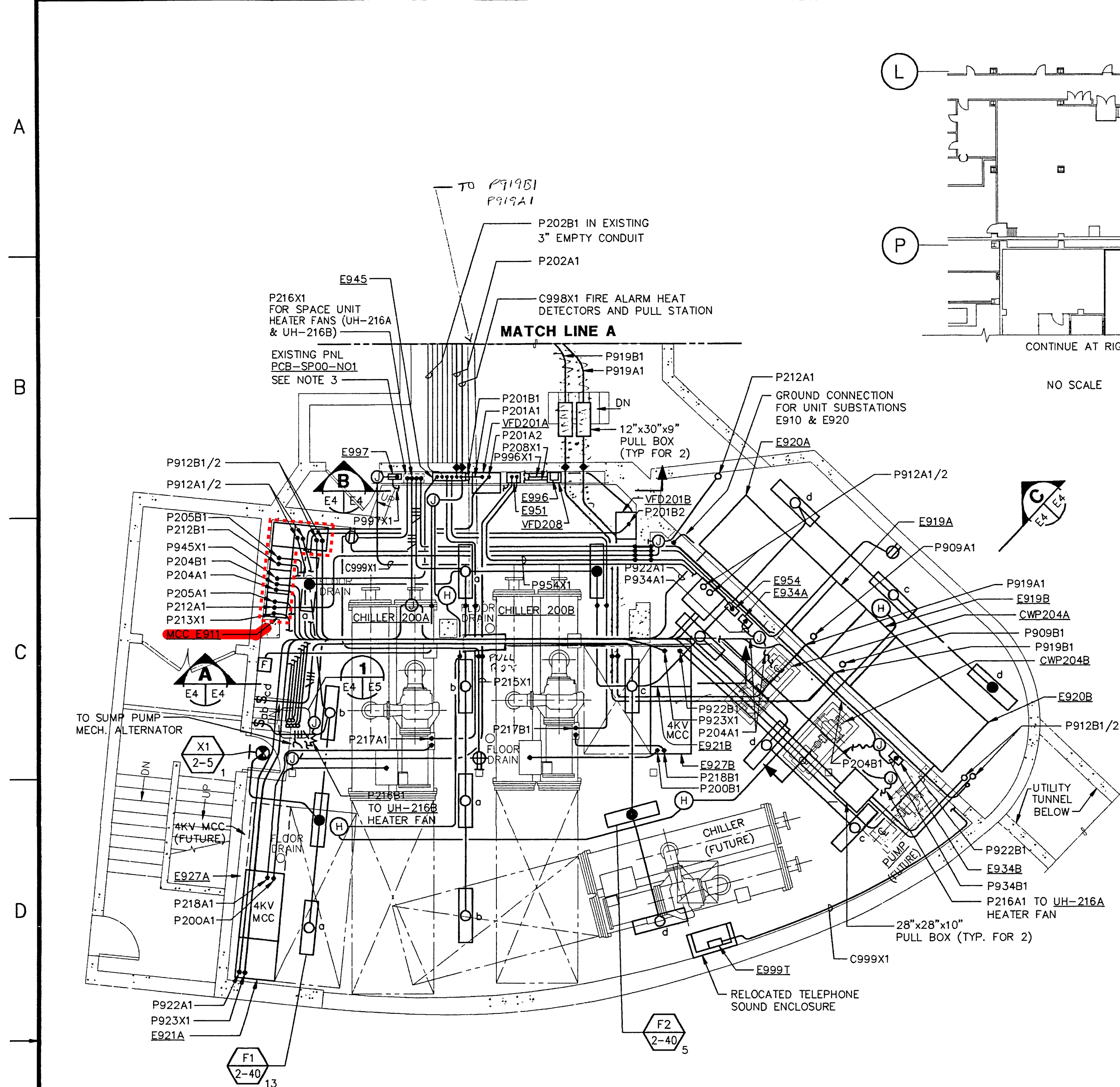
REPLACED UNDER  
PREVIOUS FIM



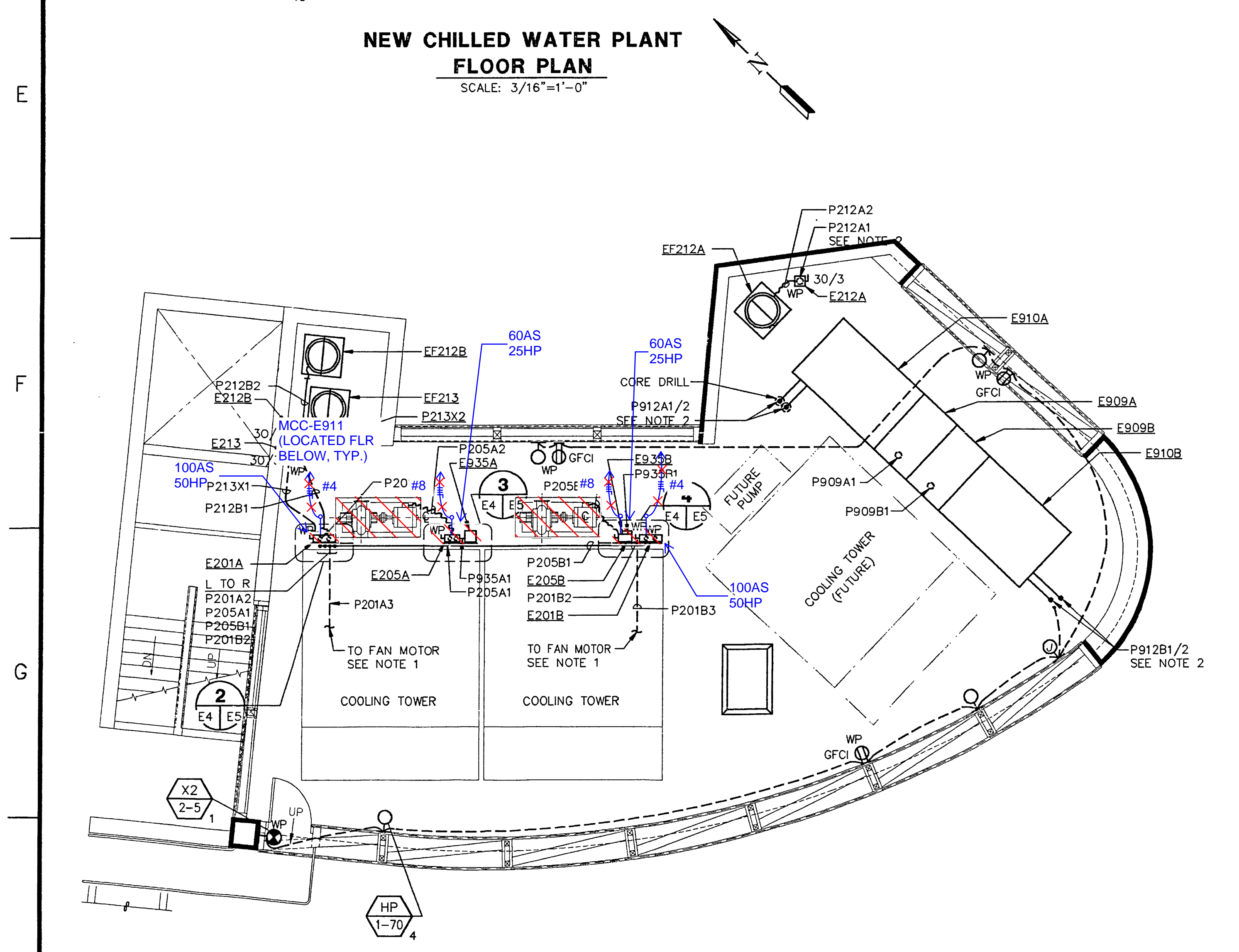
LAKE

CONDENSER WATER DIAGRAM  
NTS

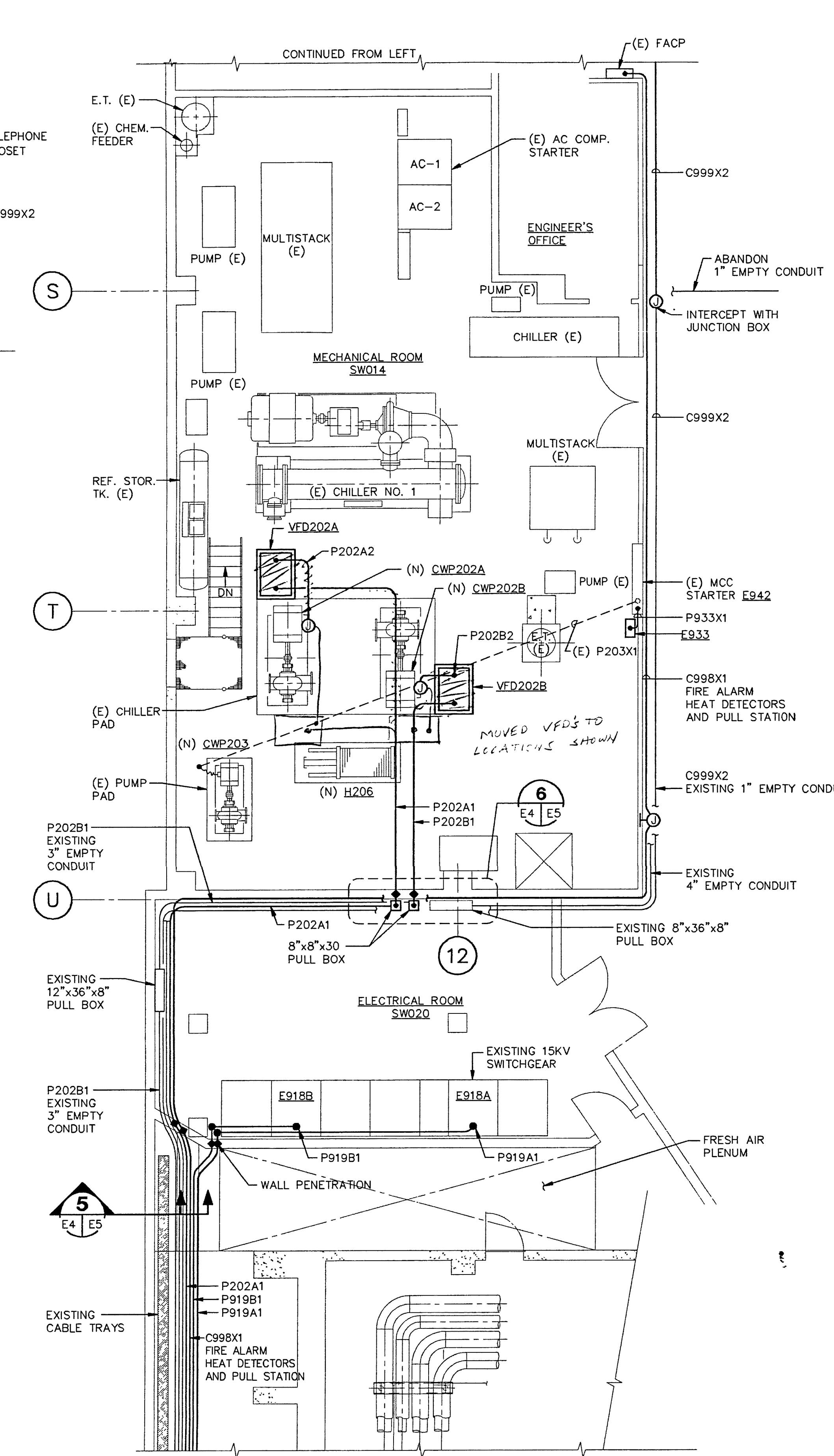




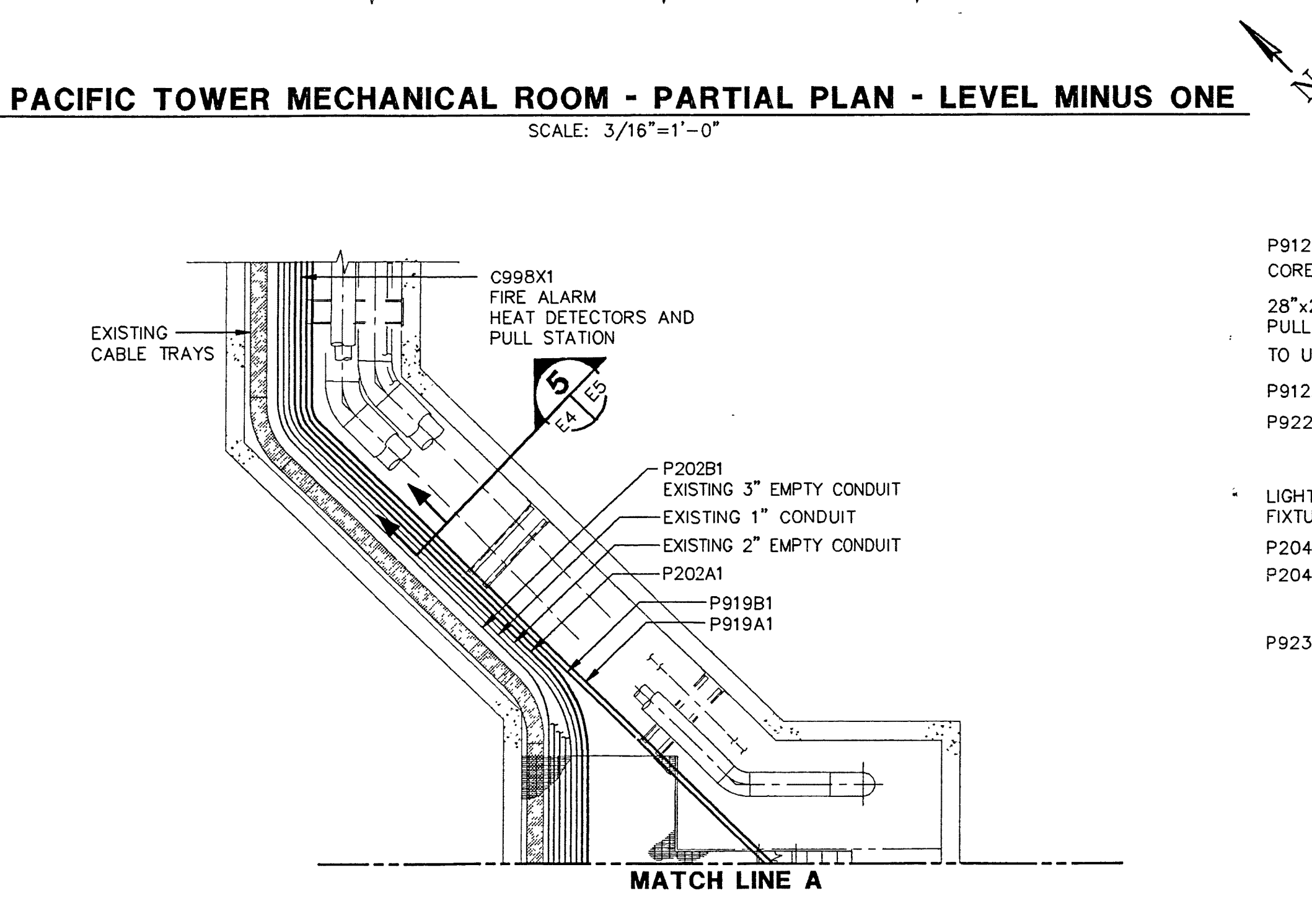
NEW CHILLED WATER PLANT  
FLOOR PLAN  
SCALE: 3/16"=1'-0"



NEW CHILLED WATER PLANT  
ROOF PLAN  
SCALE: 3/16"=1'-0"



PACIFIC TOWER MECHANICAL ROOM - PARTIAL PLAN - LEVEL MINUS ONE  
SCALE: 3/16"=1'-0"



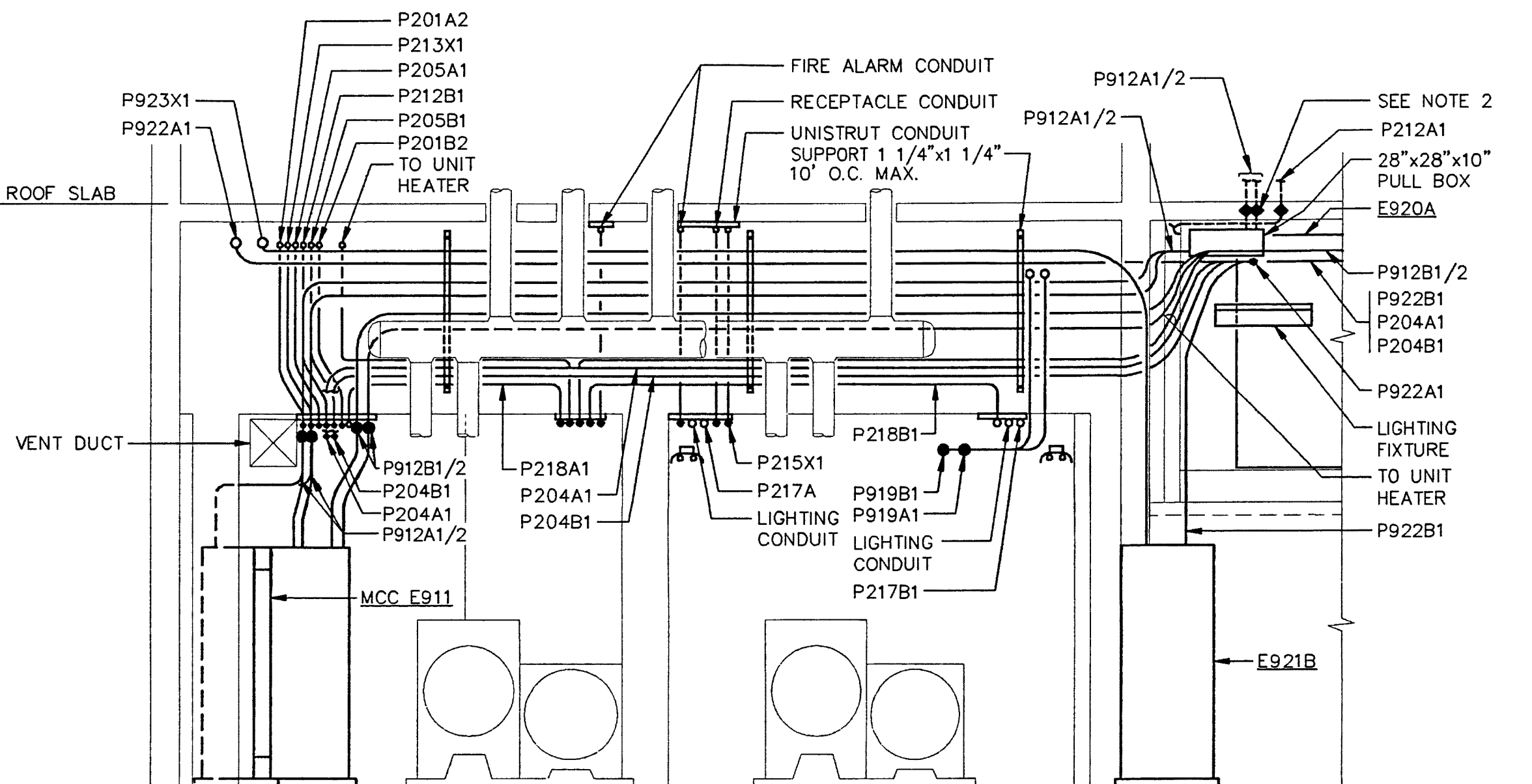
UTILIDOR PARTIAL PLAN  
SCALE: 3/16"=1'-0"

NOTES:

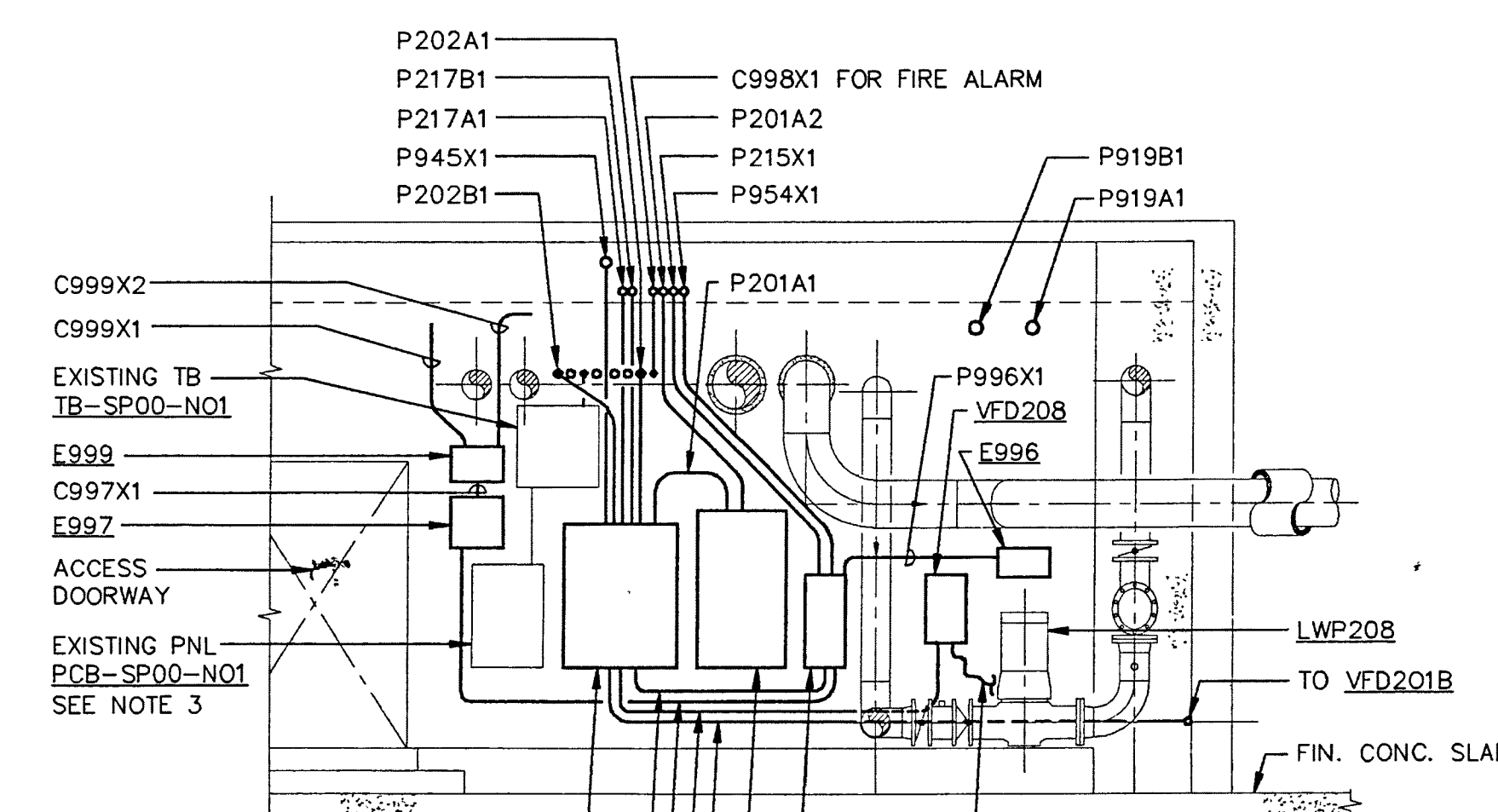
1. REFER TO MECHANICAL PLAN FOR THE EXACT LOCATION OF POWER SERVICE ENTRANCE TO COOLING TOWER FAN MOTOR.
2. REFER TO DWG. NO. A2.2 AND M16 FOR SEALING CONDUIT PENETRATION DETAIL ON WALL AND FLOOR SLAB.
3. REFER TO DWG. NO. E5 FOR (E) PANELBOARD PCB-SP00-NO-1 NEW LOAD SCHEDULE. PANELBOARD WAS PCB-SP02-NO-1.

LIGHTING FIXTURE SCHEDULE

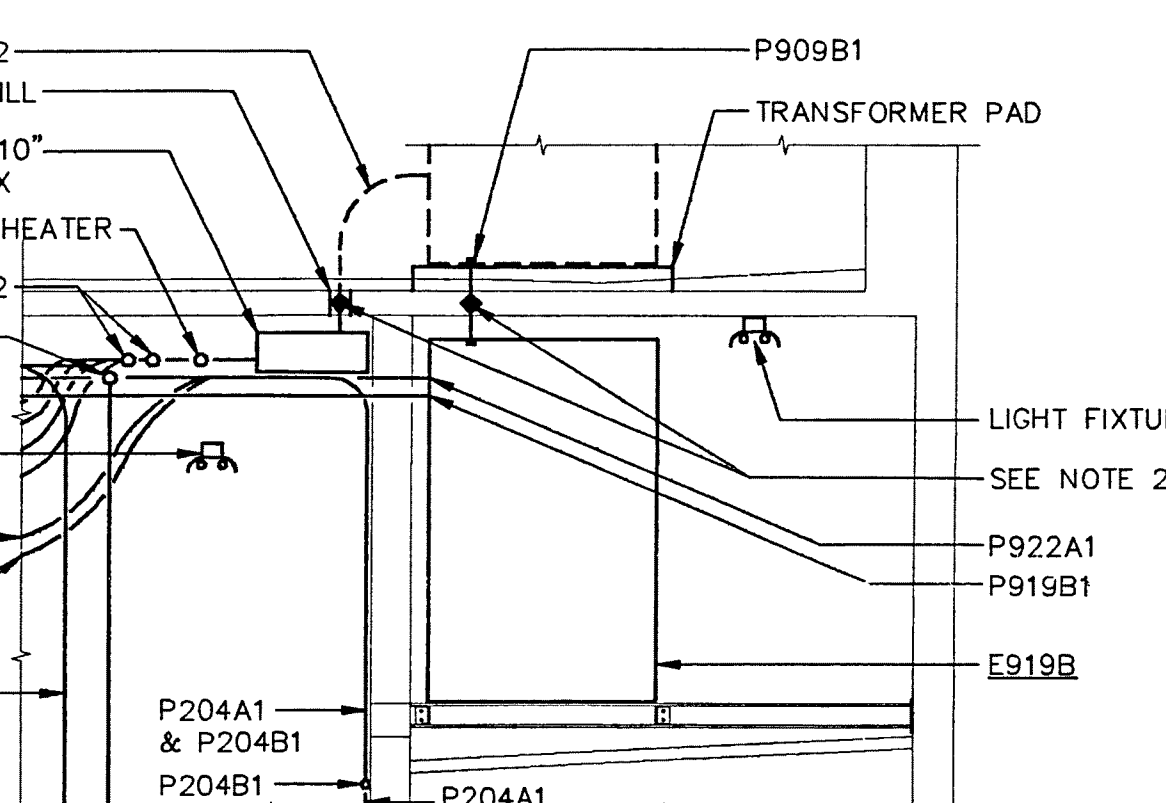
- |    |  |
|----|--|
| F1 | FLUORESCENT, INDUSTRIAL TYPE, 2-40W LAMP, RAPID START, COOL WHITE, WHITE ENAMEL REFLECTOR, SURFACE MOUNTED, 120V.  |
| F2 | SIMILAR TO F1 BUT WITH 90 MINUTES, MINIMUM BATTERY POWER PACK.   |
| HP | OUTDOOR TYPE WALL PACK, WALL MOUNTED, 70W HPS, ONE PIECE INJECTION MOLDED FRONT COVER/REFRACTOR, UV STABILIZED POLYCARBONATE, SEALED AND GASKETED, 120V. |
| X1 | EXIT LIGHT, COMPACT FLUORESCENT LAMPS, 2-5W WITH 90 MINUTES, MINIMUM BATTERY POWER PACK, WALL AND SURFACE MOUNTED, 120V.                                 |
| X2 | SIMILAR TO X1 BUT WEATHERPROOF.  |



SECTION  
SCALE: 1/4"=1'-0"

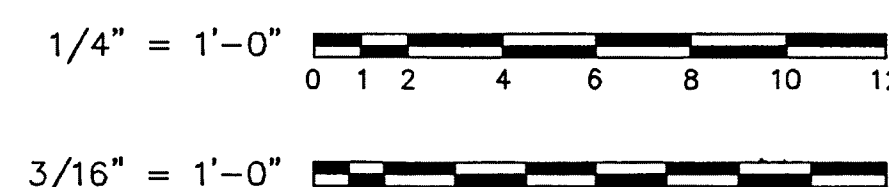


SECTION  
SCALE: 1/4"=1'-0"



SECTION  
SCALE: 1/4"=1'-0"

GRAPHIC SCALE



751928  
ALL ELECTRICAL MATERIALS & EQUIPMENT SHALL BE APPROVED BY THE ELECTRICAL DIVISION OF THE DEPT. OF CONSTRUCTION AND LAND USE. SUBJECT TO FINAL APPROVAL OF FIELD INSPECTOR.

0 5-12-97 ISSUED FOR BID			
SYMBOL	DATE	REVISION DESCRIPTION	DRAWN APP'D
<b>PARSONS BRINCKERHOFF</b> ENERGY SERVICES, INC. 303 SECOND STREET, SUITE 850 NORTH, SAN FRANCISCO, CALIFORNIA 94107			
UNIVERSITY OF WASHINGTON MEDICAL CENTER CHILLED WATER UPGRADE PROJECT			
ELECTRICAL PLANS AND SECTIONS			
DR. SK	DATE	DRAWING NO.	REV
DES. TYS	5/7/97	E4	0
CHK. BL	DATE	SHEET	OF
PRINCIPAL IN CHARGE			
BLDG. NO.: 182		DRAWING NO. E4	
BLDG. ID: UMC		REV 0	
PROJECT NO.: 1890			



# NC® 8400 steel

COOLING TOWER



## Job Information

## Selected By

Custom Mechanical Solutions, Inc. Craig Center  
2517 Eastlake Ave., #200 Tel 206-973-3900  
Seattle, WA 98102  
Craig@cmswa.com

## SPX Cooling Technologies Contact

Olympic Engineered Sales, Inc.  
PO Box 549 Tel 425.454.0701  
Bellevue, WA 98009-0549 Fax 425.454.0229  
OlympicEng@aol.com

## Cooling Tower Definition

Manufacturer	Marley	Fan Motor Speed	1800 rpm
Product	NC Steel	Fan Motor Capacity per cell	40.00 BHp
Model	NC8405TAN3	Fan Motor Output per cell	40.00 BHp
Cells	3	Fan Motor Output total	120.00 BHp
CTI Certified	Yes	Air Flow per cell	137600 cfm
Fan	9.000 ft, 6 Blades	Air Flow total	412700 cfm
Fan Speed	433 rpm, 12243 fpm	Static Lift	12.338 ft
Fans per cell	1	Distribution Head Loss	0.000 ft
		ASHRAE 90.1 Performance	46.9 gpm/Hp

Model Group Standard Low Sound (A)  
Sound Pressure Level 87 dBA (Single Cell), 5.000 ft from Air Inlet Face. See sound report for details.

## Conditions

Tower Water Flow	7000 gpm	Air Density In	0.07276 lb/ft³
Hot Water Temperature	92.90 °F	Air Density Out	0.07134 lb/ft³
Range	9.30 °F	Humidity Ratio In	0.01156
Cold Water Temperature	83.60 °F	Humidity Ratio Out	0.02835
Approach	15.60 °F	Wet-Bulb Temp. Out	87.12 °F
Wet-Bulb Temperature	68.00 °F	Estimated Evaporation	58 gpm
Relative Humidity	50.0 %	Total Heat Rejection	32446000 Btu/h
Capacity	103.9 %		

- This selection satisfies your design conditions.

## Weights & Dimensions

	Per Cell	Total
Shipping Weight	8640 lb	25930 lb
Heaviest Section	8640 lb	
Max Operating Weight	20650 lb	61950 lb
Width	19.920 ft	19.920 ft
Length	9.900 ft	30.275 ft
Height	11.996 ft	

## Minimum Enclosure Clearance

Clearance required on air inlet sides of tower without altering performance. Assumes no air from below tower.

Solid Wall	13.159 ft
50 % Open Wall	10.187 ft

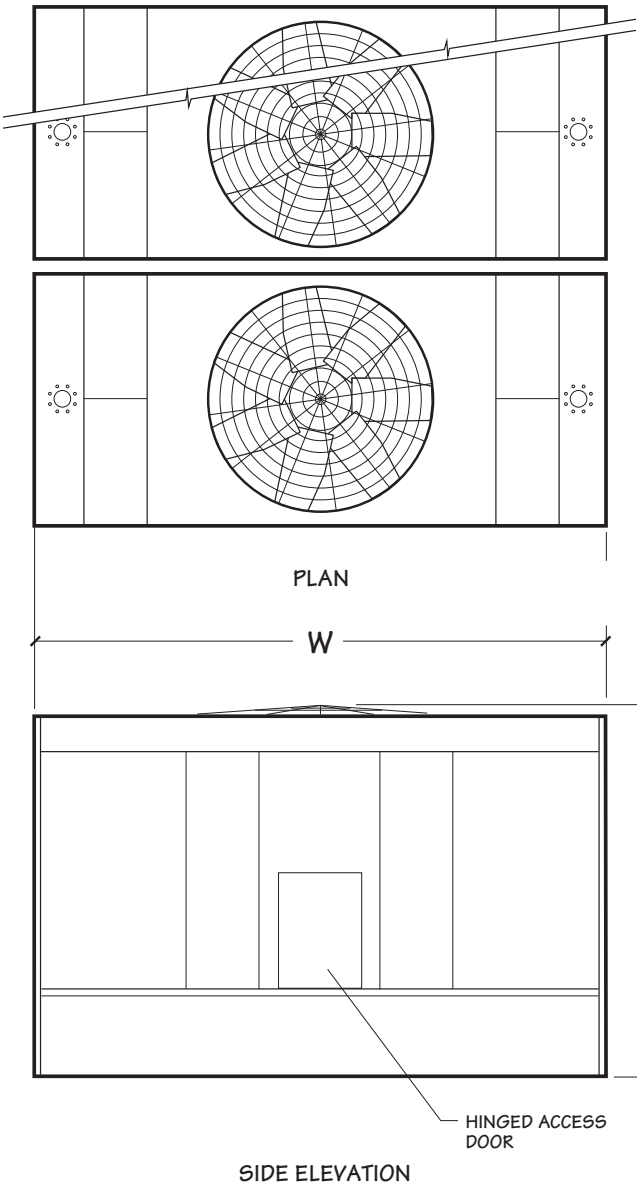
Weights and dimensions do not include options; refer to sales drawings. For CAD layouts refer to file 8405\_ALN.dxf

## Cold Weather Operation

**Heater Sizing** (to prevent freezing in the collection basin during periods of shutdown)

Heater kW/Cell	18.0	15.0	12.0	9.0	7.5	6.0	4.5
Ambient Temperature °F	-17.12	-6.95	3.22	13.39	18.47	23.56	28.64

NC8401 NC8402 NC8403 NC8405

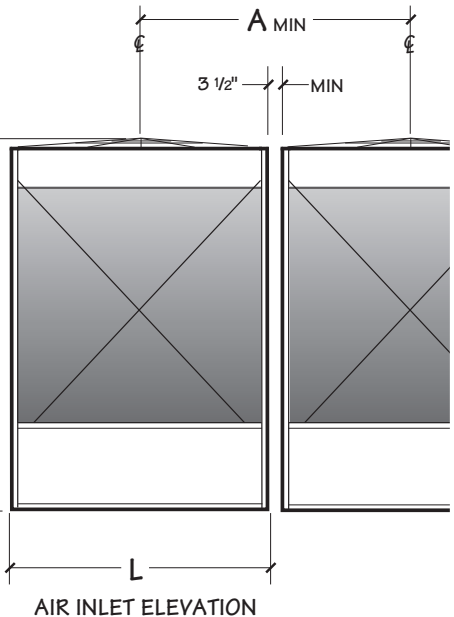


Use this data for preliminary layouts only. Obtain current drawing from your Marley sales representative.

*UPDATE™* web-based selection software, available at [spxcooling.com/update](http://spxcooling.com/update) provides NC model recommendations based on customer's specific design requirements.

*A Sound dBA Approach*

Various low sound options are available from 2 to 19 dB reduction from the standard dBA options in the schematic data table. Consult *UPDATE* selection software for performance, sound levels and dimensions.



## NC8401 NC8402 NC8403 NC8405

Model note 2	Nominal Tons note 3	Motor hp	dBA 5'-0" from air inlet face	Design Operating Weight lb	Shipping Weight lb	Dimensions			
						L	W	H	A
NC8401G-1	101	2	63	7889	4062	6'-6 <sup>1</sup> / <sub>4</sub> "	12'-10"	10'-2 <sup>1</sup> / <sub>2</sub> "	6'-9 <sup>3</sup> / <sub>4</sub> "
NC8401H-1	117	3	65						
NC8401K-1	139	5	71						
NC8401M-1	159	7.5	73						
NC8401N-1	175	10	76						
NC8401P-1	198	15	78						
NC8402G-1	131	2	64	10319	4890	8'-4 <sup>3</sup> / <sub>4</sub> "	14'-2"	10'-3"	8'-8 <sup>1</sup> / <sub>4</sub> "
NC8402H-1	148	3	65						
NC8402K-1	175	5	68						
NC8402M-1	205	7.5	74						
NC8402N-1	228	10	76						
NC8402P-1	256	15	79						
NC8402Q-1	277	20	81	15844	7442	8'-4 <sup>3</sup> / <sub>4</sub> "	18'-2"	11'-11 <sup>1</sup> / <sub>4</sub> "	8'-8 <sup>1</sup> / <sub>4</sub> "
NC8403K-1	213	5	68						
NC8403M-1	243	7.5	72						
NC8403N-1	275	10	76						
NC8403P-1	312	15	79						
NC8403Q-1	342	20	80						
NC8403R-1	366	25	81	19480	8685	9'-10 <sup>3</sup> / <sub>4</sub> "	19'-11"	11'-11 <sup>1</sup> / <sub>4</sub> "	10'-2 <sup>1</sup> / <sub>4</sub> "
NC8403S-1	386	30	84						
NC8403T-1	423	40	85						
NC8405N-1	331	10	74						
NC8405P-1	377	15	76						
NC8405Q-1	412	20	78						
NC8405R-1	445	25	81	19480	8685	9'-10 <sup>3</sup> / <sub>4</sub> "	19'-11"	11'-11 <sup>1</sup> / <sub>4</sub> "	10'-2 <sup>1</sup> / <sub>4</sub> "
NC8405S-1	472	30	84						
NC8405T-1	515	40	87						

## NOTE

- 1 Use this bulletin for preliminary layouts only. Obtain current drawings from your Marley sales representative. All table data is per cell.
- 2 Last numeral of model number indicates number of cells. Change as appropriate for your selection.
- 3 Nominal tons are based upon 95°F HW, 85°F CW, 78°F WB and 3 GPM/ton. The UPDATE web-based selection software provides NC model recommendations based on specific design requirements.
- 4 Standard overflow is a 4" dia. standpipe in the collection basin floor. The standpipe removes for flush-out and draining. See page 18 for side overflow option.
- 5 Outlet sizes vary according to GPM and arrangement. See pages 18 and 19 for outlet sizes and details.
- 6 Makeup water connection may be 1" or 2" dia., depending upon tower heat load, water pressure, and desired connections. See page 13 for additional information.

## Gerry Galvin

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**From:** Gerry Galvin  
**Sent:** Thursday, February 28, 2019 2:57 PM  
**To:** Rob Hinton (UWMC) (rhinton@uw.edu)  
**Subject:** S1 Cooling Towers  
**Attachments:** 19532 - 02 Replace S-1 Towers.pdf

Hi Rob

Following up on our meeting last week, I dug out what we did back in 2013 Re: replacing S1 Cooling Towers

Without the availability of Lake Water this scope will change a little (i.e. will not need the heat exchanger) and the overall chilled water capacity will be reduced without Lake Water to post cool. Other thing that has changed since 2013 is the energy code – they now require more efficient towers that have a larger footprint.

On the side of gaining additional cooling capacity: the potential option now to raise the towers up out of the well (match the Montlake height) and the option of inter-tying with Montlake will help with diversity

Although this is a little outdated the bottom line premise is good i.e. fill the existing well with as much cooling tower capacity as you can.

Prelim Assessment Budget back in 2013 was \$2m. Today \$3m doesn't seem out of line

There would be energy savings with this upgrade

Please let me know if there are any questions

Gerry

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