Central Washington University

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September 19, 2019

Mr. David Schumacher, Director
Washington State Office of Financial
Management Post Office Box 43113
Olympia, Washington 98504-3113

Dear Mr. Schumacher:

Central Washington University's (CWU) Fiscal Year 2020 Supplemental Capital Budget Request is hereby transmitted. This request was developed from careful review of our current 2019-2021 Capital Budget Requests knowing the direction from the Office of Financial Management is to "prioritize our highest priority capital budgets projects needed in addition to the enacted reappropriation-only capital budget."

CWU's 2020 supplemental submitted projects highlight an emphasis on enhancing student and staff safety, preserving existing facilities, and improving aging infrastructure. These supplemental projects are critical to the on-going success of CWU and supports or efforts to provide a safe campus environment with a clear focus on energy efficiencies and stewardship of existing infrastructure. Knowing the capital budget circumstances, CWU has prepared the following submittals:

- Campus Security Enhancements – Fill mission-critical and life-safety gaps in emergency response and preparedness infrastructure in response to a ghost shooter event in winter 2019.

- Chiller Addition – Installation of a new chiller to mitigate temperature control load capacity on newly occupied buildings, Science II, Samuelson Hall, and expected future capital construction projects Health Sciences and Health Education.

- Boiler Replacement – Increases the energy efficiency and life-safety conditions of campus by replacing an aged primary boiler with a new energy efficient boiler.

We look forward to working with the Office of Financial Management as the 2020 supplemental budget recommendations are put forth. If you would like more information or would like to discuss our funding requests, please contact Steve DuPont, CWU Director of Government Relations, 509-963-2111 or Steve.DuPont@cwu.edu.

Sincerely,

James L. Gaudino
President

Office of the President
400 East University Way • Ellensburg WA 98926-7501 • Office: 509-963-2111 • Fax: 509-963-3206 Office location Barge Hall Room 314 • Web: www.cwu.edu/president

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TABLE OF CONTENTS

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			Attachment 1	September 19, 2019	
CENTRAL WASHINGTON UNIVERSITY					
STATE 10-YEAR CAPITAL PLAN					
Projects	**2019-21**	**2021-23**	**2023-25**	**2025-27**	**2027-29**
Minor Works Preservation	$7,000,000	$8,885,000	$9,350,000	$8,965,000	$9,255,000
Minor Works Program	$1,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Health Sciences	$32,000,000				
Campus Security Enhancements	$3,303,000				
Boiler Replacement	$4,656,000				
Chiller Addition	$2,905,000				
Energy Efficiency Systems		$7,439,000			
Aviation Expansion		$9,900,000			
Aviation Acquisition		$5,000,000			
Health Education	$5,000,000	$60,000,000			
Farrell Hall - Design		$3,900,000	$39,000,000		
Randall/Michaelsen Upgrades		$9,900,000			
Psychology Renovation - Predesign		$300,000	$2,100,000	$22,000,000	
Lind Phase 2		$9,900,000			
Bouillon Phase 2		$9,600,000			
Mitchell Renovation		$4,900,000			
CWU Sammamish Acquisition			$9,000,000		
Brooks Library Renovation			$300,000	$5,000,000	$55,000,000
Combined Utilities		$7,000,000	$7,000,000	$7,000,000	$7,000,000
Entrepeneurship/Innovation Complex - Predesign			$300,000	$3,000,000	$30,000,000
Hebeler Renovation			$8,000,000		
Barge Renovation			$9,900,000		
Shaw Smyser Upgrade				$4,900,000	
Street & Mall Reconstruction			$3,000,000	$3,000,000	
Academic Storage Facility			$4,900,000		
Aquatics Building Renovation			$4,900,000		
University Police			$300,000	$2,500,000	$29,000,000
Land & Buildings Acquisition		$2,000,000			
Purser Hall Renovation				$4,900,000	
Language & Literature (L&L Replacement))			$300,000	$4,500,000	$51,000,000
Arts Education Complex - Predesign			$300,000	$4,700,000	$59,900,000
Solid Waste Handling Facility			$200,000	$1,700,000	$15,000,000
Sarah Spurgeon Gallery Upgrades				$2,100,000	
Wilson Creek Relocation/Stormwater				$4,900,000	$4,900,000
Government,Ethics and Civic Engagement Complex - Predesign				$300,000	$2,500,000
Plant Biology Bldg (Greenhouse)					$3,500,000
	$55,864,000	**$143,724,000**	**$103,850,000**	**$84,465,000**	**$272,055,000**

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375 - Central Washington University
Ten Year Capital Plan by Project Class
2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS001
Date Run: 9/19/2019 12:02PM

Project Class: Preservation

Agency Priority	Project by Account-EA Type	Estimated Total	Prior Expenditures	Current Expenditures	Reapprop 2019-21	New Approp 2019-21	Estimated 2021-23	Estimated 2023-25	Estimated 2025-27	Estimated 2027-29
1	**40000074 Campus Security Enhancements**									
	057-1 State Bldg Constr-State	3,303,000				3,303,000				
2	**40000075 Chiller Addition**									
	057-1 State Bldg Constr-State	2,905,000				2,905,000				
3	**40000076 Boiler Replacement**									
	057-1 State Bldg Constr-State	4,656,000				4,656,000				
	Total: Preservation	**10,864,000**				**10,864,000**				

Total Account Summary

Account-Expenditure Authority Type	Estimated Total	Prior Expenditures	Current Expenditures	Reapprop 2019-21	New Approp 2019-21	Estimated 2021-23	Estimated 2023-25	Estimated 2025-27	Estimated 2027-29
057-1 State Bldg Constr-State	10,864,000				10,864,000				

OFM

Ten Year Capital Plan by Project Class

*

Report Number: CBS001
Date Run: 9/19/2019 12:02PM

Parameter	Entered As	Interpreted As
Biennium	2019-21	2019-21
Functional Area	*	All Functional Areas
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Include Enacted	No	No
Sort Order	Project Class	Project Class
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

Allyson Brooks Ph.D., Director
State Historic Preservation Officer

August 13, 2018

Mr. Bill Yarwood
Central Washington University
400 East University Way
Ellensburg, WA 98926-7523

In future correspondence please refer to:
Project Tracking Code: 2018-08-06429
Re: CWU 2019-21 State Capital Budget Request

Dear Mr. Yarwood:

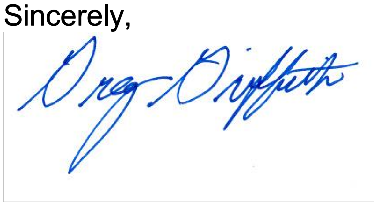
Thank you for contacting the Washington State Department of Archaeology and Historic Preservation (DAHP). Central Washington University's 2019-21 State Capital Budget Priorities Descriptions has been reviewed on behalf of the State Historic Preservation Officer (SHPO) under provisions of Governor's Executive Order 0505. As a result of our review, we are providing the following comments/recommendations:

1) For all funded Capital Budget requests that involve ground disturbing work, please conduct follow-up consultation with DAHP to assess potential to affect archaeological resources.
2) Please keep in mind that Executive Order 0505 also calls for state agencies to make contact with affected and interested tribes in order to obtain their comments about Capital Budget requests.
3) Our comments regarding expansion of Nicholson Pavilion has been provided to you in a separate letter (see DAHP project ID 2018-07-05150).
4) For all funded Capital Budget requests that affect buildings and structures that are 50 (45 recommended) years of age and older, please conduct follow-up consultation with DAHP to assess eligibility of those properties to the National Register of Historic Places.
5) For funded Capital Budget requests that affect buildings and structures that are listed in, or determined eligible for the National Register of Historic Places, please conduct follow-up consultation to assess the effect of the project on historic character-defining features. DAHP always recommends that the Secretary of the Interior's Standards for Rehabilitation (https://www.nps.gov/tps/standards/rehabilitation.htm) be used to guide design and project planning (including additions) that affect National Register listed or eligible buildings and structures.
6) While DAHP typically exempts Executive Order 0505 review of Capital Budget requests for pre-design, we do recommend affording DAHP the opportunity to review pre-design projects to assess whether cultural and historic resources may be affected by the project in future budget requests. The Psychology Building Renovation-Predesign is an example.
7) We appreciate receiving copies of any correspondence or comments from concerned tribes and other parties.

Finally, please note that in order to streamline our responses, DAHP requires that all documents related to project reviews be submitted electronically. Correspondence, reports, notices, photos, etc. must now be submitted in PDF or JPG format. For more information about how to submit documents to DAHP please visit: http://www.dahp.wa.gov/programs/shpo-compliance. To assist you in conducting a cultural resource survey and inventory effort, DAHP has developed guidelines including requirements for survey reports. You can view or download a copy from our website.

Thank you for the opportunity to review and comment. If you have any questions, please contact me at greg.griffith@dahp.wa.gov or 360-586-3073.

Sincerely,



Gregory Griffith
Deputy State Historic Preservation Officer

State of Washington • **Department of Archaeology & Historic Preservation**
P.O. Box 48343 • Olympia, Washington 98504-8343 • (360) 586-3065
www.dahp.wa.gov

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375 - Central Washington University
Capital FTE Summary
2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS004
Date Run: 9/18/2019 11:09AM

FTEs by Job Classification

	Authorized Budget 2017-19 Biennium		2019-21 Biennium	
Job Class	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**
Asst. Dir. Maintenance			0.5	0.5
Capital Projects Architect			1.0	1.0
Cartographer			0.3	0.3
Construction Project Coordinator			2.0	1.0
Engineering Assistant			0.3	0.3
Fiscal Analyst			0.5	0.5
Mgr. Facilities Planning & Construction			1.0	1.0
Program Coordinator			0.5	0.5
Project Manager			1.5	1.5
Records Analyst			0.5	0.5
Total FTEs			**8.1**	**7.1**

Account

	Authorized Budget 2017-19 Biennium		2019-21 Biennium	
Account - Expenditure Authority Type	**FY 2018**	**FY 2019**	**FY 2020**	**FY 2021**
057-1 State Bldg Constr-State			820,000	713,000
063-1 CWU Capital Projects-State			62,000	54,000
Total Funding			**882,000**	**767,000**

Narrative

An escalation factor of 1.5% is included in the labor cost calculations

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OFM

Capital FTE Summary

2019-21 Biennium

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Report Number: CBS004
Date Run: 9/18/2019 11:09AM

Parameter	Entered As	Interpreted As
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget

PRESERVATION BACKLOG REDUCTION PLAN

1. CWU's preservation backlog reduction plan is to preserve the existing campus facilities and infrastructure and provide a series of preservation projects which reduce day-to-day maintenance, reduce preventative maintenance, and defer future preservation projects for longer periods of time. The list of projects to be completed is prioritized according to life safety, and efficient use of facilities and infrastructure, and other relatable fields.

2. The CWU main campus has assessed all buildings over 2,000 square feet utilizing the OFM FCI process. The intent of the assessment process is to provide for an ongoing, living procedure that assists CWU in determining current preservation and backlog issues.

3. The preservation projects listed in the 2019-2021 Minor Works list are scheduled for completion during the 2019-2021 biennium. The specific scope of work for each separate project will be determined by emerging requirements and/or the overall goal of reducing CWU's preservation backlog. A Facility Condition Index of each CWU building is utilized in helping determine which building and/or building system is in the poorest condition and will be updated utilizing available funds. Normal maintenance activities including preventative maintenance on major building systems such as electrical, HVAC, and building envelopes are funded by the state operating budget and continue on a regular basis. This combination of strategically selected preservation minor works projects and CWU’s normal maintenance activities produce building condition scores that are used for determination of a prioritized, preservation minors works list.

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CENTRAL WASHINGTON UNIVERSITY

Strategy for Reducing Greenhouse Gas Emissions

UPDATED 9/4/2018

1. Background

In 2009, the Legislature and Governor adopted the State Agency Climate Leadership Act (Engrossed Second Substitute Senate Bill 5560 – Chapter 519, Laws of 2009). The Act committed state agencies to lead by example in reducing their greenhouse gas (GHG) emissions to:

- 15 percent below 2005 levels by 2020.
- 36 percent below 2005 by 2035.
- 57.5 percent below 2005 levels (or 70 percent below the expected state government emissions that year, whichever amount is greater.)

The Act, codified in RCW 70.235.050-070 directed agencies to annually measure their greenhouse gas emissions, estimate future emissions, track actions taken to reduce emissions, and develop a strategy to meet the reduction targets. The strategy is required by law in RCW 70.235.050 section (3):

> *By June 30, 2011, each state agency shall submit to the department a strategy to meet the requirements in subsection (1) of this section* [greenhouse gas reduction targets]. *The strategy must address employee travel activities, teleconferencing alternatives, and include existing and proposed actions, a timeline for reductions, and recommendations for budgetary and other incentives to reduce emissions, especially from employee business travel.*

Starting in 2012 and every two years after each state agency is required to report to Ecology the actions taken to meet the emission reduction targets under the strategy for the preceding biennium.

CWU Policy 2-50-020 Energy Conservation:
The Governor's Executive Order #E077-3 mandates specific energy conservation efforts and the development of an energy conservation ethic on the campuses of all state institutions.
The energy policy supports the educational mission of the university, since the educational process is dependent upon a controlled environment which utilizes energy. It is structured to provide adequate environmental quality while minimizing expenditures of energy. See the PROCEDURES manual for specific energy policy details.

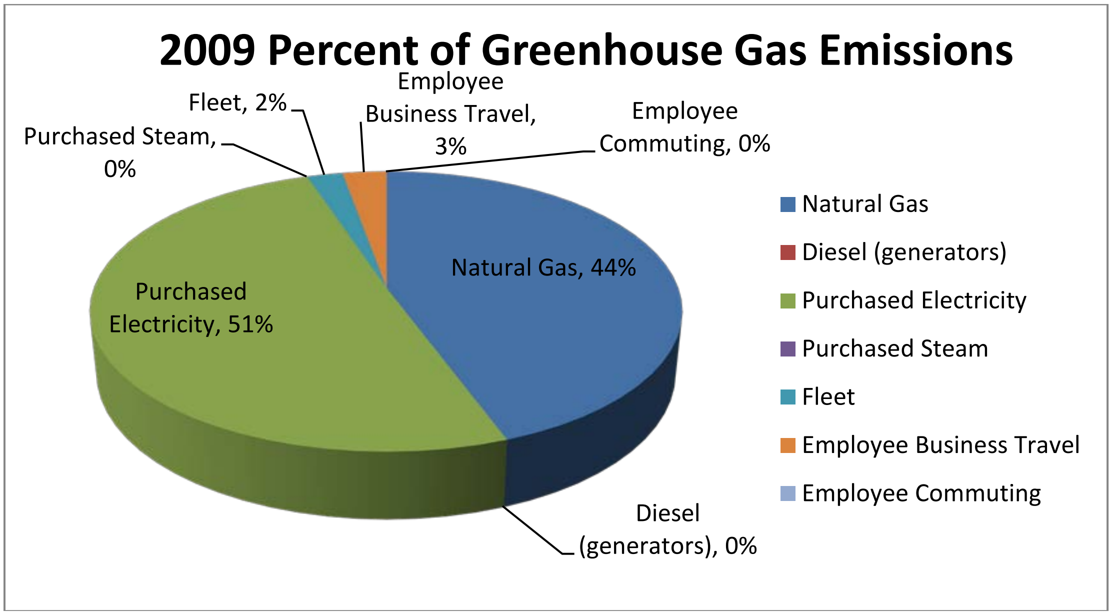
2. Greenhouse Gas Emissions from Agency Operations

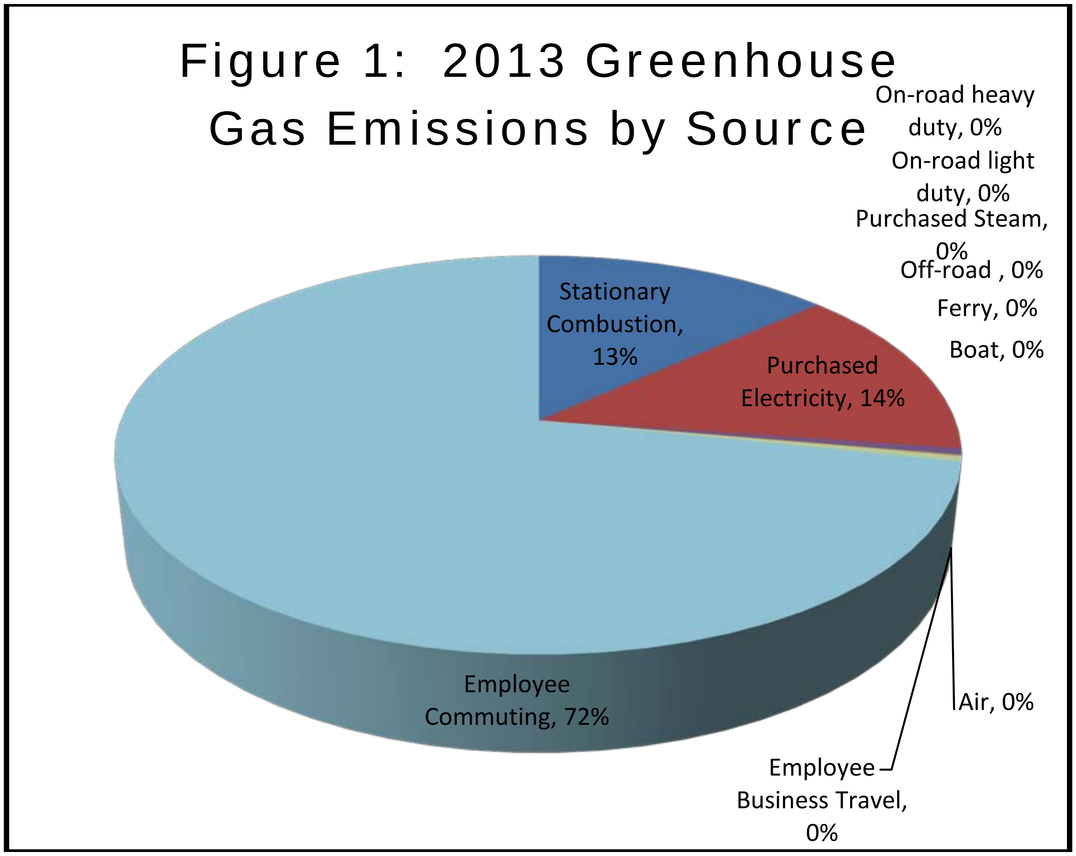
A. Direct sources of GHG emissions from building and fleet energy use

Year	**Greenhouse Gas Emissions** (metric tons carbon dioxide equivalent, $MTCO_2e$)
2005	27,537.5
2009 (Do not include business travel or commuting emission here)	29,780.5
2013 (Do not include business travel or commuting emission here)	28,598.8
2014	28,325.1
2020 (projected)	23,406.9 (85% of yr. 2005
2035 (projected)	17,624.0 (64% of yr. 2005

(Note: Figures do not include GHG emissions from buildings owned by General Administration. However, they do include GHG emissions from use of the GA Motor Pool.)

B. Main sources of direct GHG emissions





C. Greenhouse Gas Reduction Targets

Year	GHG Reduction Target ($MTCO_2e$)
2020 (15% below 2005)	**23,407**
2035 (36% below 2005)	**17,624**
2050 (57.5% below 2005)	**11,703**

D. Level of GHG Reduction Needed to Meet Targets

Year	Amount of GHG Reduction Needed to meet Targets ($MTCO_2e$)
2020	**-4,130.5**
2035	**-9,913.5**

3. Overarching Strategies (if applicable)

The agency identified several cross-cutting strategies to help in reducing GHG emissions:

(Examples may include the following)
- Improve tracking of information used to quantify GHG emissions
- Integrate GHG reduction goals and actions into sustainability efforts and track progress
- Monitor progress, implementation, and develop strategies
- Education/Outreach

4. Greenhouse Gas Reduction Strategies for Direct Emission Sources (Building and Fleet Energy Use)

A. Strategies and Actions with Low to No Cost

Strategies and Actions	GHG Reduction Estimate Annual ($MTCO_2e$)	Upfront Cost Estimate ($)	Payback Period Estimate (Years)	Date to Imple-ment Estimate
Building Energy Use				
2% Energy Reduction: Manage Campus-wide Energy through use of the networked Energy Management System to control building heating/cooling/lighting schedules, temperature set-points, and ventilation to reflect occupied demand. Also, confirm combustion calibration of boilers to minimize losses, fix steam leaks and repair/replace missing pipe/duct insulation as needed.	500	$5,000	1	11-13 biennium
The above efforts are ongoing, however due to 128,229 square feet of new buildings, net $MTCO_2$ continues to grow.				11-13 biennium
The above efforts are ongoing, however due to 117,210 square feet of new buildings, net $MTCO_2$ continues to grow.				13-15 biennium
The above efforts are ongoing, however due to 136,000 square feet of new buildings, net $MTCO_2$ continues to grow.				15-17 biennium
Fleet Energy Use				
1% Fuel Reduction: Encourage carpooling when possible. Minimize trips by encouraging remote internet access to meetings and conferences when possible	8	0	1	11-13 biennium
Purchase hybrid vehicles as replacements to less fuel efficient older vehicles	17	$131851.05	25	13-15 biennium
Maximize usage of all electric maintenance fleet vehicles	15	0	1	15-17 biennium
TOTALS:	540	$136851.05	N/A	N/A

B. Strategies and Actions with Payback up-to Twelve Years (or other time period determined by your agency)

Strategies and Actions	GHG Reduction Estimate ($MTCO_2e$)	Upfront Cost Estimate ($)	Payback Period Estimate (Years)	Date to Imple-ment Estimate
Building Energy Use				
Optimize lab ventilation in the CWU Science Facility to reduce ventilation load and coordinate ventilation to occupancy using occupancy sensors. **Completed.**	823	$577,700	5	11-13 biennium
Remove the Getz-Short Apartment Complex from the central boiler plant to avoid replacing 600 linear feet of old poorly insulated direct buried steam line. Replace space heat and domestic hot water heat from 208steam to on-site high efficiency gas boilers. **Completed.**	208	$300,000	8.1	11-13 biennium
Replace the dysfunctional economizer dampers in the air handlers of the CWU Library and Farrell Hall. **Completed.**	77.5	$82,487	6.4	11-13 biennium
Install a swimming pool blanket system in the CWU pool and upgrade controls to pool pump and ventilation system. **Completed.**	159.5	$201,557	8.8	11-13 biennium
Upgraded 2000 linear feet of old direct buried steam pipe with new insulated system. **Completed.**	1350	$8,000,000	12	11-13 biennium
Capital request for cogeneration feasibility study at CWU	n/a	$500,000	1	17-19 biennium
Fleet Energy Use				
TOTALS:	2,618	$9,661,744	N/A	N/A

C. Strategies and Actions with High Cost and Long Payback (more than 12 years or other time period determined by your agency)

Strategies and Actions	GHG Reduction Estimate ($MTCO_2e$)	Upfront Cost Estimate ($)	Payback Period Estimate (Years)	Date to Imple-ment Estimate
Building Energy Use				
Adding a new 117,210 square foot science building that will be solely heated with Heating/Cooling Plant stack heat recovery system resulting in no net increase in Natural Gas consumption **Completed**	10883	$7,415,004	15	15-17 biennium
Capital request to complete upgrades to steam distribution system and boiler replacement. **Completed**	700	$8,000,000	25	15-17 biennium
Capital request to extend campus central steam distribution in order to eliminate satellite boilers in two student housing complexes	500	$1,700,000	20	17-19 biennium
Capital request to replace two aging central plant steam boilers with new models utilizing current emissions technology	1,500	$6,800,000	20	17-19 biennium
Fleet Energy Use				
TOTALS:	13,583	$23,915004	N/A	N/A

5. Greenhouse Gas Reduction Strategies for Other Emission Sources (Employee Business Travel and Commuting)

The agency also quantified greenhouse gas emissions from employee commuting and business travel. GHG emissions from these sources were not included in the 2005 baseline because of insufficient data, and are therefore are not included in the reduction targets. Also, the agency has less operational control over these sources. The agency evaluated these sources separately in this strategy and identified reduction strategies for these sources.

Source of GHG Emissions	**GHG Emissions** ($MTCO_2e$)
Business Travel (2009)	839.5
Business Travel (2013)	n/a
Employee Commuting (2009)	n/a
Employee Commuting (2013)	n/a

Strategies and Actions	**GHG Reduction Estimate ($MTCO_2e$)**	**Upfront Cost Estimate ($)**	**Payback Period Estimate (Years)**	**Date to Imple-ment Estimate**
Employee Business Travel				
Encourage carpooling/telecommuting	50	$0	1	17-19 biennium
Employee Commuting				
Encourage carpooling	50	$0	1	17-19 biennium
TOTALS:	100	$0	N/A	N/A

6. Additional Sustainability Strategies and Actions (if applicable)

Strategies and Actions	**Co-benefits for GHG Reduction**	**Implementation Date Estimate**
n/a		

7. Next Steps and Recommendations

Next Steps: The 15-17 capital request for the Biomass combined heat and power plant was submitted but not funded. We are actively implementing all the above projects for the current/future biennia. The 17-19 capital request asked for a cogeneration feasibility study, removal of satellite campus boilers and replacement of aging central plant boilers. CWU has a long track record (18 years) of reducing energy consumption. Electrical and Natural Gas consumption have decreased despite adding 500K of square footage.

Recommendations: Without major funding for conversion away from fossil fuels, there is no way to effectively reduce CO_2 emissions.

Contact: Hunter Slyfield at (509) 963-1195 or hunter.slyfield@cwu.edu

Note: Information was e-mailed to joanna.ekrem@ecy.wa.gov, Hedia.adelsman@ecy.wa.gov, and Karisa.duffey@ecy.wa.gov . Included the agency acronym, the word GHG strategy, and the submission date – for example, ECY GHG Strategy June 30 2011.doc.

File location: J:\Admin\Reporting\DOE\GHG\2016\CWU GHG Strategy Updated_09-04-18.docx

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Preservation Projects Narrative

<u>Project Selection Process</u>

The identification of preservation projects for the capital budget request is on-going throughout each biennium. During a biennial period, the need for such projects is determined through the following activities:

- Work order system tracking of building systems and infrastructure
- Safety inspections
- Code required upgrades
- Architectural and engineering studies
- Facility Condition Index (FCI) assessment process of campus buildings

<u>Tie to Institutional Strategic Plan/Priorities of Government</u>

The criterion that is used to select appropriate projects is a combination of the standardized OFM FCI assessment process, ongoing surveillance and evaluation of existing and emergent conditions. The list of projects in this budget request was developed in support of the university's strategic plan through a process of prioritization, which was submitted to the Board of Trustees for their review and approval.

Projects that remodel and renovate outdated facilities with state-of-the-art technology improve the value of the educational experience, improve the options of the graduate in selecting employment, and extend the useful life of the structure. All of the preservation and program minor works projects are aimed at preserving the state's facilities and making them safer, more environmentally friendly, and lengthening their useful live. Especially the minor works preservation projects, but many others, update facilities systems for the comfort of the occupants, remove paints and other items found to be toxic or not well tolerated, update building interiors for safety reasons, and update building infrastructure for the safety of the occupants.

<u>Program Impact of Deferral</u>

The impact on individual buildings and programs in one of the criteria used to select and prioritize projects. The preservation plan is designed to preserve the existing campus facilities and infrastructure and to provide a series of preservation projects which reduce day-to-day maintenance, reduce preventative maintenance, and defer projects with lesser degrees of risk to inhabitants, facility systems, and buildings.

Maintenance History

Maintenance history is tracked by the Facilities Management Department work order system. This information is used as one criterion in determining the future importance of which preservation projects to fund. For instance, if a building system requires high maintenance, this is an indicator that the system may have to be replaced as a future preservation project.

Cost of Preservation versus Replacement

Pre-design and feasibility studies are commissioned to provide estimated cost data to determine if a building requires a major upgrade or replacement. Studies are initiated when a building requires more than a normal amount of maintenance or preservation. CWU uses the OFM philosophy of comparing the current replacement cost of a building vs. upgrade cost.

375 - Central Washington University
Capital Project Request

2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: **40000074**
Project Title: **Campus Security Enhancements**
Project Class: **Preservation**

Description

Starting Fiscal Year: 2020
Agency Priority: 1

Project Summary

In winter 2019, a "ghost" active shooter event revealed serious deficiencies in campus security infrastructure, which could lead to the loss of human life in the case of an active shooter. CWU is requesting $3,302,645 to purchase electronic building locking systems, a video security system, and emergency blue-light phone upgrades. These upgrades are necessary to ensure the safety of the approximately 10,000 students, 1,200 employees and daily visitors on-campus.

Project Description

Problem Statement:

In February 2019, CWU was rocked by numerous reports of gunshots and shooters in buildings on the Ellensburg campus. Students and employees created and spread hearsay about shooters using text and social media. At the height of the event, police had reports of shooters in no fewer than four buildings at once. The event eventually proved to be false, but not before it engaged no fewer than ten local, state and federal law enforcement agencies, shut down the campus and terrified students, parents, and employees all over the state.

The ghost event revealed the urgent need to modernize facilities and systems that would help keep people safe should an actual shooter event occur. Approximately 10,000 students and 1,200 state employees populate the campus and on any given day, the campus may host as many as 18,000 additional visitors. Ensuring the safety of these people is an urgent priority for the state as well as for the university.

Since February, CWU has self-funded the expansion of public safety and preparedness systems and culture at all campus locations, including but not limited to the following activities and investments:

- Incident Command System Training for staff
- Executive policy group table-top exercises
- Emergency Operations Center training and exercises
- Department-specific tabletop exercises
- New building coordinator program
- New chemical inventory-management system
- Adding emergency management staff to the Environmental Health & Safety Council
- Expanding online emergency and disaster preparedness for staff and faculty
- Monthly preparedness training events
- Increasing involvement with the local community emergency planning committee
- FEMA Integrated Emergency Management community training
- Becoming an official National Weather Service Weather-Ready Ambassador

In spite of this work, CWU still needs to fill gaps in emergency response and preparedness. CWU seeks state capital budget support to improve the university's response capabilities as well as to improve preparedness. Key aspects of a capital budget request include the following.

Safety Equipment Costs

375 - Central Washington University
Capital Project Request
2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: **40000074**
Project Title: **Campus Security Enhancements**
Project Class: **Preservation**

Description

1.Electronic Locking Systems	$1,860,000
1.Video Security System	$622,645
1.Blue Light Phones Upgrade	$820,000
TOTAL	$3,302,645

Project Components:
Modern technology can dramatically improve the effectiveness and efficiency of a small public safety unit like the CWU Police and Public Safety force. **The following outlines, in priority order, proposed investments in CWU's security and public safety infrastructure.**

1. Electronic Door-Locking Capability

The age of buildings on the CWU campus ranges from 127 years to 1 year. Only three can be locked down electronically: Science II, Samuelson, and the SURC. This technology allows first responders to electronically lock entry to exterior doors of a building, while still allowing exit capability. This capability is essential when addressing everything from chemical contamination of water to a moving threat, like a single shooter.

The total number of exterior doors that require electronic locking is approximately 229. The costs associated with upgrading exterior doors as well as classrooms and other interior doors include the following:

Item	Costs
Exterior	
New Doors for McConnell	$90,000
Installation and equipment	$1,600,000
Interior	
Locks & Cylinders	$120,000
Extra Parts	$20,000
Labor	$30,000
Total	**$1,860,000**

2. Video Security System

CWU now operates very few security cameras on the Ellensburg campus, which covers approximately 350 acres. About 60 cameras are located in the Student Union Recreation Center (SURC). A few cameras dedicated to construction projects also are stationed at points on campus, however these cameras, are not connected to a public safety monitoring station and are not

Project Number: **40000074**
Project Title: **Campus Security Enhancements**
Project Class: **Preservation**

Description

controllable remotely.

A new video system will build on the current video infrastructure, and be adjusted to ensure sustainability for the next decade and for video-system expansion in the future. An external video security system can provide an additional layer of security at remote areas and those that are hard to patrol (e.g. due to location or vegetation). As well, systems may be used to monitor hazardous material storage and utility infrastructure.

CWU proposes to purchase and mount 65 cameras throughout key service areas on campus. Had these cameras been in place during CWU's ghost event, police would have been able to instantaneously check buildings of concern for single shooters. Cameras can be accessible remotely by cellular or laptop application, as well as in a security operations center through desktop. Mounting the cameras on the exterior of buildings and elevated ensure optimal vantage points in conjunction with camera capabilities. The costs associated with upgrading to this capability and information technology upgrades for sustainability for 65 cameras are:

Product
Costs ea.
Total
Camera-SN-WR632C Outdoor
$4,000
$192,000
Mounts
$165
$7,920
Camera- SNC-VB642D
$1,000
$8,000
Mounts
$50
$400
Camera- SNC-XM637
$500
$4,500
Mounts
$25
$225
Cisco UCS expansion
$19,600
$19,600
Installation
$6,000
$390,000
Total
$622,645
Operating Impacts:
Annual Maintenance

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: **40000074**
Project Title: **Campus Security Enhancements**
Project Class: **Preservation**

Description

	$500
	$32,500
Annual Licensing	
	$168
	$10,920
	Total
	$43,420

3. Blue Light Phones
CWU currently has 28 emergency blue-light phones (EBLs) on the Ellensburg campus. These phones have the upgrade capability to house cameras and mass notification systems. However, these EBLs currently lack the infrastructure to operate during a power outage; backup power consists of a 12v battery within the phone system. The EBLs need to be upgraded to ensure seamless operation of cameras and outdoor warning systems. As well, at 12 years of age, the phones are out of date and need to be upgraded to support new technology.

The EBLs do not have voice capacity required for mass notification. Furthermore, the height in which the mass notification system will be mounted at and the location of the EBL's are not optimal for the mass notifications to be successful. Many are located near buildings that reverberation could be a concern, as well as the height of the mounting may cause a reduction of decibel level of the system.

Video camera mounting on top of the EBLs can be possible, however installation and operation are problematic. Along with the similar wiring that must occur from buildings to the EBLs for the capability, mounting of the system is not to the optimal height to achieve preferred situational awareness in the event of an emergency or for standard viewing. At the height of mounting, cameras face challenges of vegetation growth and reduction of viewpoints from other sources.

Product Costs	
EBL Upgrade	$230,000
EBL New Purchase	$320,000
Installation	$270,000
Total	**$820,000**
Operating Impact:	
Annual Maintenance	$28,000
Monthly Line Charges	$8,736
Total Annual Operating Impact	$36,736

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: **40000074**
Project Title: **Campus Security Enhancements**
Project Class: **Preservation**

Description

Problems addressed:

1. Electronic Door-Locking Capability

Currently, CWU can only remotely secure three of its 94 buildings in the case of an emergency. In the case of a moving threat, there would be no way to limit the mobility and access of the threat or the CWU personnel seeking protection. This technology would prevent an active shooter or assailant of any kind from gaining access to any buildings from outside. This would create a safe harbor for civilians who are inside buildings and not exposed. Furthermore, this technology would still allow people to exit and flee in case the threat is already inside.

2. Video Security System

Currently, if a 911 call is placed and a threat is reported, on-campus law enforcement must verify the validity of the threat in-person. Therefore, all reported threats must be assumed legitimate. A network of cameras allows law enforcement to locate threats in real-time and respond accordingly. Knowing the location of an active shooter will inform the deployment of police to neutralize the threat and for medical personnel to treat casualties. The network of cameras can also inform students and staff who are not near the threat so that they do not panic, stampede, or accidentally head towards the threat.

3. Blue Light Phones

Currently, CWU has an existing emergency blue-light phone network that is out-of-date and of limited capability. However, upgrading the EBLs will allow for mass notification as well as a ground-level video monitoring of campus sidewalks and landscape areas. This upgrade would be significant for enhancing outdoor campus security.

Alternatives explored:

Since the event that served as the impetus for this package happened less than a year ago, this is CWU's first attempt to enhance campus security infrastructure in a comprehensive way. The information presented in this proposal was gathered from current vendors, potential vendors and through current CWU stakeholders. It articulates the most-needed upgrades.

Clientele impacted:

This package enhances safety for 10,000 students, 1,200 employees, independent contractors, up to 18,000 visitors per day, first-responders, and Ellensburg residents.

Fund sources:

Since the aforementioned ghost event occurred so recently, no other potential funding source has been identified. Due to its unforeseen and emergent nature, CWU seeks funding from the 2020 supplemental capital budget.

Strategic & Campus Master Plans:

CWU STRATEGIC PLAN

The mission of Central Washington University is to prepare students for enlightened, responsible, and productive lives; to produce research, scholarship, and creative expression in the public interest; and to serve as a resource to the region and the state through effective stewardship of university resources.

The CWU Strategic Plan discusses the advancement of this mission through a specific vision, values, and core themes. One of the stated shared values in the plan is safety. The plan states "CWU believes it has a responsibility to provide a working and learning environment that is both physically and emotionally safe. CWU believes this responsibility extends to the off-campus environment of its full-time, residential students."

This shared value of safety is a necessary prerequisite to the execution of the entire strategic plan. In order to accomplish the academic mission of CWU, students, faculty, and staff must be protected from bodily harm. The sad reality of the era in which we now live is that CWU must be prepared to respond to an active shooter situation. This budget request is an urgent need for the health, safety, and well-being of the campus community.

CWU CAMPUS MASTER PLAN 2019-2029

The plan expresses an integrated vision of the development of the university environment that serves many functions: teaching and learning, business and support systems, student life, as well as platforms for communication and data transmission, public

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: 40000074
Project Title: Campus Security Enhancements
Project Class: Preservation

Description

safety, and utilities.
The campus facilities vision statement is informed and supported by ubiquitous digital technologies that connect people to teaching and learning, data, entertainment, and to each other, 24/7. Modern systems ensure the physical safety of people, and the security of personal information and intellectual property. Throughout, efficiency and sustainability are priorities. The vision is supported by thorough and true-cost budgeting, innovative funding, and rigorous stewardship

Academic quality is a priority. New facilities will be flexible and support integrated, multidisciplinary programming. CWU will develop funding strategies to ensure facilities are safe, modern, and supportive of academic goals.

Regarding green space, a stated goal in the plan is to enhance the safety of and accessibility of green spaces. The updates to the emergency blue-light phones will be crucial to making the outdoor green spaces safe and secure.

The theme of safety is throughout the plan concerning all types of campus facilities. This proposal would be campus-wide infrastructure and is necessary to achieve the safety goals in the Campus Master Plan.

Location
City: Ellensburg **County:** Kittitas **Legislative District:** 013

Project Type
Infrastructure (Major Projects)

Growth Management impacts
CWU is required to comply with the Jeanne Clery act. This federal law requires timely notification of emergencies occurring on or around campus. Central Washington University (CWU) is required to adhere to the State Environmental Policy Act (SEPA). The SEPA process is where growth management act impacts are considered. CWU coordinates planning efforts with all applicable city and county jurisdictions.

Funding

Acct Code	Account Title	Estimated Total	Expenditures: Prior Biennium	Expenditures: Current Biennium	2019-21 Fiscal Period: Reapprops	2019-21 Fiscal Period: New Approps
057-1	State Bldg Constr-State	3,303,000				3,303,000
	Total	**3,303,000**	**0**	**0**	**0**	**3,303,000**

Acct Code	Account Title	Future Fiscal Periods: 2021-23	2023-25	2025-27	2027-29
057-1	State Bldg Constr-State				
	Total	**0**	**0**	**0**	**0**

Schedule and Statistics

Start Date	End Date

375 - Central Washington University
Capital Project Request

2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: 40000074
Project Title: Campus Security Enhancements
Project Class: Preservation

Schedule and Statistics

	Start Date	End Date
Predesign		
Design	9/1/2019	9/1/2019
Construction	3/1/2020	12/1/2020

	Total
Gross Square Feet:	0
Usable Square Feet:	0
Efficiency:	
Escalated MACC Cost per Sq. Ft.:	0
Construction Type:	Other Non-Building Projects
Is this a remodel?	No
A/E Fee Class:	D
A/E Fee Percentage:	9.30%

Cost Summary

		Escalated Cost	% of Project
Acquisition Costs Total		**0**	**0.0%**
Consultant Services			
Pre-Schematic Design Services		0	0.0%
Construction Documents		0	0.0%
Extra Services		0	0.0%
Other Services		0	0.0%
Design Services Contingency		0	0.0%
Consultant Services Total		**0**	**0.0%**
Maximum Allowable Construction Cost(MACC)	**3,049,534**		
Site work		3,049,534	92.3%
Related Project Costs		0	0.0%
Facility Construction		0	0.0%
GCCM Risk Contingency		0	0.0%
GCCM or Design Build Costs		0	0.0%
Construction Contingencies		0	0.0%
Non Taxable Items		0	0.0%
Sales Tax		253,111	7.7%
Construction Contracts Total		**3,302,645**	**100.0%**
Equipment			
Equipment		0	0.0%
Non Taxable Items		0	0.0%

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375 - Central Washington University
Capital Project Request
2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:03PM

Project Number: 40000074
Project Title: Campus Security Enhancements
Project Class: Preservation

Cost Summary

	Escalated Cost	% of Project
Equipment		
Sales Tax	0	0.0%
Equipment Total	**0**	**0.0%**
Art Work Total	**0**	**0.0%**
Other Costs Total	**0**	**0.0%**
Project Management Total	**0**	**0.0%**
Grand Total Escalated Costs	**3,302,645**	
Rounded Grand Total Escalated Costs	**3,303,000**	

Operating Impacts

Total one time start up and ongoing operating costs

Acct Code	Account Title	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
FTE	Full Time Employee		0.6	0.6	0.6	0.6
057-1	State Bldg Constr-State	10,900	80,156	80,156	80,156	80,156
	Total	**10,900**	**80,156**	**80,156**	**80,156**	**80,156**

Narrative

Video Security System - Annual licensing of $10,920 and 0.35 IS FTE for $32,500. Blue Light Phones - 0.3 IS FTE for $28,000 and monthly line charges for 28 lines at $26 per line $8,736

Capital Project Request

2019-21 Biennium

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Parameter	Entered As	Interpreted As
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000074	40000074
Sort Order	Project Class	Project Class
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

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Cost Estimate Number:	183	**Report Number:**	CBS003
Cost Estimate Title:	Campus Security Enhancements	**Date Run:**	9/19/2019 12:37PM
Version:	SF CWU Supplemental Capital Submitted	**Agency Preferred:**	Yes
Project Number:	40000074		
Project Title:	Campus Security Enhancements		
Project Phase Title:			

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:	0
Usable Sq. Ft.:	0
Space Efficiency:	
MACC Cost per Sq. Ft.:	0
Escalated MACC Cost per Sq. Ft.:	0
Remodel?	
Construction Type:	Other Non-Building Projects
A/E Fee Class:	D
A/E Fee Percentage:	9.30%

Schedule

	Start Date	End Date
Predesign:		
Design:	09-2019	09-2019
Construction:	03-2020	12-2020
Duration of Construction (Months):	9	

Cost Summary Escalated

Acquisition Costs Total			**0**
Pre-Schematic Design Services		0	
Construction Documents		0	
Extra Services		0	
Other Services		0	
Design Services Contingency		0	
Consultant Services Total			**0**
Site work		3,049,534	
Related Project Costs		0	
Facility Construction		0	
Construction Contingencies		0	
Non Taxable Items		0	
Sales Tax		253,111	
Construction Contracts Total			**3,302,645**
Maximum Allowable Construction Cost(MACC)	**3,049,534**		
Equipment		0	
Non Taxable Items		0	
Sales Tax		0	
Equipment Total			**0**
Art Work Total			**0**
Other Costs Total			**0**
Project Management Total			**0**
Grand Total Escalated Costs			**3,302,645**
Rounded Grand Total Escalated Costs			**3,303,000**

Additional Details

Alternative Public Works Project: No

OFM

375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

*

Cost Estimate Number:	183	**Report Number:**	CBS003
Cost Estimate Title:	Campus Security Enhancements	**Date Run:**	9/19/2019 12:37PM
Version:	SF CWU Supplemental Capital Submitted	**Agency Preferred:**	Yes
Project Number:	40000074		
Project Title:	Campus Security Enhancements		
Project Phase Title:			

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Additional Details

State Construction Inflation Rate:	3.18%
Base Month and Year:	09-2019
Project Administration By:	AGY
Project Admin Impact to DES that is NOT Included in Project Total:	$0

375 - Central Washington University
Cost Estimate Detail
2019-21 Biennium

*

Cost Estimate Number: 183 **Analysis Date:** September 13, 2019
Cost Estimate Title: Campus Security Enhancements

Detail Title: Main Data
Project Number: 40000074
Project Title: Campus Security Enhancements
Project Phase Title:
Location: Kittitas County

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:
Usable Sq. Ft.:
Rentable Sq. Ft.:
Space Efficiency:
Escalated MACC Cost per Sq. Ft.:
Escalated Cost per S. F. Explanation

Construction Type:	Other Non-Building Projects
Remodel?	No
A/E Fee Class:	D
A/E Fee Percentage:	9.30%
Contingency Rate:	0.00%
Contingency Explanation	

Projected Life of Asset (Years):	20
Location Used for Tax Rate:	Kittitas County
Tax Rate:	8.30%
Art Requirement Applies:	No
Project Administration by:	AGY
Higher Education Institution?:	Yes
Alternative Public Works?:	No

Project Schedule

Project Schedule	Start Date	End Date
Predesign:		
Design:	09-2019	09-2019
Construction:	03-2020	12-2020
Duration of Construction (Months):	9	
State Construction Inflation Rate:	3.18%	
Base Month and Year:	9-2019	

Project Cost Summary

MACC:	$ 3,002,396
MACC (Escalated):	$ 3,049,534
Current Project Total:	$ 3,251,595
Rounded Current Project Total:	$ 3,252,000
Escalated Project Total:	$ 3,302,645
Rounded Escalated Project Total:	$ 3,303,000

ITEM	Base Amount	Sub Total	Escalation Factor	Escalated Cost
CONSULTANT SERVICES				
Construction Documents				
A/E Basic Design Services				192,664
Remove Design	(192,664)			
Other Services				
Bid/Construction/Closeout				86,559
Remove Calculated item	(86,559)			
CONSTRUCTION CONTRACTS				
Site work				
G20 - Site Improvements	3,002,396			
SubTotal: Site work		**3,002,396**	1.0157	**3,049,534**
Sales Tax		**249,199**	1.0157	**253,111**
Total: Construction Contracts		**3,251,595**	1.0157	**3,302,645**
Maximum Allowable Construction Cost (MACC)		**3,002,396**	1.0200	**3,049,534**
PROJECT MANAGEMENT				
Agency Project Management	159,127			
Remove Agemcy PM	(159,127)			

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Cost Estimate Summary and Detail

2019-21 Biennium

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Cost Estimate Number: 183
Cost Estimate Title: Campus Security Enhancements

Report Number: CBS003
Date Run: 9/19/2019 12:37PM

Parameter	Entered As	Interpreted As
Associated or Unassociated	Associated	Associated
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000074	40000074
Cost Estimate Number	183	183
Sort Order	Cost Estimate Number	Number
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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Expected Use of Bond/COP Proceeds

Agency No:	**375**	**Agency Name**	**Central Washington University**
Contact Name:	**Steve DuPont**		
Phone:	**509.963.2111**	**Fax:**	
Fund(s) Number:	**057**	**Fund Name:**	**State Building Construction Account**
Project Number:	**40000074**	**Project Title:**	**Campus Security Enhancements**

Agencies are required to submit this form for all projects funded with Bonds or COPs, as applicable. OFM will collect and forward the forms to the Office of the State Treasurer.

1. Will any portion of the project or asset ever be owned by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
2. Will any portion of the project or asset ever be leased to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
3. Will any portion of the project or asset ever be managed or operated by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
4. Will any portion of the project or asset be used to perform sponsored research under an agreement with a nongovernmental entity (business, non-profit entity, or the federal government), including any federal department or agency? ☐ Yes ☒ No
5. Does the project involve a public/private venture, or will any entity other than the state or one of its agencies or departments ever have a special priority or other right to use any portion of the project or asset to purchase or otherwise acquire any output of the project or asset such as electric power or water supply? ☐ Yes ☒ No
6. Will any portion of the Bond/COP proceeds be granted or transferred to nongovernmental entities (businesses, non-profit entities, or the federal government) or granted or transferred to other governmental entities which will use the grant for nongovernmental purposes? ☐ Yes ☒ No
7. If you have answered "Yes" to any of the questions above, will your agency or any other state agency receive any payments from any nongovernmental entity, for the use of, or in connection with, the project or assets? A nongovernmental entity is defined as ☐ Yes ☒ No
   a. any person or private entity, such as a corporation, partnership, limited liability company, or association;
   b. any nonprofit corporation (including any 501(c)(3) organization); or
   c. the federal governmental (including any federal department or agency).
8. Is any portion of the project or asset, or rights to any portion of the project or asset, expected to be sold to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
9. Will any portion of the Bond/COP proceeds be loaned to nongovernmental entities or loaned to other governmental entities that will use the loan for nongovernmental purposes? ☐ Yes ☒ No
10. Will any portion of the Bond/COP proceeds be used for staff costs for tasks not directly related to a financed project(s)? ☐ Yes ☒ No

If all of the answers to the questions above are "No," request tax-exempt funding. If the answer to any of the questions is "Yes," contact your OFM capital analyst for further review.

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375 - Central Washington University
Capital Project Request

2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:33PM

Project Number: **40000075**
Project Title: **Chiller Addition**
Project Class: **Preservation**

Description

Starting Fiscal Year: 2020
Agency Priority: 2

Project Summary

The intent of the project is to head off an impending shortage of critical cooling capacity, identified by the 2012 Abacus Load Impact Study (see attachment). The analysis concluded an additional chiller would be required when Science II and Samuelson STEM were occupied, and before the completion of new Health Science building, scheduled for January 2022. Cooling capacity is critical to the maintenance of data and computing systems in these state-of-the art STEM building and the research conducted within. As well, without air conditioning, teaching and learning in these facilities in spring and fall quarters will be compromised, when outside temperatures can hover in the 90s or even climb past 100 degrees. CWU has requested but not received state support for chiller capacity for the past two biennia, and now the need is urgent.

Project Description

Identify the problem or opportunity addressed. Why is the request a priority?

In 2012 a revision to the 2002 Central Steam and Chilled Water Load Impact Study proposed modifications to several systems in order to maintain the proper operation of equipment, and building heating and cooling capacity. One portion of that report identified the growing risk of a shortage of cooling capacity associated with the plan expansion of the Science neighborhood of buildings in Ellensburg. The report predicted cooling capacity would be maxed out with the completion of Science II and Samuelson STEM. An additional chiller was proposed to be installed prior to the completion of the Health Science Building in January 2022 in order to avoid a gap in cooling capacity during the building occupancy.

CWU has requested the replacement of this infrastructure five times since 2005, when the first serious failure of the chillers occurred. CWU has requested state support for chiller, boiler, and system expansion since the 2013-2015, biennium (Energy Efficiency Systems). The comprehensive package was proposed at $15 million; Governor Inslee support the package at $10 million for the 2013-15 and the 2017-19 biennia recommendations.

The failure of cooling capacity will impact the effectiveness of teaching and learning in classrooms that become overheated during hot spring, summer and fall weather, common to central Washington. Climate control is essential to temperature-sensitive lab samples, equipment, and conditions required for research and other lab projects.

The central plant on the Ellensburg campus houses three chillers, which are connected to a campus chilled-water distribution system that cools the entire campus. As the infrastructure has aged and building space has expanded, the cooling capacity of the three chillers (approx. 3,600 tons of cooling) has reached its limit with the expansion of the new buildings (Science II and Samuelson).

CWU immediately set out to pro-actively avoid cooling capacity issues with its initial capital request in 2013-2015,2015-2017, again with its 2018 supplemental request, and once more in the 2019-2021 Capital Request. However, each request was denied. The previous request also included larger scopes of work in order to address multiple critical systems simultaneously for efficient pricing and building coordination.

CWU seeks $2.9M for a new, more energy-efficient, modular chiller in order to provide the adequate cooling capacity.

What will the request produce or construct (i.e., building predesign or design, construction of additional space, etc.)? When will the project start and be completed?

The request will accomplish the engineering, procurement and installation of a modular chiller within the existing boiler house. Based up the anticipated 28-week, lead-time, construction would occur in 2021 during the final stages of construction of the New Health Sciences building.

How would the request address the problem or opportunity identified in question #1? What would be the result of nottaking action?

Installation of the new chiller would mitigate the significant risk of temperature control for the new Health Sciences building and surrounding science community. Failure to have this system in place prior to the opening of Health Science will result in fluctuations in temperature that would interrupt the reasonable learning conditions of classrooms, labs and offices spaces. The peak demand cooling capacity may also result in the operation failure of existing equipment being overworked at constant volume leading to multiple buildings experience cooling issues. Many of the academic resources may also be impacted such as scientific equipment, lab samples, consistent lab environments required to accurate lab testing, the microscopic temperature tolerances of sensitive research samples (e.g blood, tissue, plant, microbiota, and other cultures).

What alternatives were explored? Why was the recommended alternative chosen? Be prepared to provide detailed cost backup. If this project has an associated predesign, please summarize the alternatives the predesign considered

375 - Central Washington University
Capital Project Request

2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:33PM

Project Number: **40000075**
Project Title: **Chiller Addition**
Project Class: **Preservation**

Description

No other alternatives were explored because the proposal was previously submitted as a necessary requirement to provide the adequate infrastructure systems to support the Capital Master Plan expansion of campus.

Which clientele would be impacted by the budget request? Where and how many units would be added, people or communities served, etc.

The impacted clientele would include 50 faculty and staff and 500 students who will be the primary occupants of the new Health Sciences building. Due to the layout of the campus distribution piping, cooling capacity issues also will impact residents of in Wendell Hill (residence) Hall, McIntyre Hall (music), Hogue Technology, Barge Hall (administrative), Shaw-Smyser Hall (business), Science II and Samuelson STEM (computational sciences).

Will non-state funds be used to complete the project? How much, what fund source, and could the request result in matching federal, state, local, or private funds.

No non-state funds available that could be used to complete this project.

Describe how this project supports the agency's strategic master plan or would improve agency performance. Reference feasibility studies, master plans, space programming, and other analyses as appropriate

Theme 1: Teaching and Learning

Objective 1: Enhance student success by continually improving the curricular, co-curricular, and extracurricular programs.
Objective 2: Enhance the effectiveness of student support services.

Theme 3: Scholarship and Creative Expression

Objective 1: Increase the emphasis on and the opportunities for students, faculty and staff to participate in research, scholarship, and creative expression activities.
Objective 2: Increase the external funding received for research, scholarship, and creative expression by faculty, staff, and students.

Theme 5: Resource Development and Stewardship

Objective 4: Provide the facility and technology infrastructure and services appropriate to meet university objectives, while maximizing sustainability and stewardshi**p.**

Does this project include IT-related costs, including hardware, software, cloud-based services, contracts or IT staff? If yes, IT Addendum

This projects does not include nor funds IT-related costs, including hardware, software, cloud-based services, contracts or IT staff.

If the project is linked to the Puget Sound Action Agenda, describe the impacts on the Action Agenda, including expenditure and FTE detail. See the Puget Sound recovery chapter of the 2019-21 Operating Budget Instructions.

This project is not associated with the Puget Sound Action Agenda.

Does this project contribute to statewide goals to reduce carbon pollution and/or improve energy use? If yes, please elaborate.

This project would result in 20% energy efficiency on the load of the existing chiller. The measured output of energy usage is estimated to reduce operational wear and tear by providing consistent cooling loads throughout campus.

Is there additional information you would like decision makers to know when evaluating this request?

Not at this time.

Location

City: Ellensburg **County:** Kittitas **Legislative District:** 013

Project Type

Infrastructure (Major Projects)

Growth Management impacts

Central Washington University (CWU) is required to adhere to the State Environmental Policy Act (SEPA). The SEPA process is where growth management act impacts are considered. CWU coordinates planning efforts with all applicable city and county jurisdictions

Funding

Expenditures **2019-21 Fiscal Period**

375 - Central Washington University
Capital Project Request

2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:33PM

Project Number: 40000075
Project Title: Chiller Addition
Project Class: Preservation

Funding

Acct Code	Account Title	Estimated Total	Prior Biennium	Current Biennium	Reapprops	New Approps
057-1	State Bldg Constr-State	2,905,000				2,905,000
	Total	**2,905,000**	**0**	**0**	**0**	**2,905,000**

		Future Fiscal Periods			
		2021-23	**2023-25**	**2025-27**	**2027-29**
057-1	State Bldg Constr-State				
	Total	**0**	**0**	**0**	**0**

Schedule and Statistics

	Start Date	End Date
Predesign		
Design	3/1/2020	8/1/2020
Construction	9/1/2020	5/1/2021

	Total
Gross Square Feet:	0
Usable Square Feet:	0
Efficiency:	
Escalated MACC Cost per Sq. Ft.:	0
Construction Type:	Heating and Power Plants
Is this a remodel?	No
A/E Fee Class:	A
A/E Fee Percentage:	11.05%

Cost Summary

		Escalated Cost	% of Project
Acquisition Costs Total		**0**	**0.0%**
Consultant Services			
Pre-Schematic Design Services		0	0.0%
Construction Documents		0	0.0%
Extra Services		0	0.0%
Other Services		0	0.0%
Design Services Contingency		12,552	0.4%
Consultant Services Total		**260,212**	**9.0%**
Maximum Allowable Construction Cost(MACC)	**2,163,603**		
Site work		0	0.0%

OFM

375 - Central Washington University
Capital Project Request

2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:33PM

Project Number: 40000075
Project Title: Chiller Addition
Project Class: Preservation

Cost Summary

	Escalated Cost	% of Project
Construction Contracts		
Related Project Costs	0	0.0%
Facility Construction	2,163,603	74.5%
GCCM Risk Contingency	0	0.0%
GCCM or Design Build Costs	0	0.0%
Construction Contingencies	108,180	3.7%
Non Taxable Items	0	0.0%
Sales Tax	188,558	6.5%
Construction Contracts Total	**2,460,341**	**84.7%**
Equipment		
Equipment	0	0.0%
Non Taxable Items	0	0.0%
Sales Tax	0	0.0%
Equipment Total	**0**	**0.0%**
Art Work Total	**0**	**0.0%**
Other Costs Total	**5,160**	**0.2%**
Project Management Total	**179,111**	**6.2%**
Grand Total Escalated Costs	**2,904,824**	
Rounded Grand Total Escalated Costs	**2,905,000**	

Operating Impacts

Total one time start up and ongoing operating costs

OFM

Capital Project Request

2019-21 Biennium

*

Parameter	Entered As	Interpreted As
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000075	40000075
Sort Order	Project Class	Project Class
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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OFM

375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

*

Cost Estimate Number:	185	**Report Number:**	CBS003
Cost Estimate Title:	Modular Chiller	**Date Run:**	9/19/2019 12:37PM
Version:	SF CWU Supplemental Capital Submitted	**Agency Preferred:**	Yes
Project Number:	40000075		
Project Title:	Chiller Addition		
Project Phase Title:			

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:	0
Usable Sq. Ft.:	0
Space Efficiency:	
MACC Cost per Sq. Ft.:	0
Escalated MACC Cost per Sq. Ft.:	0
Remodel?	No
Construction Type:	Heating and Power Plants
A/E Fee Class:	A
A/E Fee Percentage:	11.05%

Schedule

	Start Date	End Date
Predesign:		
Design:	03-2020	08-2020
Construction:	09-2020	05-2021
Duration of Construction (Months):	8	

Cost Summary Escalated

Acquisition Costs Total			**0**
Pre-Schematic Design Services		0	
Construction Documents		0	
Extra Services		0	
Other Services		0	
Design Services Contingency		12,552	
Consultant Services Total			**260,212**
Site work		0	
Related Project Costs		0	
Facility Construction		2,163,603	
Construction Contingencies		108,180	
Non Taxable Items		0	
Sales Tax		188,558	
Construction Contracts Total			**2,460,341**
Maximum Allowable Construction Cost(MACC)	**2,163,603**		
Equipment		0	
Non Taxable Items		0	
Sales Tax		0	
Equipment Total			**0**
Art Work Total			**0**
Other Costs Total			**5,160**
Project Management Total			**179,111**
Grand Total Escalated Costs			**2,904,824**
Rounded Grand Total Escalated Costs			**2,905,000**

Additional Details

Alternative Public Works Project: No

375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

*

Cost Estimate Number: 185
Cost Estimate Title: Modular Chiller
Report Number: CBS003
Date Run: 9/19/2019 12:37PM

Version: SF CWU Supplemental Capital Submitted
Agency Preferred: Yes
Project Number: 40000075
Project Title: Chiller Addition
Project Phase Title:

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Additional Details

State Construction Inflation Rate:	3.18%
Base Month and Year:	09-2019
Project Administration By:	AGY
Project Admin Impact to DES that is NOT Included in Project Total:	$0

OFM

375 - Central Washington University
Cost Estimate Detail
2019-21 Biennium

*

Cost Estimate Number: 185 **Analysis Date:** September 18, 2019
Cost Estimate Title: Modular Chiller

Detail Title: Main Page
Project Number: 40000075
Project Title: Chiller Addition
Project Phase Title:
Location:

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:
Usable Sq. Ft.:
Rentable Sq. Ft.:
Space Efficiency:
Escalated MACC Cost per Sq. Ft.:
Escalated Cost per S. F. Explanation

Construction Type:	Heating and Power Plants
Remodel?	No
A/E Fee Class:	A
A/E Fee Percentage:	11.05%
Contingency Rate:	5.00%
Contingency Explanation	

Projected Life of Asset (Years):	20
Location Used for Tax Rate:	
Tax Rate:	8.30%
Art Requirement Applies:	No
Project Administration by:	AGY
Higher Education Institution?:	Yes
Alternative Public Works?:	No

Project Schedule

Project Schedule	Start Date	End Date
Predesign:		
Design:	03-2020	08-2020
Construction:	09-2020	05-2021
Duration of Construction (Months):	8	
State Construction Inflation Rate:	3.18%	
Base Month and Year:	9-2019	

Project Cost Summary

MACC:	$ 2,075,000
MACC (Escalated):	$ 2,163,603
Current Project Total:	$ 2,789,152
Rounded Current Project Total:	$ 2,789,000
Escalated Project Total:	$ 2,478,053
Rounded Escalated Project Total:	$ 2,478,000

ITEM	Base Amount	Sub Total	Escalation Factor	Escalated Cost
CONSULTANT SERVICES				
Construction Documents				
A/E Basic Design Services				166,119
SubTotal: Construction Documents				**0**
Other Services				
Bid/Construction/Closeout				74,633
SubTotal: Other Services				**0**
Design Services Contingency				
Design Services Contingency	12,038			
SubTotal: Design Services Contingency		**12,038**	1.0427	**12,552**
Total: Consultant Services		**252,790**	1.0294	**260,212**
CONSTRUCTION CONTRACTS				
Facility Construction				
D30 - HVAC Systems	2,075,000			
SubTotal: Facility Construction		**2,075,000**	1.0427	**2,163,603**
Construction Contingencies				
Allowance for Change Orders	103,750			
SubTotal: Construction Contingencies		**103,750**	1.0427	**108,180**
Sales Tax		**180,836**	1.0427	**188,558**
Total: Construction Contracts		**2,359,586**	1.0427	**2,460,341**
Maximum Allowable Construction Cost (MACC)		**2,075,000**	1.0400	**2,163,603**
OTHER COSTS				
Permits	5,000			
Total: Other Costs		**5,000**	1.0320	**5,160**
PROJECT MANAGEMENT				
Agency Project Management	171,776			
Total: Project Management		**171,776**	1.0427	**179,111**

OFM

Cost Estimate Summary and Detail

2019-21 Biennium

*

Cost Estimate Number: 185

Cost Estimate Title: Modular Chiller

Report Number: CBS003

Date Run: 9/19/2019 12:37PM

Parameter	Entered As	Interpreted As
Associated or Unassociated	Associated	Associated
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000075	40000075
Cost Estimate Number	185	185
Sort Order	Cost Estimate Number	Number
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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FINAL REPORT

CENTRAL STEAM AND CHILLED WATER LOAD IMPACT STUDY

for:

Central Washington University
Ellensburg, Washington

prepared by:

Abacus Resource Management Company
14845 SW Murray Scholls Drive, Suite 110-308
Beaverton, Oregon 97007

July 24, 2012

TABLE OF CONTENTS

SECTION I: EXECUTIVE SUMMARY

A. STEAM SYSTEM

The Central Heating Plant was constructed in 1975. It contains four high pressure steam boilers which can operate on natural gas or fuel oil. Steam is distributed to 46 buildings totaling just under three million gross square feet. Steam is used in these buildings for heating and domestic hot water production. The central steam system is a critical asset of the University requiring nearly 100 percent up time (especially during cold weather) to prevent buildings from freezing up which would lead to catastrophic water damage. The Plant is manned 24 hours per day 365 days per year and has not experienced a significant outage in the past 30 years.

The nameplate capacity of the four boilers totals 210,000 pounds per hour. Currently the plant can produce only 159,000 pounds per hour due to various conditions with each boiler which have degraded their capacities. However, the peak steam load over the next ten years is not expected to exceed 75,000 pounds per hour (an increase of about eight percent over current loads) and the longer term load forecast predicts future loads up to 100,000 pounds per hour. So, by these numbers, it appears there is not a capacity concern. The largest boiler could be out of service and the plant could still meet the peak load. This gives the University N+1 redundancy in the Central Heating Plant.

Unfortunately, Boiler No. 3 is currently 42 years old and has significant deficiencies with its controls and refractory. It has not been placed into service for several years although it is routinely tested and fired. It is not used because the load never demands three boilers and the other boilers are much more efficient and reliable. It is reasonable to count B-3 as backup capacity in its current condition and there is no reason it could not be used for periods of time should B-1 or B-2 be taken out of service. However, it is unrealistic to plan on B-3 providing reliable capacity beyond the next ten years.

Without B-3, the total plant capacity is reduced to 114,000 pounds per hour and the firm capacity (capacity with the largest boiler out of service) is only 69,000 pounds per hour which is below expected peak loads. Therefore, the University clearly needs to begin planning replacement capacity for B-3 and this new capacity should be online no later than 2020. The budget for this project is estimated to be $1.5M.

Although Boilers No. 1, 2, and 4 are a few years newer than B-3, they will all be near the end of their service lives by 2020. The planning process for replacing B-3 should also consider alternatives for extending the lives of these boilers through 2050. We estimate the budget required to make upgrades to these three boilers is $1.8M.

Compounding the need to make investments in the Central Heating Plant to address end of life issues, the University is up against the limits of its current synthetic minor emissions permit. The portfolio of emission units (boilers, water heaters, and emergency generators) currently located on campus brings current emissions to ninety two percent of the upper limit of the emissions permit. The planned addition of water heaters and emergency generators at the Samuelson Building, Science II, and the new NEHS Building are likely to push emissions over the permit limit.

Exceeding the limits of the synthetic minor permit will require CWU to secure a Title V emissions permit and begin conducting more rigorous compliance monitoring and reporting functions. Securing the new permit should pose no great problem other than cost. The Title V permit fee will be around $55,000 per year and it is estimated monitoring and reporting costs will be another $20,000 per year.

Options are available for replacing B-3 which would significantly reduce emissions and probably preclude going to a Title V emissions permit.

Outside the Central Heating Plant, several improvements remain to be completed within the steam distribution system. These include:

Replace the 12- inch section of main header piping with 18-inch ($150,000)

Replace the direct buried steam lines to Farrell Hall and Brooks Library ($600,000).

Replace the remaining direct buried steam lines along Nicholson Blvd. ($1.8M).

Replace the direct buried steam lines to Munson Retreat Center ($300,000).

Revise condensate return pumps and piping so that all condensate returns directly to the Central Heating Plant and abandon the old hot well at the Old Heating Plant ($600,000).

One final issue for reliably meeting the steam loads is the condition of the backup fuel oil storage system. Oil is currently stored in two 150,000 gallon single-wall underground tanks. Although there was a ground water contamination event over 20 years ago, it was related to a tank overflow. Monitoring wells placed around the tanks indicate the tanks themselves have probably not leaked additional oil. However, having such a large quantity of oil stored underground in single wall tanks should be considered an unacceptable risk to the University. Most State owned facilities have already mitigated this risk with double wall tanks. Planning for the Plant renovations should include alternatives for mitigating the underground fuel oil storage risk at CWU.

B. CHILLED WATER SYSTEM

The Central Cooling Plant was constructed in 1978 and is located on a partial upper floor of the Central Heating Plant. It contains three water cooled centrifugal chillers, cooling towers, and associated pumps. The Plant also incorporates a flat plate heat exchanger to perform waterside economizer cooling and a one million gallon chilled water storage tank which is charged at night and acts like a chiller during the day. Chilled water is distributed to 28 buildings totaling just under two million gross square feet. The cooling season begins in April and runs into October. However, the Plant serves some process cooling loads requiring chilled water to be circulated year round. This winter operation does not require running any chillers or towers. The ground serves as the heat sink for these small loads.

The nameplate capacity of the three chillers totals 3,300 tons. Due to pumping limitations, and to some degree the piping leaving the Plant, the current maximum output is around 2,800 tons. The peak cooling load in each of the past two years has approached this 2,800 ton limit. With an additional 220 tons of load coming on line by September 2012, it is safe to say the existing Plant cannot meet any future load growth beyond 2012. In fact, it is possible during extremely hot weather, the Plant may fail to meet some loads this summer.

Not only can the current Plant not meet any future load growth, the Plant has no redundancy to meet existing loads. There is N+1 redundancy in the chillers, meaning any one chiller could fail and the Plant could still meet the load. However, the failure of any primary or secondary chilled water pump reduces Plant capacity below the current peak campus load.

Another constraint to meeting future campus loads from this Plant is the size of the main chilled water distribution piping leaving the Plant. This 20-inch pipe is at the upper range of prudent fluid velocity (eight feet per second) under current peak loads. Increasing this velocity to meet future loads would lead to excessive erosion of this pipe and premature failure.

In order to reliably meet the cooling needs of the campus, now and into the future, CWU should plan the following improvements:

Immediately increase the capacity of the primary and secondary chilled water pumping in the Plant ($100,000).

Plan to meet future cooling loads with a separate cooling plant. The new Plant should be located somewhere on the east side of D Street to overcome the limitation of the 20-inch distribution pipe leaving the existing Plant. This could alternatively be accomplished by incorporating cooling equipment inside new buildings. ($1,800,000). If CWU desires to keep all central cooling equipment in the existing Plant, then a Plant expansion will be required and new chilled water piping will need to be run from the Plant to the east side of D Street. (add another $800,000 to the $1,800,000 budget)

If cooling is added to Randall/Michelson, or if other buildings are added to the cooling system in the northeast section of campus, then a cooling loop bypass needs to be constructed connecting the chilled water lines on the north side of Stephens/Whitney to the lines serving Barto. ($300,000)

SECTION II: STEAM SYSTEM

A. OVERALL SYSTEM DESCRIPTION

The Central Heating Plant was constructed in 1975 as a replacement to the original heating plant. The original construction included two new 60,000 pound per hour steam boilers. These boilers (B-1 and B-2) are Cleaver Brooks D-Style watertube boilers. The third boiler (B-3) is of the same manufacturer, style, and capacity but it was originally installed in the Old Heating Plant in 1970 and moved to the new plant in 1975. In 1980 a 30,000 pound per hour Cleaver Brooks firetube boiler (B-4) was added to the plant to better meet summer loads. Thus, the current installed nominal capacity of the heating plant is 210,000 pounds per hour.

All boilers in the plant can operate on natural gas or No. 2 fuel oil. Gas is supplied by the City of Ellensburg and is the primary fuel source due to its low price relative to oil. The plant has two 150,000 gallon underground fuel oil storage tanks. The current emissions permit would not allow continuous operation on oil. The permit limits oil use to 600,000 gallons per year which is only one-fourth of the annual equivalent fuel consumption at the Plant.

The plant is designed to produce steam at 150 psi but has traditionally been operated at 90-100 psi.

Plant controls were originally pneumatic but were upgraded to electronic single loop controllers manufactured by Johnson Yokogawa in 1998. Primary control of air, fuel, and feed water is still done via pneumatic actuators. The controls for B-1 and B-2 were recently upgraded, and the two boilers re-tuned. The boilers were tuned for higher efficiency; which has resulted in a reduction in steam capacity.

Steam is distributed to 46 buildings totaling about 2,988,000 gross square feet. The original distribution system employed direct buried steam and condensate piping. That piping began failing in the late 1970’s and the University has been systematically replacing the distribution system since then. Of the approximately 20,000 lineal feet of steam distribution piping, only about 3,000 feet of the direct buried piping remains. One third of that will be replaced this summer and one third is valved off and not currently in use. The only remaining active sections of direct buried piping after this summer will be the lines serving Farrell Hall/Brooks Library and Munson Retreat Center.

These sections are known to be in poor condition and are scheduled for future replacement as funding allows.

Condensate return piping parallels the steam piping and thus most of the original direct buried piping has been replaced. Most of the condensate return does still flow to the Old Heating Plant where it is collected in the old hot well and pumped back to the Central Heating Plant. This situation will need to be corrected if the Old Plant is ever replaced.

B. CURENT SYSTEM CONDITION

Boilers B-1, B-2, and B-4 have proven to be very reliable but are all within ten years of their expected useful life. Planning should begin to make major renovation of their key components or for their replacement sometime before 2022. By that date B-1 and B-2 will be 47 years old.

Boiler B-3 has not operated reliably for the past several years. This is the boiler which was moved from the Old Heating Plant and it is now 42 years old. It could be reasonably argued that B-3 should not be counted on for continuous service and maybe not even as a reliable backup boiler unless a major renovation effort is completed on its key components.

The feedwater and deareation systems are in good condition.

The underground oil storage tanks have been determined to have leaked. However, this leak could have been an overflow incident as continuous ground water and tank sampling has revealed no subsequent leakage. Regardless, the underground storage tanks represent a serious environmental risk and should be replaced if oil firing is to be retained.

Specific details about current operating conditions of the plant are presented in the remainder of this section.

<u>Controls and Combustion Efficiency:</u> Boiler controls have long been an issue in the Central Heating Plant, and to some extent are responsible for limiting the plant’s steam capacity. Some of these control issues have recently been addressed, with implications for efficiency and output capacity. B-1 and B-2 especially have been re-instrumented and re-tuned to maximize efficiency. The general feeling seems to be that B-3 is less efficient and/or less reliable than B-1 or B-2.

The data used in this report come from a recent period of data collection (late 2011 / early 2012), but also from an extensive period of data collection that took place in early 2010. The 2010 data, which was collected as part of study on a biomass-fired CHP plant for CWU, used the calendar year 2009 as the base year. A year's worth of data was collected at that time.

The general staging pattern is to use B-4 in summer. As the weather gets colder, one of the watertube boilers is brought online and B-4 is taken offline. The operators choose how the watertube boilers are staged, but the current operations favor either B-1 or B-2 as the "lead" boiler. As the weather gets colder still, a second watertube boiler is brought on. To date, it appears that the steam load has never gotten high enough to require a third boiler. This is borne out by the calculations below.

In 2009, the efficiency of the boilers was calculated as shown in Figure 1 below. These calculations were based on past stack tests – the boilers were not re-tested at that time, nor were they re-tested (specifically for efficiency) for this report.

Estimated Boiler Efficiency, 2009		
	average (1) combustion efficiency	estimated fuel to steam efficiency
B-1	0.816	0.801
B-2	0.816	0.801
B-3	0.811	0.796
B-4	0.831	0.816

(1) Over the full firing range

Figure 1, Estimated Boiler Efficiency, 2009

The differences between the combustion efficiency (measured) and the fuel to steam efficiency (estimated) are the boiler losses. These are heat loss from radiation (from the skin of the boiler to the room), and what are generally referred to as "unaccounted" losses (air leakage through the shell, etc). Combined, these are generally in the range of 0.010 to 0.020 (one to two percentage points of efficiency). In this case, an assumption of 0.015 was used.

In 2009, hourly natural gas data was combined with steam data to estimate the average annual fuel to steam efficiency of the plant at 0.806. This was an average across the entire year, and is not specific to any one boiler.

Since that time, B-1 and B-2 have been re-tuned, and each has a tuned and functioning oxygen trim system. These are thought to be the most efficient boilers at this time. Although no stack tests were available to confirm this, we can estimate the combustion efficiency of these boilers based on recent data. (There are many definitions of “combustion efficiency” – the one used here is that this value is what a stack test analyzer would record as the “efficiency” during a stack test.) Note that during the recent data collection period, B-1 and B-2 were the only boilers operating – no new data are available for B-3 and B-4.

Combustion efficiency can be estimated from net stack temperature and excess oxygen. Figures 2 and 3 below show the results of a recent test of B-1 and B-2. Efficiency was not measured, but excess oxygen and steam output were. In addition to helping to estimate combustion efficiency, these figures contain additional important information that will be expanded on further below.

B-1 Test			**24-Jan-12**
firing	steam meter		excess
rate (1)	klb/hr	lb/hr	O2
0.200	14.4	14,400	0.0282
0.300	23.1	23,100	0.0363
0.400	31.8	31,800	0.0453
0.500	37.6	37,600	0.0417
0.600	43.9	43,900	0.0462
0.626	45.2	45,200	0.0417

(1) This is the "boiler master" output; at 62.6%, the air actuator was at 100% open - however, the damper was at less than 100%

Figure 2, B-1 Test Results

B-2 Test			24-Jan-12
firing	steam meter		excess
rate (1)	klb/hr	lb/hr	O2
0.081	5.4	5,400	0.0750
0.160	8.9	8,900	0.0520
0.292	18.2	18,200	0.0400
0.324	20.2	20,200	0.0370
0.359	23.5	23,500	0.0380
0.476	28.8	28,800	0.0310
1.000	45.0	45,000	0.0428

(1) All of these except that last data point are the "boiler master" output signal - the 100% data point reflects the fact that at this point, the fuel valve was 100% open

Figure 3, B-2 Test Results

Figure 4 below shows excess oxygen as a function of steam output. It was mentioned above that B-1 and B-2 had oxygen trim systems. The boiler controls modulate gas flow to maintain steam pressure; the boiler air controls have two functions. First, modulate the airflow to provide enough combustion air for complete oxidation of the natural gas as it modulates to meet load - this is called stoichiometric air – the exact amount of air that will completely oxidize the fuel with no excess. Second, provide some excess air as a safety factor – should the boiler airflow fall below the stoichiometric rate, incomplete combustion occurs. This not only causes significant formation of carbon monoxide (CO), if enough unburned gas accumulates it can explode in the boiler once the air level returns to normal.

The function of the oxygen trim system is to “fine-tune” the air controls; to make sure that while there is enough excess air for safety, the excess airflow is minimized. Heating excess unburned air represents a boiler heat loss, so the greater the excess air, the lower the combustion efficiency. Excess air is not measured directly; instead excess oxygen is measured, and excess air then calculated from that. The oxygen trim system therefore tries to minimize excess air by measuring excess oxygen and modulating the trim system to maintain the oxygen setpoint programmed into the controller during boiler tuning. Oxygen makes up about 20.2 percent of the atmosphere by volume, so three percent excess oxygen equals 3 / 0.202 = 0.148, or 14.8 percent excess air.

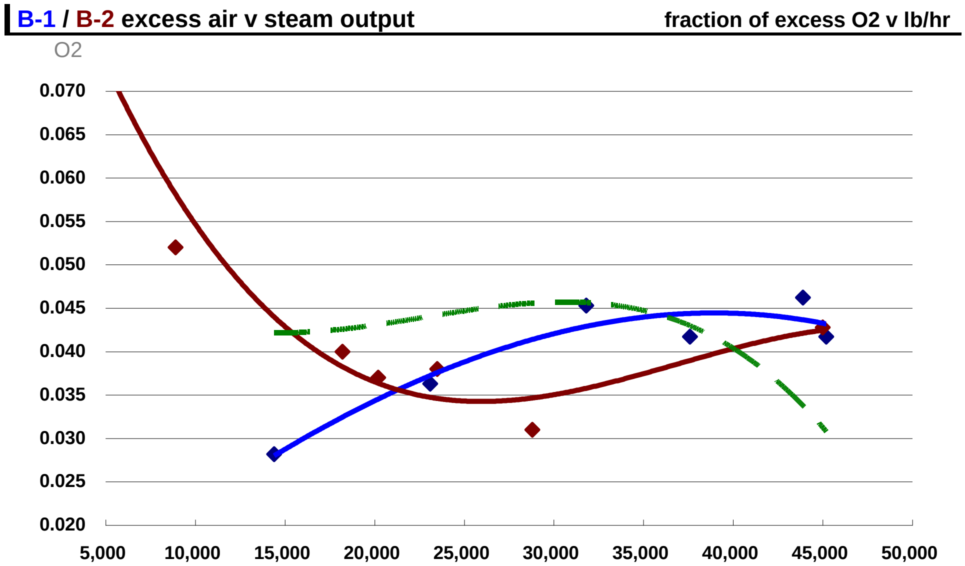


Figure 4, Excess Oxygen

The graph shows the significant difference between the two curves. B-2 (maroon) shows a more "normal" curve. The excess oxygen is highest at low loads. This is typical, because flame stability is lowest at the low end of the boiler output – thus more excess air is provided to ensure safety. The B-1 curve, however, is the opposite – it is very rare to see less than 3 percent oxygen at the low end of boiler output. So rare that we wondered if the data were recorded in an inverse fashion, and the values reversed. The dashed green curve represent this scenario (that the O2 readings were inverted compared to the steam readings). While this curve does not show the characteristic upturn at low loads (as with B-2), it does have the lowest O2 values at the high end of the output, as normally occurs.

Since the data were recorded by hand, and each reading was taken one at a time, it is hard to see how the data could have been inverted unless the final sheet sent to us was incorrectly transcribed from field notes. It will be assumed that the values shown are correct, although unusual.

The other value needed to calculate combustion efficiency is the net stack temperature, stack temperature minus inlet air temperature. In the current recording period, both the stack temperature and the inlet air temperatures were recorded (by data loggers) on five minute intervals for nine days in December 2011 and all of January 2012. Steam output during this time was not measured, because the values from the steam meters are suspect. Instead, the hourly natural gas data were used to calculate steam load for the hour – the average net stack temperature each hour was calculated from the logger data. The results are shown in Figure 5:

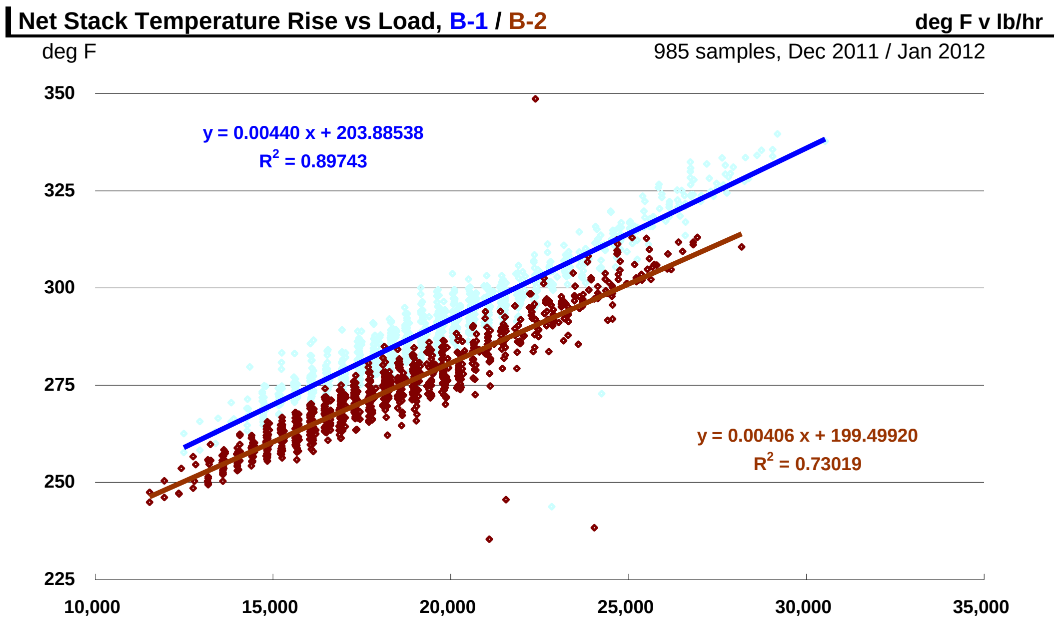


Figure 5, Net Stack Temperature

Note that at all load points, B-1 always has the higher net stack temperature, an average of 17 deg F over the 985 hours in the sample. This "delta T" will come into play in the capacity section below. In terms of efficiency, it means B-2, with the lower temperatures, would appear to be more efficient than B-1. However, because of the large amount of excess air that B-2 pulls at low loads, Figures 6 and 7 will show that at low loads, B-1 is actually more efficient despite the higher net stack temperature.

Figures 6 and 7 reproduce the data in Figures 2 and 3, with additional efficiency data added.

B-1 Test with calculated efficiency							
firing	steam meter		excess	(1) load	net T	combustion	est FTS
rate	klb/hr	lb/hr	O2	fraction	deg F	eff	eff
0.200	14.4	14,400	0.0282	0.319	267	0.854	0.839
0.300	23.1	23,100	0.0363	0.511	306	0.844	0.829
0.400	31.8	31,800	0.0453	0.704	344	0.833	0.818
0.500	37.6	37,600	0.0417	0.832	369	0.829	0.814
0.600	43.9	43,900	0.0462	0.971	397	0.821	0.806
0.626	45.2	45,200	0.0417	1.000	403	0.822	0.807

(1) As a fraction of the highest recored output

Figure 6, B-1 Test Results with efficiency data added

We have again assumed 1.5 percent combined radiation and unaccounted losses when converting combustion efficiency to fuel to steam (FTS) efficiency. In all likelihood, given the age of the boilers, this value is probably closer to 2.0 to 2.5 percent – we used the same value as was used in 2009 for consistency, so direct comparisons could be made.

B-2 Test with calculated efficiency							
firing	steam meter		excess	(1) load	net T	combustion	est FTS
rate (1)	klb/hr	lb/hr	O2	fraction	deg F	eff	eff
0.081	5.4	5,400	0.0750	0.120	221	0.849	0.834
0.160	8.9	8,900	0.0520	0.198	236	0.853	0.838
0.292	18.2	18,200	0.0400	0.404	273	0.849	0.834
0.324	20.2	20,200	0.0370	0.449	282	0.848	0.833
0.359	23.5	23,500	0.0380	0.522	295	0.845	0.830
0.476	28.8	28,800	0.0310	0.640	316	0.842	0.827
1.000	45.0	45,000	0.0428	1.000	382	0.826	0.811

(1) As a fraction of the highest recored output

Figure 7, B-2 Test Results with efficiency data added

Although B-1 and B-2 have the same nameplate capacity, we see from Figures 2 and 3 that they no longer have the same actual steam output capacity. Therefore, Figure 8 graphs combustion efficiency (calculated) v load fraction (faction of full load), rather than efficiency v output in lb/hr. This makes the two curves directly comparable, and allows the reader to visualize the efficiency data in Figures 6 and 7.

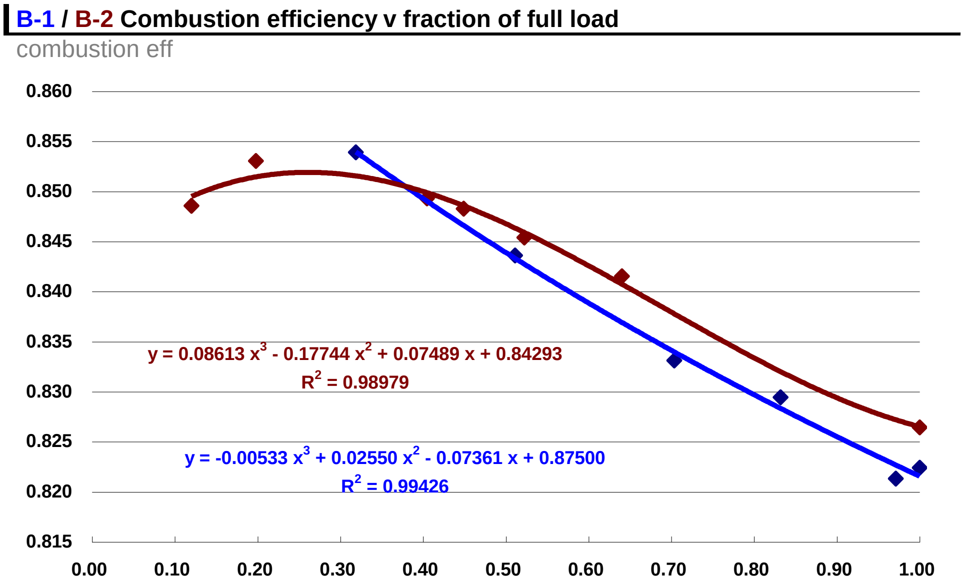


Figure 8, Combustion Efficiency

Going back to the 2009 data (Figure 1), we see that the weighted average combustion efficiency for B-1 and B-2 was calculated as 0.816. With the added controls and the functioning O2 trim, the efficiency of both boilers is now higher than this at all load points – this increase in efficiency represents a significant annual dollar savings.

In both cases, efficiency increases significantly at lower load fractions. This is because as the amount of gas (and air) decrease with falling load; the resulting stack gas has more boiler heat transfer area per pound of stack gas, as well as more dwell time in the boiler. The result is a higher heat transfer rate at low loads than at higher load (as thus the lower net stack temperatures). This effect can be offset, and often is, by high excess air (heating the excess air represent a loss). A “flatter” efficiency curve would indicate excessive air at low loads. The steepness of these curves shows graphically the effect of the oxygen trim. Note that at very low loads, when a significant amount of excess air is required for stability, the “excess air” effect overwhelms the “greater heat transfer area” effect, and the efficiency curve bends over the top (B-2 above). In the Test Data, B-1 never got below 32 percent of full load – still too high to show this effect.

There are operational reasons to use boilers known to be less efficient; the need to ensure the boilers remain useable, and to prevent excessive wear on a single boiler, and so on. There is also the issue of turndown – in summer, CWU uses B-4 because the load remains comfortably within the boiler's output range at all times, where it could easily drop below the minimum turndown of the larger boilers. In the absence of similar testing on B-3 and B-4, it has to be assumed that their efficiencies remain very close to those tabulated in Figure 1. Therefore, from a cost standpoint, operational considerations aside, CWU should maximize the use of B-2 first, then B-1, and only use B-3 and B-4 when required by other considerations.

Stack Economizers: All four of the boilers have feedwater heaters (stack economizers. Again, in the recent data collection period only B-1 and B-2 were operating, so only these two economizers were evaluated. The data indicate that while there are variations in the efficiency, they are small.

The operators report that the feedwater flow through the economizers is modulated by a control valve, which attempts to maintain a constant leaving stack gas temperature out of the economizer (240 deg F was the reported setpoint). This is intended to maximize heat recovery, while preventing the stack gas temperature from dropping so low it falls below the dewpoint of sulfuric acid (H_2SO_4). However, while leaving stack temperatures rarely drop below 240 deg F, they do in fact rise as inlet stack temperatures rise, so the control, if any, is ineffective. Figure 9 shows the "control" curves for the B-1 and B-2 economizers; as noted, they largely overlap, indicating similar heat transfer rates.

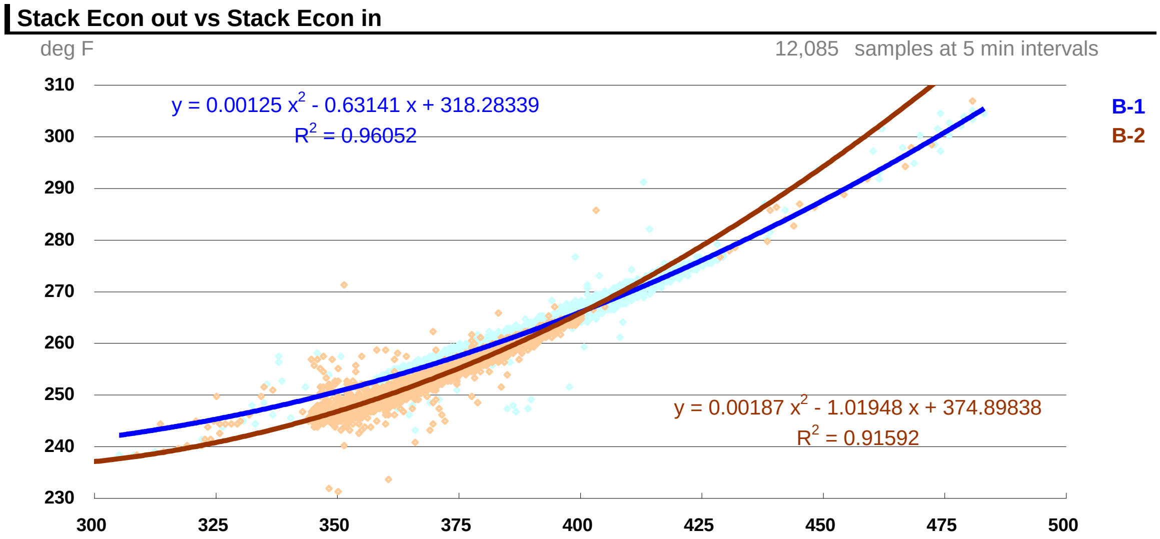


Figure 9, Stack Economizer Performance

Although the performance of the two economizers is similar, the B-1 economizer has the potential for greater heat recovery. This is because, as Figure 5 above shows, B-1 has higher stack temperatures at all load conditions.

This is borne out in Figure 10 below, these calculations assume that the average mass rate of stack gas is 1.12 times the mass rate of the steam, and the average Cp value (specific heat) of stack gas is 0.255 BTU/lb/deg F (both very average values):

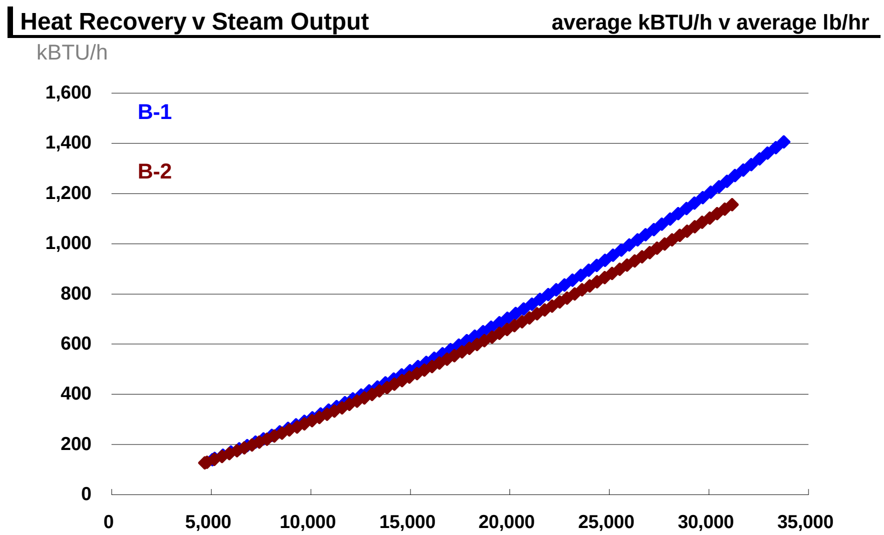


Figure 10, Stack Economizer Recovery

Using average Ellensburg weather (OAT bin data), and the assumed load profile (see Plant Capacity section below), one can predict the potential annual heat recovery from the B-1 and B-2 economizers. This assumes that B-2 is brought online (and B-4 taken offline) below 66 deg F (gas data shows this is when the heating load picks up), and that B-1 is brought on line in unison with B-2 when the load reaches 35,000 lb/hr. This is basically the load staging suggested above.

Given that staging scheme, and "average weather, with the current load profile, B-1 is calculated to recover 1,331.3 mmBTU per year. At the weighted average FTS efficiency calculated from Figure 6 above (0.815), this recovered heat would displace 16,334 therms of gas per year. B-2, because it runs so many more hours in the staging scenario (and despite less recovery per pound of steam), has the potential to displace more heat. The calculated recovery for B-2 would be 2,878.3 mmBTU; the associated gas displaced equals 34,872 therms (weighted average FTS efficiency of 0.825). At current prices, these 51,206 therms are worth about $37,280 per year.

In overall efficiency terms, the displaced gas represents about 0.021 of total gas use – a 2.1 percent savings. Given that B-3 and B-4 also have stack economizers, and are not included in the calculation above, the annual savings is probably closer to 2.25 percent.

Boiler / Plant Capacity: The nameplate capacity of the boilers was given above; however, as figures 2 and 3 above show, B-1 and B-2 are essentially now limited to 45,000 lb/hr each, a de-rate of 25 percent. This is not to say that they could not produce more steam if required, but it would require a re-programming of the controls, and would likely result in a loss of efficiency. Rework of the fuel valves and air dampers may also be required.

The footnote of Figure 2 indicates that currently B-1 is limited by the amount of air the boiler can pass. At 100 percent actuator travel, the air damper is actually less than 100 percent open, but that is how the boiler has been tuned for efficiency and stability, so barring a re-programming, the airflow control limits the output to about 45,000 lb/hr.

Likewise, the footnote of Figure 3 indicates that B-2 output is limited in a similar manner by the control of the gas valve. At 100 percent open, the boiler output is about 45,000 lb/hr.

The evidence for the capacity of B-3 and B-4 is more anecdotal, since the same tests have not been run on them. B-3, if anything, is expected to perform worse than B-1 and B-2. B-4 is believed to be limited to about 24,000 lb/hr. Figure 10, then, shows the nameplate and "current" (estimated) boiler and plant capacity. The term "Firm Capacity" is the plant capacity with the largest single boiler out of commission – it is considered unlikely that two boilers would be down at the same time, although it becomes more likely as the plant ages (see Plant Future below).

Boiler / Plant Capacity

	capacity, lb/hr		
Boiler	nameplate	current est	firm
B-1	60,000	45,200	
B-2	60,000	45,000	45,000
(1) B-3	60,000	45,000	45,000
(1) B-4	27,600	24,000	24,000
plant total	207,600	159,200	114,000

(1) estimated from anecdotal evidence

Figure11, Boiler / Plant Capacity

The current estimated plant capacity of 159,200 pounds per hour represents a twenty three percent de-rate in plant capacity compared to nameplate.

C. CURRENT SYSTEM LOADS

Steam Demand: Current steam demand was determined in detail in 2009, and has likely not changed much since then. Hogue Hall has been remodeled and expanded and Barto Hall is being replaced. However, for purposes of this study, the current load profile is considered to be very nearly the same as it was in 2009.

The steam load is considered to be comprised of three elements: 1) building demand, 2) system losses, and 3) DA steam.

Deareation: The amount of steam required to de-aerate the feedwater can be calculated if three enthalpies are known – the enthalpy of the water to the DA, the enthalpy of the feedwater from the DA, and the enthalpy of the DA steam. The latter values are considered constants, in that CWU does not change these values. DA steam is 5 PSIG, and feedwater temperature varies little from 225 deg F (the associated enthalpies can be looked up from this data). What does change is the temperature of the water going to the DA – this changes as groundwater temperature (make-up) changes, and as make-up water volume changes.

DA steam can be stated generically in the units of lb/lb – the number of pounds of DA steam it takes to raise a pound of incoming water to the feedwater enthalpy. The mass rate of the feedwater is assumed to be the same as the steam rate – it may vary from minute to minute, but long term they must equal or the boiler would trip off on low or high water.

In 2009, the annual DA steam rate was 0.0885 lb/lb – 8.85 percent of the plant steam went to de-aerating feedwater. The recent data collection period was not a year long, but for the duration of the period, at least, the make-up rate had dropped since 2009 (it fluctuates with leaks in the condensate system). For the Dec 2011 / Jan 2012 period, the DA steam rate was 0.0839 lb/lb.

Steam Distribution: The other “non-load” component is system losses, primarily heat lost from the steam piping. These losses are difficult to calculate directly – it would require knowing the length, diameter, and actual insulation value for every section of steam pipe in the system. However, it can be estimated by looking at a time when no "building load" is occurring, one can assume that any load present is a loss (not forgetting that some of the steam being used in these periods is in fact DA steam)

The 2009 data showed a distinct break in the steam load profile at 66 deg F. It is assumed that this is when actual space heating kicks in, although at a very low level, of course. It was further assumed that any other "load" user (DHW heating, reheat) would be zero or near zero between midnight and 4:00am. Sorting the 2009 data for data points that meet both criteria yields Figure 12:

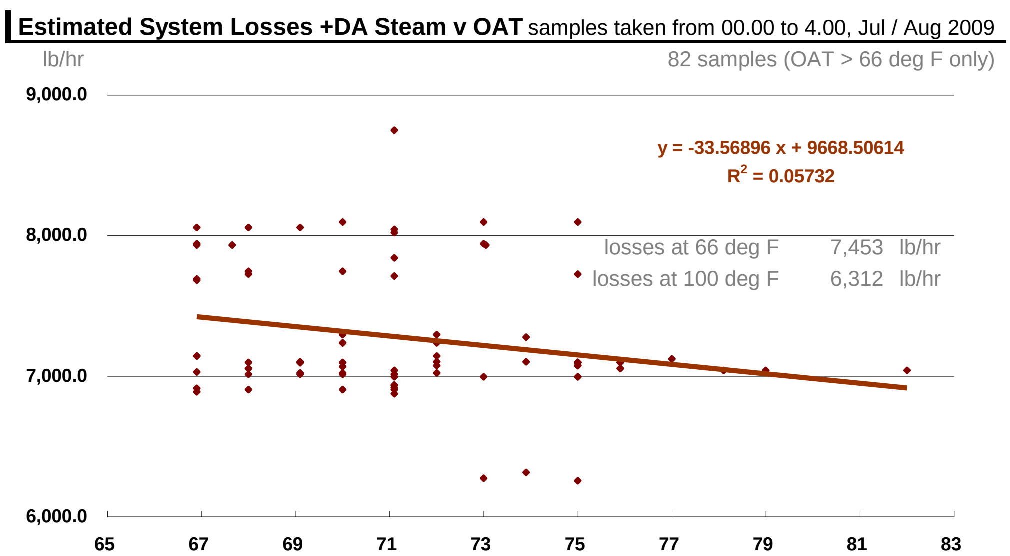


Figure12, System Losses and DA Steam

The correlation between data points and the trend line is not very good. In part, this is because the gas data is only reported to the nearest 1/10th of an MCF (thousand cubic feet of gas), or basically to the nearest 100,000 BTU. It also reflects the fact that some activity exists, even in the middle of the night. The trend line is best thought of as a long term average.

As noted above, this curve represents both system losses and DA steam (the DA never stops). The curve has a negative slope – losses increase as air temperature (and ground temperature) decrease. The graph shows two values, 7,543 lb/hr at 66 deg F, and 6,312 lb/hr at 100 deg F. Using the figures above, we can subtract out the DA steam, and the modified values would be 6,793 and 5,753 lb/hr, respectively.

These are the losses for the steam piping only – the boilers do not see the condensate piping losses directly. They manifest themselves as the difference between the condensate return temperature leaving the building, and the temperature of the condensate in the hotwell in the plant. Here, the condensate is then mixed with make-up water, and sent to the DA; so ultimately, condensate losses increase DA steam.

And of course, any leaks in the condensate system (leaks at CWU are almost exclusively in the condensate piping) must be made up with make-up water. This also lowers the overall temperature (and thus enthalpy) of the water to the DA. Every BTU lost in the system must be made up by burning additional gas. During the recent logging period, the average condensate temperature was 159.3 deg F (h = 127.3 BTU/lb). The average make-up temperature during the same time was 48 deg F (h = 16.05 BTU/lb. Therefore, for each thousand gallons (kgal) of condensate lost to leakage, the plant must generate 928,268 BTU to make up for the lost enthalpy. At an overall plant efficiency of 0.840 (boiler plus economizers), that requires 11.05 therms, or about $8.00 worth of energy per kgal. The actual cost of the water and the chemical treatment is not included in this calculation.

<u>Building Loads:</u> Having calculated total steam output from natural gas records, DA steam from make-up records and measured temperatures, and estimating losses by selectively sorting the steam data set, we estimated the actual building demand by subtraction. That graph is shown in Figure 13.

This graph shows not only the 2009 load (shades of blue), but also the expected load once the three buildings in the short term master plan of the University are added (shades of orange). The graph shows three curves for both load scenarios. The lowest line is losses only, and shows the same slight negative slope as in Figure 12. The second curve is DA steam + losses. DA steam is a constant fraction of total steam, so that curve follows the total steam curve at a much lower level. Finally, the last curve of each scenario is total plant steam. Building steam, then, is the area between total steam and DA + losses.

Note that total steam goes up with the addition of three buildings, as expected. However, the losses do not increase by the same percentage. In fact, they would be considered virtually constant between the two load cases (the amount of added pipe for the three buildings, plus their small size, means the additional losses fall well within the margin of error on the graph), except for the fact that CWU has lowered their steam pressure, in part to lower losses. The two curves are so close, they are hard to distinguish, but the "future" losses are actually 2.8 percent lower than the 2009 losses because of the lower pressure (temperature) steam.

Unlike losses, DA steam does increase with added building load, but as noted above, DA steam has dropped due to lower make-up mass rates. So the percent increase in DA steam is less than the percent increase in building demand. As with the "losses" curves, the DA + losses curves lie so close to each other they are hard to make out individually.

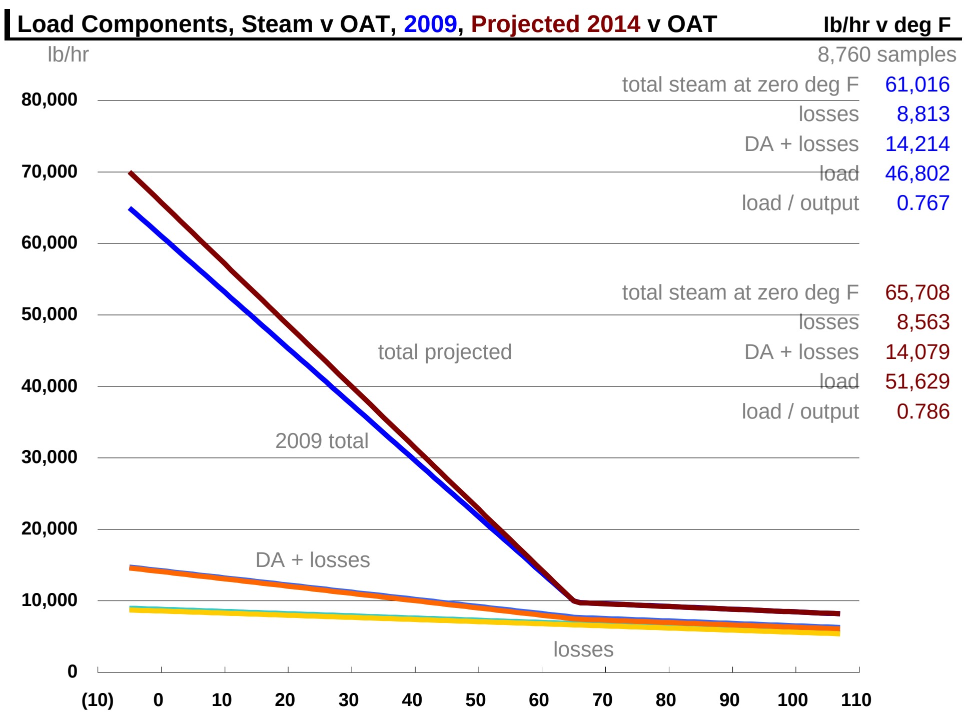


Figure13, Steam Demand by Component (instantaneous)

Note that at the peak existing load at zero deg F, 76.7 percent of the plant steam goes to building demand. This varies throughout the year, of course – the percent of "losses" is much higher in warm weather. Again using average Ellensburg OAT bin data, one can calculate the "system efficiency" on an annual basis using these curves. That calculation is shown in Figure 14 below.

total steam	207,683,282	lb/yr	1.0000
system losses	63,861,740	lb/yr	0.3075
DA steam	18,384,063	lb/yr	0.0885
building steam	125,437,479	lb/yr	0.6040

Figure 14, Steam Demand by Component (annual)

As Figure 14 shows, on an annual basis, 60.4 percent of the steam generated goes to the buildings.

In 2011, the average cost of gas was $0.728 per therm. The estimated gas usage based on the load curves was 2,429,090 therms, the estimated steam output was 204,674 klb (thousand pounds). At the stated gas cost, the cost of steam of was:

($0.728 * 2,429,090) / 204,674 = $8.64 / klb. This is based on "gross" pounds of steam.

The calculation in figure 14, however, indicates that on an annual basis only 60.4 percent of the steam is consumed in the buildings. The real (or net) cost of steam to the buildings, therefore, is $8.64 / 0.604, or $14.30 / klb. (This does not mean that saving 1 klb of steam therefore saves $14.30 – the system losses are unaffected by energy savings at the building level.) Another way to look at it is that while generating steam uses 0.840 of the heat content of the gas, only 0.840 * 0.604 = 0.507 of the heat content does "useful" work at the building level.

Boiler Loading: One final comment on boiler output, as it relates to B-1 and B-2. It was noted that B-1 always has a higher stack temperature than B-2, and this was attributed B-1 being to a less efficient boiler. However, if for some reason it was producing more steam than B-2 for a given firing signal, then that would also account for some or all of the discrepancy.

The test data indicate that the maximum capacity of B-1 is perhaps 200 lb/hr greater than that of B-2 (Figures 2 and 3) – this is only a 0.44 percent variation. One would expect that when modulating in unison, they would produce the same amount of steam. However, the data indicate that they don't.

Figure 5 shows net stack temperature vs load. During the recent data collection period, the average deviation of B-1 net stack temp minus B-2 net stack temp was 17.1 deg F. The average OAT was 29 deg F. Net stack temperature was measured independently for both boilers. Total steam load was determined by using gas data, as mentioned several times above. The first assumption was that both boilers provided one half of the total steam output. If this were true, then the plot shown in Figure 5 should show a 17 deg F difference at the load equivalent to 30 deg F – it did not. The "split" between the boilers was adjusted until the expected 17 deg F delta appeared (thus Figure 5 does now show the expected deviation).

This does not affect total steam output, just individual boiler output. Based on this data, it appears that when B-1 and B-2 are in "unison" modulation, B-1 is picking up 52 percent of the load, versus 48 percent for B-2. This is an eight percent difference in output (1-(52/48)), far more than the difference in "capacity" of 0.44 percent. Given that B-2 is more efficient than B-1, if anything the bias should be shifted to B-2.

D. PLANNED FUTURE LOADS

Near Term Additions: In the near term, steam loads will increase as the Hogue Hall renovation comes on line. The Samuelson Building renovation and the construction of Science II and NEHS may add significant load over the next 3-5 years. The affect of these load additions were shown previously in Figure 13 (a net addition of about 5,000 pounds per hour or just under eight percent).

Long Term Additions: There are no specific details on other future loads. However, the long term Campus Master Plan shows potential growth in several areas. There could be load growth in the northeast, northwest, and even in the middle of campus which could all be connected to the central steam system. These loads could total an additional 20,000 pounds per hour (or just under 30 percent).

E. SYSTEM CONSTRAINTS TO MEETING LOADS

Plant Capacity: The projected peak steam load with all planned near term future loads online is around 70,000 pound per hour. This is based on continuing recent winter weather which has not delivered temperatures in Ellensburg below zero for several years. Even if the longer term historical lows of minus 10 to 15 were to return, the peak steam load would only climb to 75,000 pounds per hour. The total plant capacity is currently 159,000 pounds per hour. The capacity with the largest boiler out of service is 114,000 pounds per hour. Thus, one could argue that plant capacity is not a constraint given the expected near term steam loads.

However, consideration should be given to the fact that Boiler No. 3 is 42 years old, its controls are obsolete, finding knowledgeable people who can work on this boiler is difficult, and it is known to have several deficiencies which keep it off line most of the time already. If B-3 is not going to be renovated in the very near future, one could also argue that its capacity should not be relied upon. That assumption takes the total plant capacity down to 114,000 pounds per hour and the firm capacity (using N+1 redundancy which assumes the largest boiler is then off line) is only 69,000 pound per hour. The system loads are projected to exceed this level and thus plant capacity becomes a serious issue.

Based on current conditions, it is probably not necessary to completely ignore any contribution from B-3. However, it is also not completely realistic to consider B-1 and B-2 completely reliable for the long term (beyond 2020). Our opinion is that B-3 needs complete renovation or replacement before 2018 (six years) and that B-1 and B-2 are in need of major renovation before 2022 (ten years) in order to sustain reasonable plant capacity and reliability.

Piping System Capacity:

Just as the plant has capacity constraints, the steam distribution piping has constraints as well. An issue for steam piping capacity is the fact that steam is compressible – the higher the steam pressure, the more of it you can force down a pipe. However, each increase in steam pressure has a corresponding increase in fuel required, and because temperature rises with pressure, piping heat losses also rise with rising pressure. Good energy practice is to always use the lowest pressure the system can handle.

This calculation is not always simple, because the specific volume of steam (in cubic feet per lb, the inverse of density) does not vary in a linear fashion as pressure varies. For that reason a model of the piping system was created.

Often, the variable which drives pipe sizing is pressure drop. If you need 5 psig at a building, the steam has to leave the plant at a high enough pressure such that when it reaches the building, it is still 5 psig or greater. The model shows that at any plant pressure above about 75 psig, pressure drop in the system is negligible – pressure drop is not the limiting variable on the piping system at CWU.

At CWU, the limiting variable is steam velocity. As the steam get less dense (higher specific volume), steam velocities go up. If velocities get too high, the steam and water droplets cause excessive wear on the pipe and fittings. Elbows are especially vulnerable to very small water droplets entrained in the steam at high velocity – the droplets cannot “make the curve” and impact the fitting walls.

Exposed piping is less of an issue, since leaks can be seen, and repaired inexpensively. The distribution piping at CWU is below grade which makes leaks very hard to find and expensive to repair. For these reasons, the model (although it calculates pressure drop, because pressure affects specific volume) uses velocity to highlight “hot spots” in the piping as load changes, plant pressure changes, or new building come on line.

The range of recommended velocities according to Spirax Sarco in their texts is 80 – 120 feet per second (fps). Converted to feet per minute (fpm), this is 4,800 to 7,200 (the model uses fpm). Because the piping is below grade, and is expected to last 40 years or more, it is better to operate towards the lower end of the recommended range.

CWU has historically generated steam in the range of 90 to 100 PSIG. Plugging 90 PSIG steam, zero deg F OAT, and the near-term additional steam loads into the model results in two sections of pipe being of specific concern. First is the ~ 100 foot long section of 12" pipe that leads from the plant header towards "D" street. This pipe jumps up to 18" after the first hundred feet, and there is no issue with the 18" section. The model shows that the velocity in this 12" section would be 1.261 times the limit, or 6,052 fpm. This section should be increased to 18".

The 18" pipe crosses "D" Street and then at a tee intersection (called N50 in the model), it splits north into a 12" section, and south into an 8" section. The second "failed" section is the 8" section of pipe that proceeds south from the N50 intersection. The velocity is this pipe is calculated at 1.177 times the limit, or 4,943 fpm. Raising the pressure to 100 psig helps, but both segments still exceed the 4,200 fpm limit.

In addition to these segments, 10 smaller segments (each feeding only one building) fail. These are of less concern. One thing the model cannot account for is that piping losses are constant, and do not "move" with the steam – the losses are not dependent on mass flow through the pipe, only on the temperature of the steam. For the two segments of concern, they are the closest to the plant, and little or no "loss" steam has dropped out of the pipe. In the case of the ten remote buildings, the actual flow to the building is less than the model indicates, because of the losses between the plant and the building have dropped out. The model assigns the building steam and loss steam to the building. DA steam is not counted – it never makes out of the plant.

There are no practical "failed sections" if CWU is willing to accept an upper limit of 7,200 fpm.

So how serious is the velocity related erosion issue? If the 8" pipe south of N50 fails, it is part of a loop, and can probably be back-fed around in all but the highest load conditions. There would likely be no disruption to normal services in any building. However, if the 12" segment near the Plant fails, no steam reaches the campus. This would be catastrophic making replacement of this 12" section of the highest priority.

In summary, the distribution system presents few constraints to meeting expected steam loads. There are however, some near term needs:

1. The 12-inch section of main steam header in the Central Plant should be increased to 18-inch.
2. The remaining sections of direct buried piping along the north side of Nicholson Boulevard are likely to fail within the next 10 years which would put delivering steam to all buildings north of Nicholson at some risk. This would leave only one flow path available to these buildings and any outage along that path would take out many buildings.
3. This same condition exists on the steamline serving Farrell Hall, Brooks Library, and Munson Retreat. All of these direct buried lines should remain on the Combined Utilities Improvement Plan.
4. The condensate return system should be modified so that each building condensate pump delivers directly back to the Central Plant (eliminate the path to the Old Plant hotwell).

Alternate Operating Modes (summer):

CWU would like to explore the possibility of operating in an "unmanned" mode in summer, using B-4. To do this, they need to reduce the steam pressure at the boiler to 15 psig or less. This raises a number of issues. Most are related to the specific volume of 12 psig steam (15.33 cf/lb) vs that of 90 psig steam (4.2426 cf/lb). The 12 psig steam takes up 3.6 times as much space as 90 psig steam. We use 12 psig steam as the basis because if the boiler is "rated" for 15 psig the actual steam pressure must be 10 – 15 percent below the rating, thus 12 psig was used as the basis. Several questions arise when considering lowering the plant pressure to 12 psig:

Can the boiler be adapted to lower pressure?

There is no issue with the boiler per se, but there may be an issue with the regulatory agencies. The boiler must be protected by pressure relief valves. These are currently set to protect the boiler at 150 psig. The regulatory agency may insist that the boiler relief protection be set at 15 psig to ensure that CWU is not simply claiming to be below 15 psig. Or they may simply ask for trend data or boiler pressure charts.

If they do require low pressure protection, the second question is, "will they accept partial relieving capacity?" The relief openings in the boiler were sized for higher pressure steam, and it may not be possible to relieve the nameplate 27,600 lb/hr of steam through those openings, even if new valves are installed. The summer load is not expected to exceed 15,500 lb/hr, so if they will accept partial capacity, it may be as simple as replacing the valves in summer.

How much steam can B-4 produce at 12 psig?

Output steam capacity is an issue due to the difference in specific volume. The steam nozzle (outlet) on a 150 psig rated 800 HP boiler has an 8" diameter. On the 15 psig version of the same boiler, the nozzle is 12" diameter (2.25 times the free area) to allow the "less dense" steam out of the boiler without excessive velocity. Excess velocity through the steam nozzle forces water into the nozzle with the steam (carryover), and can even fill the discharge with a solid plug of water (priming). The question is, "how much steam can reliably get out of B-4 at 12 psig?". The load profile (near-term loads included) predicts the average steam load at 60 deg F to be 14,250 lb/hr. Based on the logger data recently collected, the "morning warm-up "bump" in the load is expected to be between 8.5 and 9.5 percent, so assume a worst case summer load of 15,530. This is 0.563 of nameplate capacity.

Based on the past experience of some boiler experts we consulted, one should be able to get 50 - 70 percent of nameplate capacity without excessive carryover. A lot depends on water treatment. Some chemicals have the property of causing very large bubbles to form, instead of many smaller ones. Such large bubbles can literally get sucked whole into the nozzle if they form right below it. Determining the actual capacity of B-4 at 12 psig would require some trial and error process.

Installing a 12" diameter by 5 to 8 foot long spool piece above the existing isolation valves would not prevent carryover or priming at the nozzle, but it would likely eliminate water from getting to the header.

CWU could simply hire an ASME welder to make a 12" nozzle for the boiler. This would mean cutting into the shell, but it should eliminate any water issues at the lower pressure. Cost is estimated at $10,000. After an ASME spool piece of 5 – 8 feet above the new nozzle, CWU could neck back down to 8" and re-use the existing non-return and isolation valves.

The same welder could over-size the relief valve openings, if the regulatory agency required full 15 psig relief capacity.

Are there other plant issues?

The existing feedwater pumps may ride so far out on their curves that they cavitate, or flow fluctuates (which makes maintaining water level in the boiler harder). CWU could try it and see if it works first.

CWU could put a VFD on one pump, open the bypass around the B-4 feedwater valve, and just use the VFD to maintain water level.

They could buy a “pony pump” sized for the duty, and install it in the plant.

Can the distribution and building piping handle the lower pressure without excessive pressure drop or velocity?

This is simply not possible with Randall/Michelson on the system. This building alone has enough load to require its own boiler. If Randall/Michelson were retrofit with stand-alone capacity, then about 14,000 lb/hr would (worst case) would have to cross “D” Street. The model shows that the only issue is the infamous 12” section of the main plant to “D” Street segment. Even there, the velocity is only expected to be 4,625 fpm, above the strictest velocity limit, but well within the range of limits.

The model predicts that the pressure drop at the far end of the system will be as much as 4 psig, meaning those building would see only 8 psig.

The distribution traps are another potential issue. Relative steam flow through a fixed orifice size is proportional to the ratio of the absolute pressures. Dividing (8 + 14.7) / (90 + 14.7) = 0.217 means that the traps will pass only 21.7 percent of the “normal volume. However, traps are usually sized for at least twice the expected load, so capacity would be cut to perhaps 40 to 50 percent of that at 90 psig. Since the summer load is only about 20 percent of the peak, running trap load capacity should not be a limiting factor.

Warm-up trap loads could be an issue, however, since load typically doubles at this time (thus the over-sizing). Start-ups in summer could take substantially longer than they do now.

In the buildings, the PRVs will not function – they need to see an inlet pressure of 10 – 15 psig greater than the outlet in order to work. The staff would have to go to each building and manually open the bypass around the PRV. If the bypass is not “full size”, CWU would need to up-size the bypass or provide alternate heat to those affected buildings.

Aside from the ability to run the plant unmanned, the intent is to save money, which leads to the question of how much would this mode of operation save. There are four sources of savings, and they work together. In descending order of effect; first, the steam is cooler (a relative term – it is still over 212 deg F), so the piping losses are lower. Second, it takes less energy to make 12 psig steam than it does to make 90 psig steam. Third, less overall steam means less DA steam. Finally, the boiler is marginally more efficient, because the stack temperatures are lower. However, in this case, the lower stack temperatures mean the economizer is virtually useless, so this last effect has been considered "a wash".

First, we can estimate the reduction in losses. At 100 deg F, the current losses are estimated at 5,590 lb/hr. Losses are proportional to the ratio of the temperature differentials (steam to ground). It is actually more complex, but this is good estimate. 90 psig steam is 331.2 deg F, and 12 psig steam is 243.7 deg F. Steam utilidor temperature was logged in two places recently, and averaged 114 deg F. The calculation would then be:

(243.7 – 114.0) / (331.2 – 114.0) = 0.693, or 69.3 percent of current losses (or a 30.7 percent reduction)

Using the same load profile we have been using for the rest of the report, and using the new loss values and DA steam values, we can plug the modified profile into the OAT bin model. The results are shown in Figure 15 below (June though August was chosen for simplicity):

Summer Low Pressure Steam Savings						**(plant eff est at 0.84)**
	Existing (90 PSIG, 956.6 BTU/lb			**Proposed (12 PSIG, 929.8 BTU/lb)**		
	steam produced lb	output energy kBTU	input gas therms	steam produced lb	output energy kBTU	input gas therms
Jun	9,869,664	9,441,022	112,393	8,267,559	7,687,315	91,516
Jul	7,915,024	7,571,272	90,134	6,326,647	5,882,622	70,031
Aug	8,726,716	8,347,712	99,378	7,109,096	6,610,157	78,692
total	26,511,404	25,360,006	301,905	21,703,302	20,180,094	240,239
savings				4,808,102	5,179,912	61,666

Figure 15, Summer Low Pressure Steam Operations

At $0.728 per therm, this would represent nearly $45,000 in gas savings alone.

However, there is one more issue not discussed above. That is the summer temperature range in Ellensburg. Using the four year average (2006 through 2009) OAT dry bulb data from the airport, it can drop as low as 38 deg F in June, as low as 40 deg F in July, and 44 deg F in August. These temperatures are rare; they are not reached very many hours in these months, but it does not take many hours to complicate this concept.

The project load at 44 deg F (even at 12 psig with lower losses) is ~25,500lb/hr (warm-up peak, ~ 28,000). B-4 might be able to produce this load, if the steam nozzle was enlarged, and the boiler had sufficient relief capacity at this level. There are three other issues, however:

Seven segments of pipe exceed the lower velocity limit of 4,800 fpm, and three fail even the most lenient limit of 7,200 fpm (the usual suspects). The 12" main section at the plant would exceed 9,000 fpm.

The load is approaching the calculated limit for the distribution traps.

The issue of building PRV bypasses gets much more critical.

None of this says it can't be done, but it may mean a lot of scrambling if cold temperatures occur unexpectedly. CWU could also always start up a watertube if B-4 cannot handle it, but this would mean A) going to each building and shutting the manual bypass (even if the watertube only produces 25 psig steam, for instance, it will still blow the pressure relief on the downstream building equipment if the bypass valves are open), and B) manning the plant.

<u>Alternate Operating Modes (winter)</u>:

The question has also been asked as to whether CWU could operate unmanned with 12 psig steam year round.

As with summer operation, Randall/Michelson would have a standalone boiler at that building.

The 12-inch section of header pipe at the Central Plant is also increased to 18-inch.

Then, at a minimum, CWU would have to convert all four boilers to larger steam nozzles, at a cost of perhaps $40,000.

The logical next step might seem to be to move B-4 to the Alford/Montgomery (A/M) site and have it feed from there. However, as the section above shows, in summer B-4 might handle the steam loads, but the 12" segment of pipe from the plant to "D" Street cannot. The back-feed pipe from the A/M to the campus is only 8". There is no point in putting a boiler at A/M any bigger than the 8" back-feed can handle at 12 psig plus loads at Wendell Hill Hall and any future loads which might be added in this area.

Assuming CWU will accept 7,200 fpm for peak loads, since they do not last long, the capacity of the A/M back-feed is only 7,000 lb/hr. The 18" pipe from the Plant to the campus could deliver 44,000 lb/hr bringing the total capacity to the main campus to 51,000 lb/hr.

Since the assumption was that Randall/Michelson was to be taken off the grid, Wendell Hall A and B loads are on the "other side" the A/M site, and distribution losses are much smaller at 12 psig, the remaining peak load at 0F ambient is 55,000 lb/hr. So with a few modifications to warmup loads, the campus could possible run year round at 12 psig.

However, going back to the last section, we believe that to do this, CWU would have to replace all of the distribution traps. There is no way they keep water out of the pipes at full load and only 12 PSIG.

To summarize, the six potential costs would be:

1) Modify Randall/Michelson to be stand-alone building.
2) Modify the steam nozzle on all four boilers.
3) Install a new boiler at the A/M location.
4) Potentially upsize some building bypass piping (and perhaps even some steam branches)
5) Replace all the distribution traps, and
6) Replace the 100 feet of 12" pipe from the plant with 18" pipe.

Long Term Future Loads: If the campus grows by anything close to an additional 20,000 pounds per hour of steam load, then the need to renovate the heating equipment becomes magnified. The plant would operate many hours with three boilers online. Any boiler being out of service would leave the plant with no redundancy. It is safe to assume that by the time the campus grows this much, two or three of the existing boilers will be unreliable if a major renovation is not completed before then.

F. EMISSIONS

Overview: Because the CWU campus is a single facility type under common ownership, all air pollutant emission sources located on the campus must be considered together for purposes of air quality permitting.

The facility is currently permitted as a “synthetic minor” facility, which implies that potential emissions of one or more individual air pollutants could exceed 100 tons per year, but limits in the permit restrict maximum emissions to less than this threshold. Being classified as a synthetic minor facility allows CWU to avoid the requirements of the Title V permitting program.

So, any plans to add emission sources to the campus need to take into consideration whether or not the added source is likely to trigger Title V.

Existing Permitted Sources: The following table lists the emission sources (in addition to the paint spray booth) currently included in the existing air quality permit for the CWU facility. These emission units provide steam for space heating and electrical generation for emergency power loss replacement.

Boilers		Emergency Generators			
Description	Location	Size (hp)	Fuel	Make	Model
Boiler #1	Central Power Plant	749	Diesel	Caterpillar	3412T
Boiler #2	Central Power Plant	749	Diesel	Caterpillar	3412T
Boiler #3	Central Power Plant	643	Diesel	Detroit	8083-7416
Boiler #4	Central Power Plant	490	Diesel	Caterpillar	D346
Boiler #5	Student Village	470	Diesel	Cummins	DQAF
Boiler #6	Student Village	325	Diesel	Perins	1306-E8TTA300
Boiler #1	WAHLE	115	Nat Gas	Cummins/Ford	
Boiler #2	WAHLE	148	Diesel	Onan/A/C	3500
Boiler #1	Health Center	32	Diesel	Onan	
Boiler #2	Health Center	65	Diesel	Perkins	1100
Boiler #1	Brooklane				
Boiler #2	Brooklane				
Boiler #1	Student Union				
Boiler #2	Student Union				
Boiler #3	Student Union				
Boiler #1	President's House				

Table A. Central Washington University – Currently Permitted Emission Units

The existing air quality permit for the campus contains the following emission limits:

Emission Units	NO_x (tpy)	CO (tpy)	SO_2 (tpy)	VOC (tpy)	$PM_{10}/PM_{2.5}$ (tpy)
Central Steam Plant and Student Village Boilers #1-#6 (while fired on natural gas)	60.00	50.40	0.36	3.30	4.56
Central Steam Plant Boilers #1-#4 (while fired on No. 2 distillate fuel oil)	6.00	1.50	0.06	0.10	0.99
Other 10 Specified Boilers (fired solely on natural gas)	4.35	3.65	0.03	0.24	0.33
9 Specified Emergency Generators (fired solely on diesel)	19.48	3.72	1.88	2.27	1.16
Cummins/Ford Emergency Generator (fired solely on natural gas)	0.70	0.61	0.0001	0.07	0.002
Paint Booth	0	0	0	1.30	0
Total	**90.53**	**59.88**	**2.33**	**7.28**	**7.04**

Table B. Central Washington University - Currently Permitted Emission Limits

As long as the sum of all emission limits at the facility for each pollutant remain under 100 tons per year after the addition of new emission units, the facility can continue to be permitted as a synthetic minor source. If this was not feasible (emission sources were added to the point of taking one or more pollutants over 100 tons per year), then the facility would need to apply for a Title V air operating permit with the DOE. Although this would not affect the ability of the facility to operate onsite emission units, the Title V permitting program does require a higher level of compliance monitoring and has higher associated annual fees than are required under the current synthetic minor permit (discussed further below). Note that if potential emissions of any individual air pollutant were to exceed 250 tons per year, the facility would need to apply for a Prevention of Significant Deterioration (PSD) air permit, which can have significant permit application requirements.

The current emission permit also contains the following usage limits to ensure emissions will not exceed the limits shown in Table B:

Emission Unit Group	Permit Usage Limit
Central Steam Plant and Student Village Boilers #1-#6 (while fired on natural gas)	1,200 million (10^6) cubic feet of natural gas per 12-month period
Central Steam Plant Boilers #1-#4 (while fired on No. 2 distillate fuel oil)	600,000 gallons of No.2 distillate fuel oil per 12-month period
Other 10 Specified Boilers (fired solely on natural gas)	No limits – may operate at maximum capacity for all 8,760 hours per 12-month period
9 Specified Emergency Generators (fired solely on diesel)	500 hours per 12-month period maximum for each generator
Cummins/Ford Emergency Generator (fired solely on natural gas)	500 hours per 12-month period maximum
Paint Booth	55 gallons of paint per month

Table C. Central Washington University – Permit Usage Limits

Greenhouse Gases: Although the CWU facility is nowhere near emitting 250 tons per year of any individual air pollutant, there is one exception to this threshold. Greenhouse gases (GHGs) are treated different from all other air pollutants under air quality permitting programs. As a result of the U.S. EPA "Tailoring Rule", special emissions-based thresholds have been set for GHGs. A facility with GHG emissions (expressed as CO_2 equivalent emissions; CO_2e) exceeding 100,000 tons per year becomes a Title V major source.

As shown in the table below, the CWU campus is currently very close to exceeding the 100,000 ton per year threshold for GHGs, with estimated potential GHG emissions of 91,686 tons per year of CO_2e.

Table D. Central Washington University - Estimated Potential GHG Emissions

GHG Emission Source(s)	Annual Usage Data				GHG	lb/MMBtu	CO_2e (tpy)
Natural gas limit for Central Plant and Student Village Boilers #1 - #6	1,200,000,000	ft^3/yr	1.03E-03	MMBtu/ft^3	CO_2	116.644	71,946
	1,200,000,000	ft^3/yr	1.03E-03	MMBtu/ft^3	CH_4	0.0022	28.50
	1,200,000,000	ft^3/yr	1.03E-03	MMBtu/ft^3	N_2O	0.00022	42.07
Fuel oil limit for Central Plant and Student Village Boilers #1 - #6	600,000	gal/yr	1.38E-01	MMBtu/gal	CO_2	161.15	6,671.6
	600,000	gal/yr	1.38E-01	MMBtu/gal	CH_4	0.0066	5.7
	600,000	gal/yr	1.38E-01	MMBtu/gal	N_2O	0.00132	16.9
Other 10 Specified Boilers (fired solely on natural gas)	10.13	MMBtu/hr	8,760	hrs/yr	CO_2	116.644	5,175
	10.13	MMBtu/hr	8,760	hrs/yr	CH_4	0.0022	2.05
	10.13	MMBtu/hr	8,760	hrs/yr	N_2O	0.00022	3.03
9 Specified Emergency Generators (fired solely on diesel)	192.24	gal/hr	500	hrs/yr	CO_2	161.15	7,744.9
	192.24	gal/hr	500	hrs/yr	CH_4	0.0066	6.7
	192.24	gal/hr	500	hrs/yr	N_2O	0.00132	19.7
Emergency Generator (fired solely on natural gas)	0.81	MMBtu/hr	500	hrs/yr	CO_2	116.644	24
	0.81	MMBtu/hr	500	hrs/yr	CH_4	0.0022	0.01
	0.81	MMBtu/hr	500	hrs/yr	N_2O	0.00022	0.01
Total							**91,686**

These emission estimates are based on U.S. EPA factors provided in the federal mandatory GHG reporting rule (40 CFR Part 98, which could currently apply to the CWU facility depending on actual fuel usage levels) and the equipment usage limitations in the current air permit.

Therefore, if any new sources were to be added to the CWU air permit, it would be important to keep track of the effect on potential GHG emissions to ensure that the 100,000 ton per year CO_2e threshold was not exceeded if possible (to prevent becoming a Title V source). Any usage limit may be applied to any emission unit to restrict potential emissions as long as the usage can be monitored and recorded (e.g. based on monitoring hours of operation, fuel usage, etc.).

Consequences of Exceeding Title V/PSD Emissions Thresholds: As noted above, the CWU campus emission units are currently permitted under a synthetic minor air permit. If permitted emissions for any individual air pollutant were to exceed 100 tons per year, the facility would be required to obtain a Title V permit. Obtaining this permit would be relatively straightforward, but would entail likely additional monitoring, recordkeeping, and reporting, as well as the payment of annual emissions-based fees to support the DOE Title V permitting program.

DOE Title V annual permit fees for a facility of the complexity of the CWU facility would include an annual flat fee of roughly $55,000 plus an emissions based fee of about $40 per ton of actual emissions of PM_{10}, SO_2, NO_x, and VOC (based on data from 2009 – 2011). Fees are adjusted as necessary to cover the cost of the Title V permitting program. Also, as a Title V source, additional source emissions testing might be required, increasing annual compliance costs by another $20,000.

If, in the future, permitted emissions of any individual air pollutant exceeded 250 tons per year, the facility would become a major source under the PSD permitting program. While the operating permit under this program would still be a Title V permit, the requirements to obtain a PSD construction permit for new emission units becomes significantly more burdensome.

SECTION III: CHILLED WATER SYSTEM

A. OVERALL SYSTEM DESCRIPTION

Originally, there was a south chiller plant co-located with the old boiler plant, and a "north chiller plant", located on an upper floor of the current boiler plant. The south chiller plant was abandoned in 2000, and the "north" chiller plant is now the only central chilled water plant.

The chilled water plant (the "CW Plant", or "Plant") includes four "cooling units". Three of the units are water cooled centrifugal chillers, and one is a flat plate heat exchanger, designed to be used for "free cooling" when ambient conditions fall within certain parameters. The total mechanical cooling capacity is 1,200 / 900 / 1,200 = 3,300 tons. The flat plate heat exchanger (HX) appears to have been designed to produce a 5.0 F delta T with 1,800 GPM, or 365 nominal tons.

There are three cooling towers (CTs) to serve the four cooling units. Each tower was matched to a corresponding chiller. Originally, the condenser water pumps (CWPs) both pumped into and pulled from common condenser water headers. Thus any combination of CTs and CWPs could work with any combination of chillers, as long as the CT/CWP combination provided enough condenser water flow and heat rejection capacity to satisfy the operating chiller(s). Likewise, any CWP could also serve the "cold side" of the flat plate heat exchanger (HX) in the free cooling mode. When Chiller 1A was installed in 2006, however, new chilled water and condenser water pumps were installed, as was a new cooling tower. This tower can be connected to the common condenser water inlet / outlet piping shared by the other two towers, but only by operating the manual valves that isolate CT-1A. Normally, as Figure 17 below shows, CT-1A is isolated, and can serve only CH-1A.

The Plant chilled water pumping is configured in a primary / secondary arrangement. There are two constant volume primary chilled water pumps (CHPs), one variable speed thermal energy pump (TEP), and three variable speed secondary chilled water pumps (SCHPS).

The two CHPs (including CHP-1A) have common suction and discharge headers, and can thus serve any chiller or the flat plate HX. The TEP is piped such that it can also draw from the common chilled water suction header, and pump into the common discharge header. However, using actuated control valves, it can be isolated from the common headers in a number of configurations (or cooling modes – see below).

The plant also contains a 1,000,000 gallon chilled water storage tank. The tank uses the buoyancy principal to separate the colder, denser water on the bottom from the warmer, less dense water on top. CWU's experience indicates that about 90 percent of the volume is useable storage.

The secondary chilled water pumps (SCHPs) are a skid-mounted package, with built-in controls. The pre-packaged system is by the manufacturer Systecon – and uses commercially available pumps, variable frequency drives, etc, which are packaged with Systecon controls to produce a compact, factory-assembled pumping / control package.

The chilled water, condenser water, and thermal storage systems are controlled by a direct digital control (DDC) system, manufactured by Alerton. This system automates the control of the plant. As originally programmed, it contained a large number of "cooling modes", based on combinations of chillers, free cooling, storage charge/discharge, and so on. Depending on "mode", the status of the individual pieces of equipment and the flow of water is controlled by approximately sixteen 2-position control valves. See the cooling modes subsections below for more detail.

Figures 17 and 18 below show the control graphics for the chilled and condenser systems, respectively.

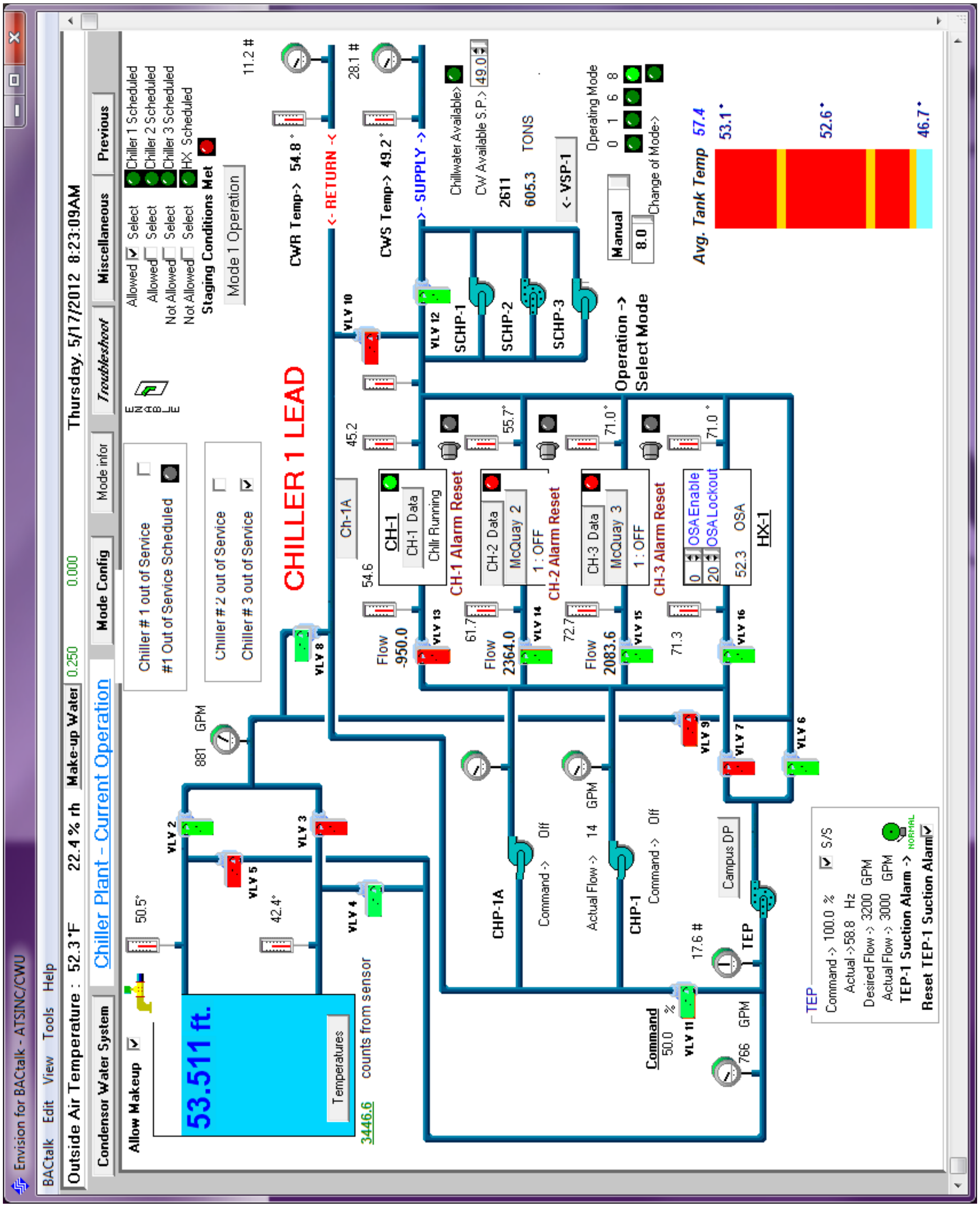


Figure 17, chilled water control graphic

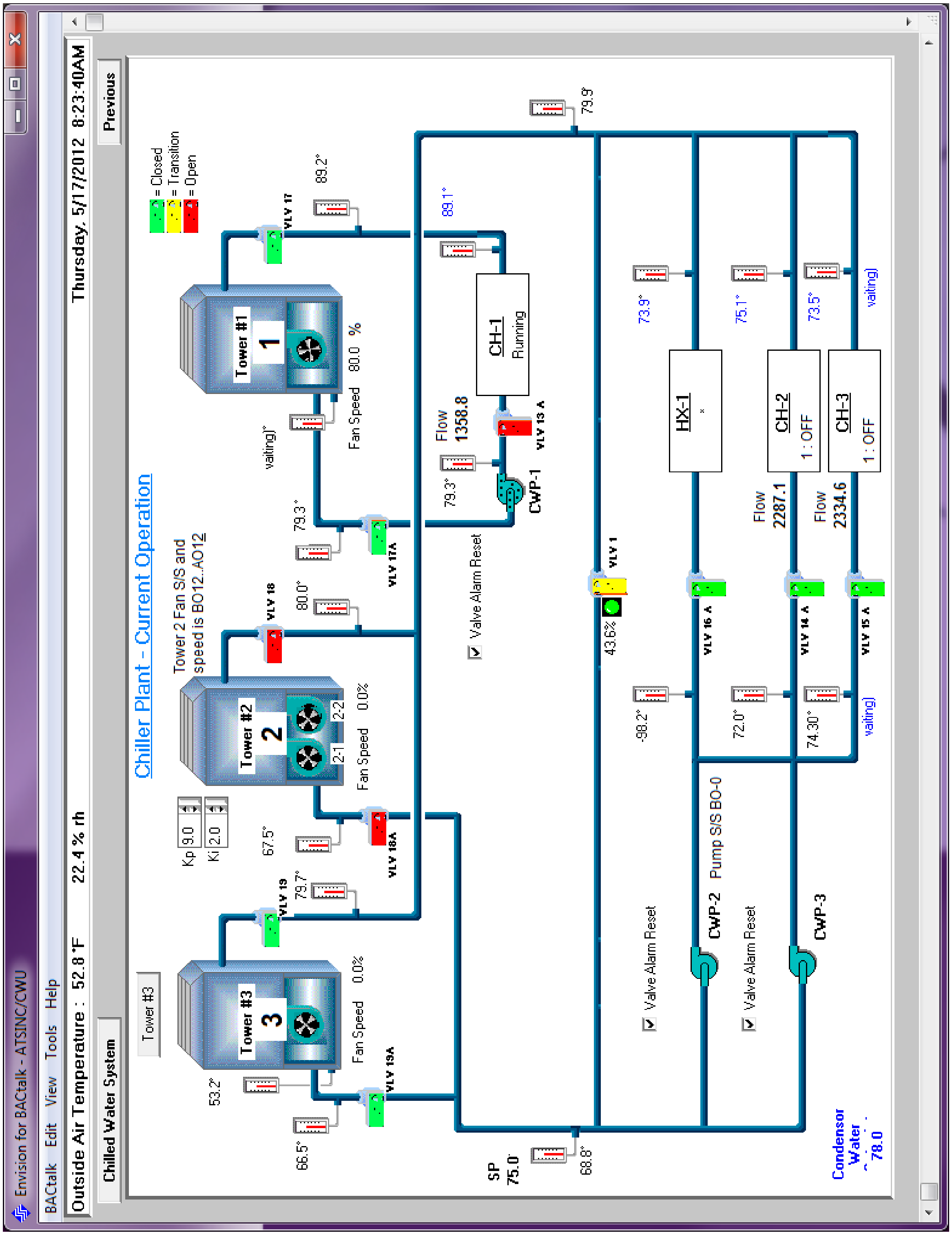


Figure 18, condenser water control graphic.

Cooling Modes – As Designed: As originally conceived, there were 10 distinct cooling "modes" – a mode here is defined primarily by the operating equipment and the flow path the water takes, which in turn is determined by the position of the 16 control valves. The location of the control valves can be seen in Figure 17 above. There are additional control valves associated with the condenser water flow, but this subsection deals specifically with cooling modes, and thus only those valves that control chilled water flow.

The primary reason for the thermal storage tank was not, as it is often is, because of punitive time-of-day electrical energy and demand charges. It was to take advantage of the fact that in the Kittitas Valley, nights are often relatively very cool and very dry, regardless of how hot it gets during the day (OATs in excess of 100 deg F are not uncommon). Given the cool, dry nights, there is generally little or no campus night-time cooling load to be met. Because the ambient wet bulb temperature is also low, the cooling towers can produce very cold condenser water with minimal fan energy. The storage tank full of warm return water (from the day's cooling load) provides a large, stable chilled water load.

Therefore, during night time tank charging, the active chiller can be run in the most energy efficiency manner; low inlet condenser water temperature and a stable fixed cooling load. Chillers are generally at their peak efficiency between about 80 and 90 percent of full load – in the charging mode, the chiller output can be fixed in this "sweet spot". These cooling modes were therefore devised to minimized energy use by taking advantage off the cool nights, and are made possible by the thermal storage tank.

The 10 cooling modes are summarized below (and abbreviated as CM1, CM2, etc):

- **CM1**: Normal Chiller (1 or 2 chillers). Chilled water return (CHR) from the campus distribution flows into the common CHP suction header. One or more CHPs pump through the active chiller(s). The primary chilled water supply (PCHS) water flows to the secondary chilled water pumps (SCHPs), which modulate the SCHS flow to meet campus cooling loads. If, as is usually the case, PCHS flow exceeds SCHS flow, the excess PCHS flows through the primary / secondary bridge into the CHR. If, on the other hand, SCHS flow exceeds PCHS flow, then CHR flows the other direction through the bridge to the SCHP inlet. This "reverse flow" would dilute (raise) the SCHS temperature, and is generally to be avoided.
- **CM2**: Normal Chiller (3 chillers). Same as CM1, except that all three chillers are one. This is considered a distinct mode.
- **CM3**: Manual. Same as CM1 or 2 (depending on No. of chiller operating), except that the SCHPs are bypassed. The operating CHPs pump all the way out to the

distribution system and back. The primary / secondary bridge still bypasses excess CHS into the CHR.

- **CM4**: Tank Discharge Only. CHR is diverted to the top of the storage tank. All CHPs are off. The variable speed TEP draws cold water off the bottom of the storage tank. This chilled water bypasses the SCHPs, and is pumped directly into the distribution system, and out to the buildings. Because TEP is variable speed, no flow through the bridge in either direction is required.
- **CM5**: Tank Discharge with Mixing. When the cooling load is low, there are times that the buildings do not require very cold chilled water. In such times, this mode can be used to lengthen the time the storage tank can operate before depleting the tank. In this mode, some of the CHR is diverted to the top of the tank, but some is bypassed to the inlet of TEP. This warm CHR mixes with the cold CHS flow that TEP is drawing from the bottom of the tank – the result is "warmer" (perhaps 45 – 48 deg F) chilled water. This lengthens the time before the cold stored chilled water is diluted with warmer CHR.
- **CM6**: Tank Discharge and 1 or 2 Chillers. The control valves isolate TEP from the common CHP suction header. TEP draws cold water from the storage tank, and pumps it into the common discharge header. One or more CHPs pull CHR from the common suction headers, through the operating chiller(s), and into the common discharge header. The tank water and chiller water mix, and then flow to the SCHPs (or through the primary / secondary bridge) as in CM1 or 2 - the SCHPs modulate the SCHS flow to the campus to meet load.
- **CM7**: Tank Discharge and 3 Chillers. Same as CM6, except all three chillers operate.
- **CM8**: Charge Tank with Chiller: TEP draws warm water from the top of the tank. It pumps though one operating chiller. The flow path to the SCHPs and the bridge are shut off by valves, and chilled water is diverted to the bottom of the tank. Because the colder water is the densest in the tank, it continually pushes the warmer water to the top, where it is drawn off to be cooled. The capacity of TEP is such that it can cycle all the tank water through the operating chiller twice in an 11 hour charging period (see Figure 3).
- **CM9**: Charge Tank with HX-1. Same as CM8, except that the tank is cooled using "free cooling" via the flat plate HX. This mode was intended to be used in during that part of the year when the temperature at night is in the 40's or below, and the daytime temperature is in the 60's or low 70's (May and late Sept / early Oct). During such times, the night-time temperature low enough to allow the cooling towers and HX-1 to generate water cold enough to charge the tank. Given the lower flow rate through the HX, however, it cannot fully charge the tank as a chiller can. Thus, this mode can only be used when the subsequent day-time cooling loads are mild – i.e. when the OAT is in the 60's or early 70's. This is intended as an energy saving measure.
- **CM10**: Charge Tank and Serve Load.   In its simplest form, this mode uses one chiller. TEP draws warm water from the top of the tank (as in CM8). The system CHR is diverted to the inlet of the TEP (as in CM5). The two warm flows mix, and

are pumped though the operating chiller. Unlike CM8, however, the flow path to the SCHPs is not shut off at the valves. The cold chilled water from the common discharge header splits – some goes to the SCHPs for distribution to the campus, and some flow to the bottom of the tank, charging it. A modulating control valve controls the tank inlet flow rate, while the speed of the SCHPs controls the flow to the campus. For the remainder of this report, this will be called **CM10-A**.

- **CM10-B**. CWU also uses a variation on this, which was not part of the original cooling mode programming. In this mode, two chillers are used, not just one. Both pump into the common chilled water discharge header. This increases the amount of flow that go to the campus SCHS loop, while still maintaining the tank charging flow.

<u>Cooling Modes – As Utilized</u>: In practice, CWU does not utilize all these cooling modes. Basically, CWU has reduced the operating modes to three simple schemes:

1) They charge the tank at night using one chiller **(CM8)**

2) They serve the day-time load with tank discharge water only (**CM4**, relatively cool weather)

3) As it gets hotter, they serve the day-time load with a combination of tank discharge water and up to two chillers (**CM6**).

CWU also uses the **CM10-A** mode, but they do not consider it a separate "mode", simply a variation of their "basic three" modes. As the weather gets hotter, these modes are applied as follows:

<u>Minimal day load / No night load</u>: Tank is charged at night using one chiller. Tank is discharged during the day to meet load.

<u>Medium day load / Minimal night load</u>: Tank is charged at night using one chiller. Some chilled water is diverted from the night-time tank charging and used for campus cooling. The proportion of flow to the campus may be increased around 4.00 AM or later to make sure the loop is cool prior to the buildings switching to Occupied Mode. Once tank charging is complete, the campus may be cooled by the tank only during the early morning, but as day heats up, a chiller is brought on line to supplement the tank.

<u>Large day load / Medium night load</u>: A single chiller is used to charge the tank, with some diversion of chilled water to the night-time load. However, in order to meet the night load and make sure the tank gets fully charged, a second chiller (usually the 900 ton unit) is brought on line during the charging process (generally in the morning).

Day-time load is met with the tank discharge and two chillers, generally a 1,200 ton and the 900 ton unit.

Very Large day load / Medium night load: Charging is again done with one chiller dedicated to the charging, and second chiller brought on the help meet campus load. In the hottest weather (~ 95 - 100 deg F plus), however, CWU must use the tank and two 1,200 ton chillers to meet campus day-time loads. This need for two 1,200 ton chillers has only come about in the last year or two, as new chilled water loads have been added.

B. PLANT CAPACITY AND COOLING LOADS

There are currently three water-cooled centrifugal chillers, as shown in Figure 19 below: As noted above, on most occasions, only a single chiller is needed, and it is generally CH-1A or CH-3. When two chillers are required, it is often CH-2 that is used as the Lag Chiller.

Chillers									
	nom			evaporator		condenser			
	cap		year	temps	flow	temps	flow	refrig-	volts
tag	tons	mfg	installed	deg F	gpm	deg F	gpm	erant	@ 3 ph
CH-1A	1,200	Carrier	2006	52>42	2,880	85>95	3,600	134A	4,160
CH-2	900	McQuay	1994	52>42	2,160	85>95	2,700	134A	4,160
CH-3	1,200	McQuay	1999	50>40	2,880	80>90	3,600	134A	4,160

Figure 19, chiller data.

Within the last year or two, the peak cooling load has reached a point where the two largest chillers are sometimes required; thus the plant mechanical cooling capacity has slightly less than n+1 redundancy (since the loss of a 1,200 unit would leave CWU unable to meet the worst case loads). Although the chilled water storage tank could be viewed as a "fourth chiller" (at least when charged), it does not add to the redundancy. This is because on the hottest days, the load requires three "chillers" – two chillers and the tank discharge. Chiller reliability is thus an important issue.

Using the data from Figure 20 below, if we use 660 tons as the "capacity" of the thermal storage tank, total plant capacity is 3,960 tons.

Peak Cooling Load – Current: Anecdotally, CWU believes their peak load to be about 2,700 – 2,800 tons. Part of the uncertainty arises from the fact that the thermal storage tank "stores" ton*hrs of cooling, not tons. The actual delivered cooling in tons depends on the rate at which the tank chilled water is pumped out.

The tank was designed for a 10 deg F delta T (the change in temperature between the warm CHR at the top and the cold CHS below that top layer), and has reportedly achieved a 15 deg F delta T. However, CWU personnel report that current practice is to charge the tank at 43 deg F. If the CHS setpoint is 44 deg F in hot weather, and the loop achieves the target loop delta T of 10 deg F, the tank would operate at about an 11 deg F delta T. As noted above, CWU considers the "fully charged" cold storage volume to be about 90 percent of the total volume (with the warm stratified layer taking up the other 10 percent).

At 43 deg F, the density of water is 62.4251 lb/ft^3. The peak storage capacity would be calculated as:

> 1,000,000 gal * 0.90 useable * 231 in^3/gal / 1,728 in^3/ft^3 * 62.4251 lb/ft^3 * 1.0 BTU/lb/deg F * 11 deg F / 12,000 BTU/h/ton = 6,885 ton*hrs.

If the tank were discharged at a uniform rate over the whole "cooling day" (~ 7.00 AM to 11.00 PM, or 16 hours), the tank would be equivalent to a 6,885 / 16 = 430.3 ton chiller. Of course, when the tank is the sole cooling unit, the output varies as the load does, so the tank does not discharge uniformly. When used in conjunction with chillers, however, the discharge rate is fairly stable. Figure 20 shows a matrix of "equivalent tank capacity" as a function of discharge period. In addition to a number of "whole-number" periods (16 hours, 12 hours, etc), the matrix calculates the discharge periods that correspond to 900 and 1,200 tons – the capacities of the existing chillers.

Chilled Water Storage Tank Capacity	
discharge period hours	equiv capacity tons
16	430.3
14	491.8
12	573.8
11	625.9
10	688.5
8	860.6
7.65	**900.0**
6	1,147.5
5.74	**1,200.0**
4	1,721.3

Figure 20, storage tank equivalent capacity.

CWU reports that on a typical "very hot" day, the tank would start discharging at about 9.00 AM and by "7.00 or 8.00 PM", it would be depleted – a total of 10 to 11 hours of discharge. Figure shows that this is equivalent to an average output of between 626 and 689 tons.

The upper bound on the current peak load: 2 chillers at 1,200 tons + 689 tons of tank output = 3,089 tons. However, we know that until just recently a 1,200 ton and a 900 ton chiller (plus the tank) was sufficient and that two 1,200 ton chillers are needed only on the very hottest of days. A more likely peak load might be:

> 2 chillers at 1,100 tons + 660 tons of tank output (~ the average value) = 2,860 tons. This is a good match to the anecdotal value, so for this study, we will consider the current peak chilled water load to be 2,860 tons at 100 deg F OAT

The current estimated load profile is showed in Figure 21 below. In addition, the load profile calculated in a 2009 study is included. This study made use of data from the control system to plot the load. One major difference between the two (aside from the fact that the load has increased since 2009) is that the current profile shows the Shaw - Smyser (S-S) load. Due to internal loads, this building requires mechanical cooling in ambient conditions all the way down to 35 deg F OAT.

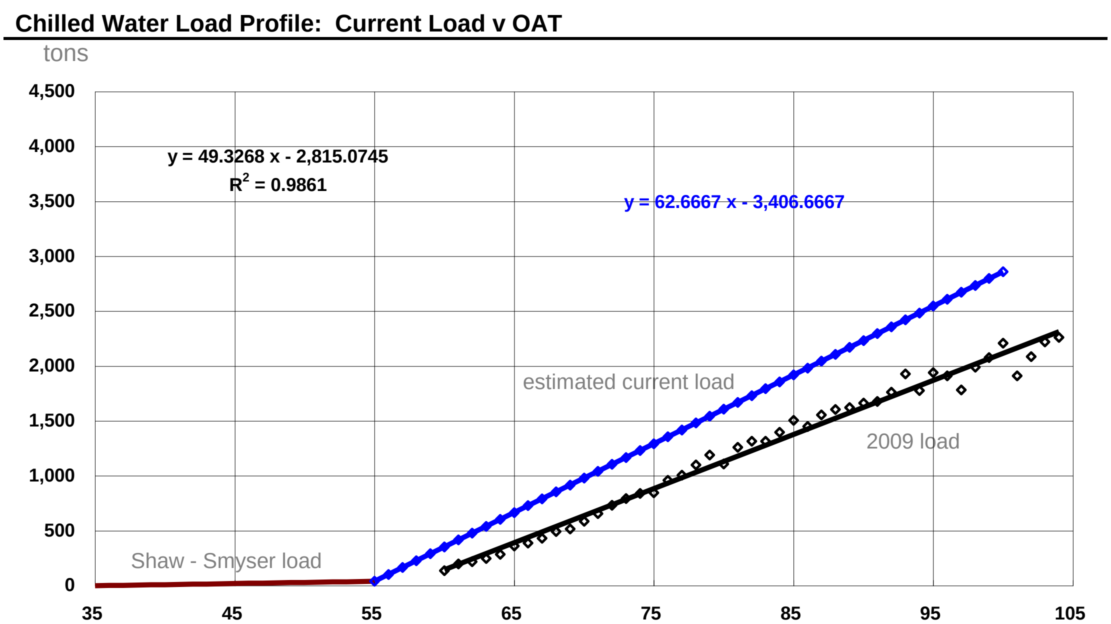


Figure 20, chilled water load profile.

Note that the 2009 data shows a very close correlation ($R^2 = 0.986$) between the OAT and the chilled water load – this linear relationship is assumed to hold for all of the projected load profiles.

Chilled Plant Peak Load – Future: Future chilled water loads (buildings to be added to the loop) are divided into three categories: immediate term (IT) loads, near term (NT) loads, and unknown term (UT) loads. Figure 22 below shows the estimate peak loads of all three types of load, by building.

Future Chilled Water Loads	estimated load, tons		
Building	(1) imm term	(2) near term	(3) unk term
Hogue Renovation	90		
New Barto Hall	130		
Science II		395	
NEHS		260	
Samuelson Renovation		300	
Randall			205
Michaelson			155
total 1,535	220	955	360

(1) immediate term - next cooling season
(2) near term - in the next ten years
(3) unknown term - the building and piping exists - CWU could hook the building up to the loop at any time

Figure 22, future chilled water loads.

The values in Figure 22 pose a significant challenge to CWU; within 10 years, the peak cooling load could increase by 50 percent or more – easily exceeding the existing plant capacity. Assuming these estimates are valid, the peak load could increase to ~ 4,400 tons by 2022. This exceeds the combined capacity of all the chillers plus the tank (3,960 tons, see above) by 400 tons.

Even the IT loads pose a problem – if the current peak is in fact 2,860, the addition of Hogue and the new Barto would increase the peak load to 3,080 tons. Not a large increase, but the issue is that it pushes the peak right to the edge of or slightly beyond the capacity of the two 1,200 tons chillers plus the tank (estimated at 3,060 tons). By the end of the 2012 cooling season, CWU may require the tank plus all three chillers to meet the load on a 100 plus OAT day.

However, there are only three primary chilled water pumps (see below), and four "chillers" (if one counts the tank as a chiller), so it is not currently possible for CWU to run three chillers and discharge the tank at the same time. Since CH-2 has more instantaneous capacity than the tank, once the load exceeds about 3,060 tons, CWU would have to shut down the tank, and run three chillers. This extends their capacity out to 3,300 tons, but it defeats the purpose of the tank by running the chiller full out during the day. In addition, given that they have condenser water flow problems (see below) when both 1,200 ton chillers run, they may not be able to run three chillers in any event.

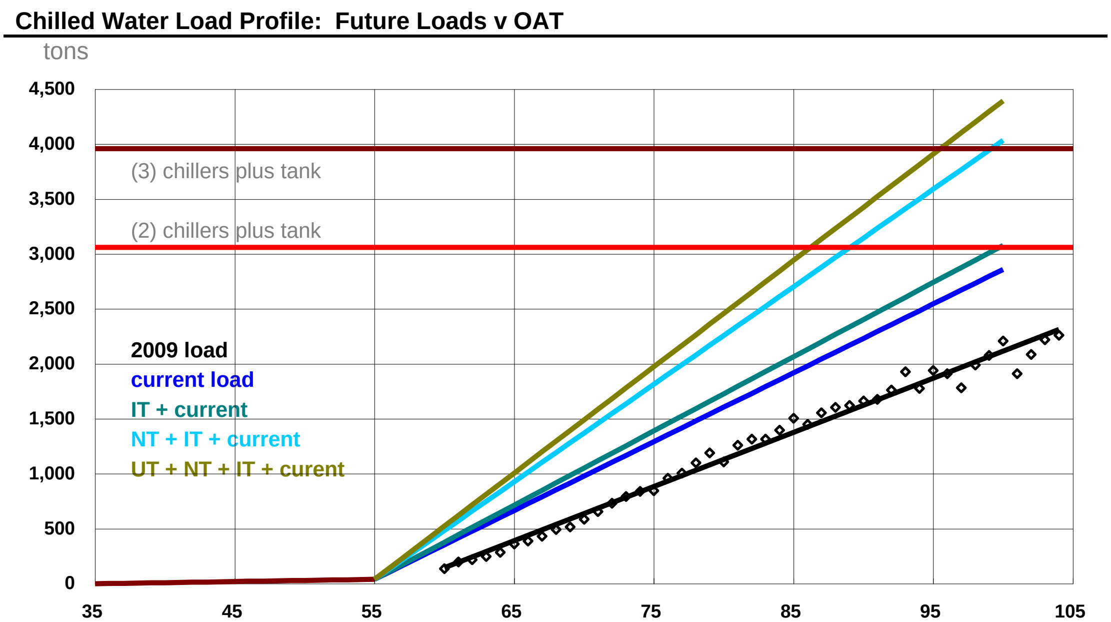
Even if CWU can successfully run three chillers, they may not be able to get the chilled water to the campus. Secondary chilled water pumps have a maximum scheduled SCHW flow of 6,480 GPM. At 2.4 GPM per ton (which equates to a 10 F loop delta T), this is enough water to transport 2,700 tons of cooling – this is less than the current peak load, even before the IT loads are added. The pumps appear to be able to meet the current peak, but it is obvious that CWU will run out of pumping capacity before it runs out of cooling capacity.

It is theoretically possible for CWU to use the primary chilled water pumps to pump water into the campus loop. The chiller flows are constant, and the loop flows are variable; there are two potential ways to resolve the differences in flow. First, CWU could simply let the primary pumps "ride the pump curve" – to reduce flow as system head pressure rises, and vice versa. In this scenario, the chiller flows would become variable. This is common today, but it is unknown how a 1994 chiller would respond to variable flow. In the second scenario, the valve in the primary secondary bridge could modulate to bypass excess primary chilled water back to the system return water. The existing valve is probably not suitable for this, and would likely need to be replaced.

Having said that it is possible, CWU has never tried using the primary pumps to pump the loop, so it is a very large unknown. What is known is that the primary pumps have enough flow capacity to pump all three chillers, and they have significantly more head capacity than the secondary pumps – 115 FT vs 90 FT. The combined flow capacity of the primary pumps plus TEP is 8,040 GPM, more than enough to transport 3,080 tons. By the end of 2012, therefore, CWU may be forced to attempt primary pumping in order to get the required cooling out the buildings on the campus loop. This should be considered a short term fix only.

Many facilities place more importance on redundancy in the heating plant than in the cooling plant; by the end of 2012 CWU will effectively have zero cooling redundancy based on their existing cooling units.

Beyond the IT loads, the NT and UT loads mean that within ten years, not only would CWU not have a redundant chiller, they could not meet load at all on the hottest days. The effect of these future loads on the load profile is shown in Figure 23 below:



Fgure 23, future chilled water loads.

In addition to the load profiles, Figure 23 shows the chilled plant capacity using two and three chillers in conjunction with the tank.

Finally, in terms of peak load, it should be noted that some buildings have dedicated chillers for process loads – the Computer Center, Dean Hall, Science, Archives, etc. In some cases, the "primary" cooling is the loop, and the back-up is the dedicated chiller; in some case it is the reverse. This brings up two issues: 1) should a dedicated chiller fail, that could increase the chiller plant load beyond even the figures shown above, and 2) except when the load is very high, it would seem to make sense that the campus loop be the "primary" chiller – since the loop runs year round. The exception would be cases in which the chilled water temperature required by the process is less than the loop temperature – one building should not "drive" the entire system setpoint.

In terms of redundancy, it is important to remember that the "balance of plant" (BOP) equipment can have an effect on Plant capacity as well as the chillers. The BOP equipment is those pieces, such as pumps, cooling towers, etc, that support the chillers. Each type of BOP equipment is discussed in its own subsection below, but BOP in general is included here due to its effect on redundancy.

There are only three CTs, and three chillers, so the loss of any tower means that one chiller would also need to be shutdown. Likewise, the loss of any condenser water pump (CWP) or primary chilled water pump or TEP would mean that one chiller would not be available. Because the pumps were sized for the associated chiller, CHP-1 (confusingly, CHP-1 is paired with CH-2) and CWP-2 cannot support CH-1A or CH-3 – the flow rate is too low. So despite the common pumping headers, it does matter which pump or CT fails. More detail is provided below.

<u>Chiller Issues</u>:

ASHRAE lists the service life of a centrifugal chiller as 23 years, on average. Chillers in the NW part of the country do not always get worked as hard as those in other areas, so 25 years is probably a fair life expectancy. That would mean that CH-2 should be schedule for replacement no later than about 2019, and CH-3 four years after. That is about the time scale on which CH-2 would need to be replaced for capacity reasons. Until that time, however, CWU must keep the chillers running, and there have been a number of operational issues with the chillers.

> CH-1A is the newest chiller. However, use has been limited until very recently by flow problems and an apparently faulty surge sensor. Surge occurs when the discharge pressure of the compressor is less than the compressor inlet pressure – the refrigerant then attempts to flow backwards through the compressor, causing a series of pressure waves, or surge, through the unit. This can quickly destroy the impeller. Thus a surge sensor trips the unit off-line before surge can occur. CH-1A has a history of tripping off-line due to incipient surge. There are a number of issues that can cause this pressure "reversal", including low condenser water temperature or flow. CWU did seemingly have a low condenser water flow problem, and so surge may in fact have been an issue. However, once the flow problem was solved, the chiller still tripped out on incipient surge. The manufacturer felt that it was still a flow problem, which delayed the use of CH-1A further. It seems to have finally been determined that the unit was not in pre-surge; the sensor was faulty, causing false trips. The operators have recently begun using CH-1A as the Lead Chiller.

CH-2 is the oldest chiller, and the smallest in capacity; however, it is the only chiller that has not had any major issues that would affect reliability.

Until very recently, CH-3 has been the most reliable chiller, and was generally the Lead Chiller. Historically, however, it has suffered several incidents of damage and subsequent rebuild. In 2005, due to internal faults, the compressor impeller shifted so far axially that it rode up against the thrust bearings – at that point, the impeller was destroyed, and shards of metal were strewn through the unit. All of these shards had to be removed for fear of future damage. Subsequently, the chiller has had tube failures – on a high pressure machine (such as an R134A machine), this means the refrigerant leaks into the water; but ultimately, both fluids end up contaminated. CH-3 had to have a complete refrigerant replacement after the tubes were fixed. Nevertheless, after several rebuilds and repairs, CH-3 was until recently the chiller of choice. Now that CH-1A is operating reliably, it is normally the lead chiller.

Flat Plate Heat Exchanger:

The flat plate heat exchanger (HX) was installed in 1999, and was intended as an energy saving measure. Given the cool, dry nights in the Kittitas Valley, the original intent (based on the control schematics) was that given the right conditions, the cooling towers could be used to generate water cold enough to charge the storage tank and meet low load cooling loads. The flat plate HX offers a way to transfer the heat from the chilled water to the condenser water, which is then cooled by the cooling towers. Cooling towers use much less energy than chillers, thus saving energy (despite the name “free cooling”, it does require cooling tower fan energy).

The HX, manufactured by Alfa Laval, was designed for 1,800 GPM flow on both sides, hot and cold (with a five degree delta T, or 375 nominal tons). A flat plate heat exchanger was used because the usefulness of the concept depends on the smallest practical “approach” between the two flows (chilled and condenser water). The approach temperature in this case is the difference in temperature between the cooling medium (condenser water) and the medium being cooled (chilled water). Flat plate heat exchangers, unlike shell and tube heat exchangers, can produce true counter-flow heat exchange, thus they produce significantly smaller approach temperatures. The value of a small approach temperature is shown below.

Cooling towers also transfer heat, from water to air, and thus approach temperature applies here as well. Because cooling towers use evaporative cooling, the relevant approach temperature for a cooling tower is the difference between the ambient wet bulb temperature and the leaving condenser water temperature. Ultimately, then, the ability of the system to utilize the HX depends on the total approach temperature between the ambient wet bulb and the desired chilled water storage temperature.

<u>Storage Tank:</u>

The storage tank is an above-ground, 1,000,000 gallon vertical storage tank. It was built on site, and is open to the atmosphere. It stores thermal energy by “floating” a layer of less dense, warm water on top of denser, colder water below. The border between these two layers, which must be kept distinct, is the thermocline.

The piping in the tank is arranged to avoid turbulence, and thus mixing. If excessive turbulence were to occur, the thermocline would be upset, and the tank water would mix, rending it largely or completely useless as a thermal storage device.

As Figure 16 shows, the piping is arranged such that the TEP and CHPs can draw from top and bottom of the tank; likewise, they can pump into the top or bottom as well.

At the end of a cooling day, the tank is largely filled with warm return water (CHR). The thermocline is at a very low elevation in the tank, if it still exists. To charge the tank, water is drawn off the top of the tank, pumped through a chiller, and then back into the bottom of the tank. Over the eight hours of charging the thermocline is gradually elevated as more cold water is pumped in – eventually about 90 percent of the tank water is cold water below the thermocline.

To discharge the tank, the pump (usually the TEP) now pulls from the bottom of the tank. The cold tank water is pumped out the campus distribution, and the warm CHR is piped into the top of the tank, above the thermocline.

The subsection Cooling Modes – As Designed above details all the pumping variations that the tank makes possible. Figure 19 above tabulates the storage capacity of the tank at various discharge rates.

Primary Pumping:

There are two primary chilled water pumps; in addition, TEP can act as a primary pump. Figure 24 provides detail on the pumps.

Primary Chilled Water Pumps / Thermal Energy Pump								
			flow			motor		
	assoc		rate	head	impeller			volts
tag	chiller	mfg	gpm	ft	in	HP	rpm	@ 3 ph
CHP-1A	CH-1A	PACO	2,880	115	11.55	100	1,800	480
CHP-1	CH-2	PACO	2,160	115	11.80	100	1,800	480
TEP	none	PACO	3,000	115	11.70	100	1,800	480

Figure 24, primary chilled water pumps.

TEP is a variable speed pump while the other two are constant speed. The pump head, at 115 ft, is high for a primary chilled water pump, but as noted above, in some cooling modes, the three pumps are expected to pump all the way through the campus loop without the use of the secondary pumps (as also noted above, CWU has never attempted this).

In terms of Plant redundancy, it was noted above that BOP equipment affect Plant operations as much as the chillers themselves. In this case, there are three pumps, just as there are three chillers. However, note that the combined flow of TEP and CHP-1 (5,160 GPM) is not enough to operate the two 1,200 ton chillers (required flow 5,760 GPM) – so not all pump failures are “equal”.

On the hottest days, CWU uses the storage tank and two 1,200 ton chillers. Any single primary pump failure would make this impossible; however, this mode represents very few days per year of operation. The most common summer configuration is the storage tank plus one of the 1,200 tons chillers. In this case, a failure of either TEP or CHP-1A would make this configuration impossible, although the tank and the 900 ton chiller could be used – lowering the plant capacity by about 12 percent. A failure of CHP-1, on the other hand, affects only the Tank + (2) chiller configuration.

Finally, a failure of TEP does not disable the storage tank, because either of the other two primary pumps can both charge and discharge the tank. These pumps are not as operationally flexible as TEP, however, because they are constant speed.

Secondary Pumping:

The three secondary pumps are part of the pre-packed, skid-mounted, package manufactured by Systecon. Originally, only two pump were installed, but the package was designed for a third pump, which has since been added. The three pumps are detailed in Figure 25 below:

Secondary Chilled Water Pumps							
		flow			motor		
		rate	head				volts
tag	mfg	gpm	ft	speed	HP	rpm	@ 3 ph
SCHP-1	Bell & Gossett	2,160	90	variable	75	1,785	480
SCHP-2	Bell & Gossett	2,160	90	variable	75	1,785	480
SCHP-3	Bell & Gossett	2,160	90	variable	75	1,785	480
	sum	6,480					

Figure 25, secondary chilled water pumps.

The original Plant design called for the campus loop flow to be 4,200 GPM (only SCHP-1 and -2 were installed). SCHP-3 was added in 2005. Using a 10 deg F delta between SCHS and CHR equates to 2.4 GPM per ton, so the original loop “capacity” was 1,750 tons and the current capacity is 2,700 tons. The current peak campus cooling load, estimated above, is 2,860 tons. Thus, it could be said that CWU is already out of SCHP capacity – by the peak of the 2012 cooling season, they may be failing to meet load due to lack of pumping capacity, especially as the IT loads come on line.

In some cooling modes (**CM3**, **CM4**, **CM5**), the primary pumps bypass the secondary pumps and pump directly into the campus loop. **CM3**, in particular, is called the “manual mode”, using 1, 2, or 3 chillers. In this mode, CWU could conceivably pump the entire chiller capacity (3,300 tons, 7,920 GPM) out to the campus loop.

If the primary pumps can in fact pump the loop (and they have 25 ft more head capacity than the SCHPs), and the secondary pumps are a near term constraint on campus cooling, it is not obvious why CWU even uses the secondary pumps. However, if they intend to continue using the primary / secondary pumping, they will have to upgrade the secondary pumping capacity by next cooling season.

Condenser Water Pumping:

The characteristics of the condenser water pumps are shown in Figure 26 below.

Condenser Water Pumps								
			flow			motor		
	assoc		rate	head	impeller			volts
tag	chiller	mfg	gpm	ft	in	HP	rpm	@ 3 ph
CWP-1A	CH-1A (1)	PACO	3,600	80	10.05	100	1,800	480
CWP-2	CH-2	PACO	2,700	80	10.20	75	1,800	480
CWP-3	CH-3	B&G	3,600	80		100	1,800	480

(1) This pump can only serve this chiller

Figure 26, condenser water pumps.

Unlike the primary chilled water pumps, not all the condenser pumps connect to common suction and discharge headers. CWP-1A, is piped directly to CH-1A (and CT-1A). Thus a failure of CWP-1A means CH-1A cannot be used. (The condenser water piping associated with CT-1A and CWP-1A can be made "common" with the other units, but the valves are manual, thus an automated failure response cannot be made by the DDC system.)

CWP-2 and 3 are connected to common headers, so CWP-3 can work with CH-2 or CH-3. CWP-2, however, was sized for CH-2 (2,700 GPM) and thus cannot substitute for CWP-3 (3,600 GPM) in the event of CWP-3 failure.

To summarize,

A) a failure of CWP-1A takes CH-1A off-line,

B) a failure of CWP-2 does not take CH-2 or CH-3 off-line, but it does mean only one of the two can operate, and

C) a failure of CWP-3 takes CH-3 off-line.

In addition to the impact of pump failures, CWU has had an ongoing issue providing enough condenser water flow to run two chillers at a time, especially the two 1,200 ton chillers. As noted above, CWU is very close to having to run three chillers to meet peak load. Given the existing issues, it does not seem likely that the condenser water pumps / piping will support this mode of operation.

Cooling Towers:

The characteristics of the cooling towers are shown in Figure 27 below.

Cooling Towers										
					temperatures			motor		
	assoc	year		type (1)	inlet	outlet	wet bulb			volts
tag	chiller	installed	mfg		deg F	deg F	deg F	HP	rpm	@ 3 ph
CT-1A	CH-1A	2,006	BAC	ID	95	85	66	50	1,800	480
CT-2 (2)	CH-2	1,994	BAC	FD	95	85	70	(2) - 40	1,800	480
CT-3	CH-3	1,999	Marley	ID	90	80		50	1,800	480

(1) ID = induced draft, FD = forced draft

(2) This chiller originally had two 40 HP main motors, and two "pony" motors - the belts on the pony motors were removed when the VFDs were installed on the main motors

Figure 27, cooling towers.

The CT-1A cooling tower installed at the same time as CH-1A is piped only to CWP-1A and thus to CH-1A (unless manually valved into the common headers). The other two cooling towers have common supply and return headers, and can serve either CH-2, CH-3, or both. As with the condenser water pumps, CT-2 was sized for CH-2 and thus cannot serve CH-3 at full load.

CT-2 could serve CH-3, but only at partial loads; it cannot cool 3,600 GPM by 10 deg F (as required) except perhaps in the coolest of weather. It could keep CH-3 on line at reduced capacity in the event of a CT-3 failure.

To summarize,

A) a failure of CT-1A takes CH-1A off-line,

B) a failure of CT-2 does not take CH-2 or CH-3 off-line, but it does mean only one of the two can operate, and

C) a failure of CT-3 means that CH-3 can operate, but only at approximately ¾ capacity.

C. SYSTEM CONSTRAINTS TO MEETING LOADS

As pointed out in previous paragraphs, several things can go wrong within the Plant that will decrease cooling output. There is more to worry about than the fact that the existing plant cannot meet the future loads expected with the new buildings in the Science Neighborhood. Clearly, to meet those loads the Plant will need to be expanded or additional cooling capacity added elsewhere in the system.

However, other failures within the Plant would have significant impacts on meeting cooling loads. Figure 28 summarizes the effect of different failure modes: Secondary chilled water pumps are not shown because it appears the plant can function without them. This pumping concept is not proven, however, and as shown above, the SCHP package is already out of capacity at peak load. The failure of any SCHP would reduce Plant capacity by one third, or would force CWU to attempt primary-only pumping to make up for the failure.

Equipment Failure vs Plant Capacity

failed equip	avail cap tons (1)	CH-1A	CH-2	CH-3	storage tank
CH-1A	3,300		1.00	1.00	1.00
CH-2	3,600	1.00		1.00	1.00
CH-3	3,300	1.00	1.00		1.00
s tank	3,300	1.00	1.00	1.00	
CHP-1A	2,100	0.33	1.00	0.33	0.33
CHP-1	2,400	0.67		0.67	0.67
TEP	2,100	0.33	1.00	0.33	0.33
CWP-1	3,300		1.00	1.00	1.00
CWP-2	3,600	1.00		1.00	1.00
CWP-3	3,300	1.00	1.00		1.00
CT-1A	3,300		1.00	1.00	1.00
CT-2	3,600	1.00		1.00	1.00
CT-3	3,300	1.00	1.00		1.00

(1) This is the maximum capacity under this failure mode

[grey] This unit cannot operate

[green] A value of 0.33 spread across three units means only one of the three can operate in this mode. A value of 0.67 means any two can operate

Figure 28, failure modes.

As Figure 28 shows, only a primary chilled water pump failure can materially affect the Plant capacity. One of the reasons for this is that the storage tank, which functions as the “fourth chiller”, does not “run” (get charged) during peak load times – thus one chiller running at night charging the tank equates to two chillers the next day when the tank is discharging. It only takes one chiller, one tower, and one CHP to charge the tank, so the “fourth chiller” is always available unless a primary CHP goes down (or unless, as Figure 28 shows, the tank itself is down for maintenance)

Only primary chilled water pumps (including TEP) can deliver chilled water, either direct to the campus or to the secondary pumps – therefore, the loss of one of these three pumps limits the Plant Capacity to the output of two chillers, or one chiller and the tank.

The Plant is physically very crowded; however, if CWU were going to do one thing to improve Plant redundancy, it should probably be the addition of a third primary chilled water pump and a fourth secondary chilled water pump. A third primary chilled water pump would mean the plant could utilize all three chillers plus the tank, assuming: 1) they add another secondary chilled water pump, or 2) they use primary-only pumping in this mode, and 3) regardless of chilled water pumping, it would require good condenser water flow to maintain three chillers on line, which does not appear to be assured.

Plant Issues – flow:

The Chilled Water Plant has a long history of flow problems, both on the evaporator side of the chillers and the condenser side. The problem has often been too little total flow, but sometimes it is simply getting the flow to go where needed. In an attempt to at the least prevent excess flow through any one device (and divert it to the lower flow devices), a number of flow limiters have been installed in the piping.

These devices, manufactured by Griswold, will limit the flow to a pre-set value, as long as the pressure differential across the unit falls within the specified limits.

These appear to have significantly helped to solve the flow issues, although as noted above, when CH-1A was installed, it had low flow issues on the condenser side. This low flow condition manifested itself as incipient surge in the compressor. Even when the flow problem was solved, the chiller still tripped off on incipient surge – it now appears that a sensor was faulty. The unit was installed in 2006, and only now are the operators beginning to use it as the Lead Chiller.

Any future changes to the Plant must deal with both pipe sizing and flow issues in order to be successful, especially if the addition the IT loads forces CWU to use three chillers this season.

Plant Issues: - Water Treatment:

Condenser water loops are generally “open” loops, meaning they are open to the atmosphere at some point (in the basin of the cooling tower, generally). This is very common, and the water treatment regimens to take care of both particulate (dust from the air, silica in the water) and biologicals (organisms that grow in the water) are well established.

Condenser water loops are small compared to chilled water loops, and the water treatment generally occurs right at the tower basin (which is a small, well mixed body of water). Water sampling and chemical metering and monitoring are all automated, and generally effective.

Chilled water loops are usually closed – there is no contact with the atmosphere. Particulate is generally large (rust that spalls off the pipe, etc) and can usually be handled with strainers. With no sunlight and no exposure to air, biologicals generally do not exist. Chemical treatment is minimal in closed loops, and often focuses on combating corrosion in metal pipes. Most of CWU’s chilled water pipe is plastic, and therefore not prone to corrosion.

CWU, however, has the storage tank, and that is open to atmosphere. As a result, they do have both wind-blown particulate and biologicals in their chilled water. Because of the low temperatures, the biological growth is slow, but it is also very difficult to treat. The storage tank is a very large volume of water, in which by definition, the water cannot be mixed. This makes distributing any sort of chemicals widely throughout the tank impractical. Likewise, the system is constantly collecting particulate too small to be removed by strainers.

CWU is trying to solve this ongoing water treatment issue – the ultimate solution is not known. In the meantime, they circulate chilled water all year round. In winter, 600 – 1000 GPM are circulated by the secondary chilled water pumps. CWU has found from experience that if the water flow stops, all the particulate and the biological organisms tend to settle to bottom the pipes, or in devices. On the next start-up, large concentrations of these particles are pumped into valves and heat exchangers, clogging up these devices and causing significant start-up issues. So for now, the SCHPs run all the time.

CHILLED WATER DISTRIBUTION

There are two flow-related constraints on chilled water piping, pressure drop and velocity. Pressure drop is important because if the delta P (pressure drop) of the system gets too large, the pumps will not be able to push the chilled water to the most remote buildings on the loop. Velocity is important in that higher flow rates cause greater pipe wear and scouring. Given that all of CWU's distribution piping is plastic, and the water contains significant amounts of particulate, scouring is an issue. CWU needs to set limits on both of these parameters so they can evaluate the distribution piping.

These two variables change at different rates depending on the overall size of the pipe. With larger pipes (~ 18 inch diameter and greater), pressure drop increases more slowly than velocity. With smaller pipes, pressure drop may become an issue before velocity.

<u>Pressure Drop</u>: The distance "as the pipe lays" from the Plant to the farthest chilled water load (Wendell Hill Hall B) is approximately 4,000 feet. Including the return trip back to the plant, the distance is lineal 8,000 ft. In piping design, the concept of equivalent feet is used. Each fitting, whether a coupling, a 90 deg F ell, or a tee, imposes an additional pressure drop on the system that can be expressed in feet of head loss. The total "hydraulic" length of the piping is usually expressed as a multiplier on the actual length of piping. For smaller (say building scale) systems, a multiplier of 1.5 is often used. However, at CWU, the distribution piping often travels tens or hundreds of feet with no fittings. For that reason, we will use a multiplier of 1.25 in this report. Using this value, the pumps "see" 8,000 * 1.25 = 10,000 ft of piping to the farthest load.

The head capacity of the secondary pumps is 90 feet of head. Assuming that 10 PSIG maximum is required at the buildings to get through control valves, etc., this leaves 90 – (2.307 * 10) = ~ 67 ft of head loss available for piping losses. Dividing by the hydraulic length of 10,000 ft, this means that in general, piping pressure drop should be limited to 67 / 10,000 = 0.0067 ft of head per foot. Because number like this are so small, they are generally given in ft of head loss per 100 feet of pipe – using this criteria, CWU should aim for a friction rate of 0.67 ft per 100 ft of pipe.

Obviously, not every segment need meet this criterion – that is an average over the entire 4,000 lineal feet out and 4,000 feet back. Nevertheless, an upper limit of 0.67 ft of pressure drop per 100 is a good guideline to use when evaluating individual pipe segments.

Velocity: Some designers use 12 feet per second (FPS) as an upper limit on water velocity within the pipe. This rule of thumb is generally applied to steel piping. However, it is not unusual to use 12 FPS as a limit for plastic pipe as well.

However, CWU has a heavy load of particulate in the pipe, which increases the rate at which the pipe is eroded. For that reason, we are suggesting that CWU use 8 FPS as an upper limit, at least until they find a way to mitigate the particulate in the piping.

Existing Piping: The majority of the chilled water loop piping is considered to be more than adequate to handle current and future loads; however, two sections of pipe are of particular concern.

The first is the 20 inch diameter pipe carrying the chilled water across "D" Street. The second is the 12" diameter pipe that runs past Randall / Michelson (R / M) out to Wendell Hill Hall.

The 20 inch pipe must carry the entire chilled water plant load (less only Jongeward). This pipe is asbestos cement except for the section under D Street which is steel. The pipe parameters of the D Street pipe under current and future loads is shown in Figure 29 below:

Pipe Parameters			**(20" dia segment crossing D street)**		
		current peak	current peak plus IT	IT + NT	IT + NT + UT
load	tons	2,860	3,080	4,035	4,395
flow rate	gpm	6,864	7,392	9,684	10,548
dp	ft/100 ft	0.79	0.90	1.49	1.75
velocity	ft/s	7.93	8.54	11.18	12.18

Figure 29, D street chilled water piping parameters.

The peak load conditions do not last very many hours per year, and this section of piping is only about 450 feet long. For that reason, the flow rate associated with the current peak, and even the current peak plus the intermediate term loads, are likely acceptable. However, this segment of pipe will experience excessive erosion if it carries the near term added cooling loads.

Once the pipe crosses “D” Street, it splits into two 20 inch segments – both of these segments are within limits for the foreseeable future.

The second pipe segment of concern is the 210 foot long section from the Walnut Mall loop piping to the R / M take off. This R / M pipe serves fewer buildings, but it is the “end of the line”, and the campus is expanding in that direction. The current and future pipe parameters for this segment are shown in Figure 30 below:

Pipe Parameters					**(12" dia segment in front of R / M)**
		current	current peak plus		
		peak	IT	IT + NT	IT + NT + UT
load	tons	571	791	791	1,151
flow rate	gpm	1,370	1,898	1,898	2,762
dp	ft/100 ft	0.36	0.67	0.67	1.35
velocity	ft/s	3.93	5.45	5.45	7.93

Figure 30, R / M chilled water pipe parameters.

The data in Figure 30 indicate that this segment of piping is within limits for at least the next ten years. The potential issue is that this segment feeds a very long leg, and if campus expansion proceeds to the Northeast, this leg will have more and more pressure put on it. If, or when, Randall/Michelson cooling is added, or additional buildings are constructed in this part of campus, a new cooling connection should be made between the 14” just north of Stephens/Whitney and the line feeding Barto. In fact, if CWU adds new communication ductbank form Stephens/Whitney to Randall/Michelson, the chilled water could parallel this route.

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Expected Use of Bond/COP Proceeds

Agency No:	**375**	**Agency Name**	**Central Washington University**
Contact Name:	**Steve DuPont**		
Phone:	**509.963.2111**	**Fax:**	
Fund(s) Number:	**057**	**Fund Name:**	**State Building Construction Account**
Project Number:	**40000075**	**Project Title:**	**Chiller Addition**

Agencies are required to submit this form for all projects funded with Bonds or COPs, as applicable. OFM will collect and forward the forms to the Office of the State Treasurer.

1. Will any portion of the project or asset ever be owned by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
2. Will any portion of the project or asset ever be leased to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
3. Will any portion of the project or asset ever be managed or operated by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
4. Will any portion of the project or asset be used to perform sponsored research under an agreement with a nongovernmental entity (business, non-profit entity, or the federal government), including any federal department or agency? ☐ Yes ☒ No
5. Does the project involve a public/private venture, or will any entity other than the state or one of its agencies or departments ever have a special priority or other right to use any portion of the project or asset to purchase or otherwise acquire any output of the project or asset such as electric power or water supply? ☐ Yes ☒ No
6. Will any portion of the Bond/COP proceeds be granted or transferred to nongovernmental entities (businesses, non-profit entities, or the federal government) or granted or transferred to other governmental entities which will use the grant for nongovernmental purposes? ☐ Yes ☒ No
7. If you have answered "Yes" to any of the questions above, will your agency or any other state agency receive any payments from any nongovernmental entity, for the use of, or in connection with, the project or assets? A nongovernmental entity is defined as ☐ Yes ☒ No
   a. any person or private entity, such as a corporation, partnership, limited liability company, or association;
   b. any nonprofit corporation (including any 501(c)(3) organization); or
   c. the federal governmental (including any federal department or agency).
8. Is any portion of the project or asset, or rights to any portion of the project or asset, expected to be sold to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
9. Will any portion of the Bond/COP proceeds be loaned to nongovernmental entities or loaned to other governmental entities that will use the loan for nongovernmental purposes? ☐ Yes ☒ No
10. Will any portion of the Bond/COP proceeds be used for staff costs for tasks not directly related to a financed project(s)? ☐ Yes ☒ No

If all of the answers to the questions above are "No," request tax-exempt funding. If the answer to any of the questions is "Yes," contact your OFM capital analyst for further review.

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375 - Central Washington University
Capital Project Request
2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:35PM

Project Number: 40000076
Project Title: Boiler Replacement
Project Class: Preservation

Description

Starting Fiscal Year: 2020
Agency Priority: 3

Project Summary

The project increases the energy efficiency and life-safety conditions of campus by replacing one of four primary boilers with a new energy efficient boiler.

Project Description

Problem statement. Central Washington University's residential campus in Ellensburg is heated by four large boilers in the central plant and two satellite boiler plants, each with two small boilers. This boiler system serves facilities remote from the central steam distribution system. The central plant boilers are 42 years old, at the end of service life, and must be replaced. The CWU air emissions from gas-burning equipment are approaching the maximum limit of nitrogen-oxide (Nox) emissions allowed by CWU's air emissions permit (issued by Department of Ecology). Removing several small "satellite boilers" from the campus inventory and supplying steam from the central boiler plant to their loads will lower the Nox emissions within a reasonable margin of the permit limits.

The boiler-chiller plant was built in 1974 and has operated continuously since then. Over time the pressure vessels of boilers have become less safe due to incremental metal loss and scale deposition. Normal wear and tear on the boilers has brought them to the end of their 45-year, reasonable life expectancy. Replacement of the boilers is required to safeguard the safety and health of students and employees, to improve energy efficiency and reduce costs, and to ensure uninterrupted operations, especially during the very coldest weather in Ellensburg.

CWU has requested the replacement of the boilers four times since 2005. The increasing frequency of issues related to the boilers interrupts operations and wastes energy.

Continued operation of end-of-life equipment increases the failure rate of the equipment exponentially, placing CWU students, employees, and visitors at risk of a catastrophic failure. External corrosion damage to the pressures vessel observed during repairs to the insulating jacket is very disconcerting because any corrosion damage degrades the integrity of the pressure vessels.

1. History of the Project or facility:

In 1974 the Boiler Plant was constructed to accommodate 2.4 million square feet of campus facilities. The load on the plant has increased 30 percent since 1974. Today the plant heats and cools 89 buildings, representing 3.3 million square feet of space.
In 1996 CWU upgraded the original pneumatic combustion controls with modern electronic industrial controls to maximize combustion efficiency and insure a higher degree of operational safety.
In 2009 Boiler 3 required reconstruction of the burner refractory ($10,650).
In 2011 Boiler 3 required major refractory repair ($99,320).
In 2013 Boiler 3 required replacement of shell casing with exterior corrosion of pressure vessel detected ($63,000).

Priority: Failure of the university's boiler plant would place health and safety of students, employees and the community at risk, and also would threaten the integrity of critical systems and resources .The boiler systems support the critical operation of the university especially during extreme cold weather conditions.

What will the request produce or construct (i.e., design of a building, construction of additional space, etc.)? When will the project start and complete? Identify whether the project can be phased, and if so, which phase is included in the request.

The request will enhance the CWU campus with an energy efficient replacement boiler.

The project would be completed during the 19-2021 biennium.

Since the project request is for only one of the needed replacements, phasing is not feasible.

How would the request address the problem or opportunity identified in question #1? What would be the result of not taking action?

Project benefits. This project increases energy efficiency and life-safety conditions by replacing old, unreliable infrastructure with new, energy-efficient technology. Replacing one of the four primary boilers with a new energy-efficient, cleaner boiler.

Which clientele would be impacted by the budget request? Where and how many units would be added, people or

Project Number: 40000076
Project Title: Boiler Replacement
Project Class: Preservation

Description

communities served, etc. Be prepared to provide detailed cost backup.

The project supports virtually all university programs and activities**,** from residential life to academic programs, from administrative operations to recreational activities. None of these entities can function without environmental modification when temperatures drop into the teens or below, or when they rise into the 90s or even beyond 100 degrees. Appropriate heating also can be essential to the preservation and operations of critical equipment and other resources, for example digital technology, archival records, scientific and artistic display, research, and instructional materials.

The project would enhance energy efficiency and sustainability by replacing worn-out, old technology with modern, efficient systems. Because the equipment provides heating for the entire university, this project affects all operations and all programs. The climate extremes of Ellensburg require reliable, safe temperature control systems. The impact of this project on existing operations and programs would be to ensure consistent, safe, campus-wide heating. Funding this project increases the risk of system failures that interrupt academic programs and university operations. The failure of the system also places at risk delicate scientific and artistic equipment and resources, and to scientific projects and research sensitive to temperature extremes (e.g. blood, tissue, plant, microbiota, and other cultures or samples). The failure of heating also threatens the integrity of paper collections in the library and archives. CWU is a repository for state and federal documents, most of which are paper and many of which are invaluable and irreplaceable.

Does the request include IT-related costs? (See the IT Appendix for guidance, and follow directions to meet the OCIO review requirement.) What alternatives were explored? Why was the recommended alternative chosen?

This proposal does not fund the development or acquisition of a new or enhanced software or hardware system or service.
This proposal does not fund the acquisition or enhancements of any agency data center.
This proposal does not fund the continuation of a project that is, or will be, under OCIO oversight.

Will non-state funds be used to complete the project? How much, what fund source, and could the request result in matching federal, state, local, or private funds?

There are no non-state funds available that could be used to complete the project.

Describe how the project supports the agency's strategic/master plans, contributes to statewide goal, or enables the agency to perform better. Reference feasibility studies, master plans, space programming, and other analyses as appropriate.

CWU STRATEGIC PLAN - The project supports three of five themes of the CWU Strategic Plan.

Theme 1: Teaching and Learning

Objective 1: Enhance student success by continually improving the curricular, co-curricular, and extracurricular programs.
Objective 2: Enhance the effectiveness of student support services.

Theme 3: Scholarship and Creative Expression

Objective 1: Increase the emphasis on and the opportunities for students, faculty and staff to participate in research, scholarship, and creative expression activities.
Objective 2: Increase the external funding received for research, scholarship, and creative expression by faculty, staff, and students.

Theme 5: Resource Development and Stewardship

Objective 4: Provide the facility and technology infrastructure and services appropriate to meet university objectives, while maximizing sustainability and stewardshi**p.**

CWU CAPITAL FACILITIES MASTER PLAN

Academic and Administrative Buildings

Goal: Enhance space utilization and functionality to provide facilities of high quality and sufficient quantity to meet academic and administrative program needs and support the strategic planning priorities of the university.

Objectives:

· Expand opportunities for instructional facilities to keep pace with technological innovations.
· Integrate and continue to develop technical opportunities and infrastructure.

Sustainability and Energy Conservation

Goal: Reduce utility expenditures and the use of natural resources through conservation programs and incentives.

Objectives:

· Design all new and renovated building projects for certification to the LEED Silver level, at a minimum.
· Make timely investments to conserve electricity, heating, and water in existing buildings.
· Target conservation measures for high-intensity water and energy uses (such as irrigation, residential, and laboratory) as a

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:35PM

Project Number: **40000076**
Project Title: **Boiler Replacement**
Project Class: **Preservation**

Description

first priority.
· Develop educational and conservation programs with on-campus groups, off-campus non-profit organizations, and governmental agencies.
· Engage the faculty, students, and staff in performance operations to promote more proactive and efficient behavior toward resource conservation.
The Capital Master Plan specifically articulates concerns about the capacity of the utility infrastructure for energy and resource distribution calling out the need to replace aging boilers and to expand the heating and cooling plant.
Goal: Provide efficient utility infrastructure to gain capacity for future facility growth.
Objectives:
· Consider the impacts on the utility infrastructure distribution systems in any major capital project.
· Improve and/or expand utility systems as necessary.
· Increase and improve the central plant operating capacity to provide for new buildings and renovations.
· Coordinate utility upgrades with other capital projects and developments.
· Coordinate underground utility lines with other developed features. For example, place steam lines under sidewalks to avoid grassless patches and reduce the need for winter ice removal and snow shoveling.
For projects linked to the Puget Sound Action Agenda, describe the impacts on the Action Agenda. See Chapter 14.4 in the 2017-19 Operating Budget Instructions
This project is not linked to the Puget Sound Action Agenda.
Is there additional information you would like decision makers to know when evaluating this request?
The boiler industry has progressed considerably since the 1970s in improved energy conversion efficiency (fuel to steam energy) and reduced air pollution emissions from the combustion of both natural gas and diesel fuel. Although natural gas is the primary fuel for the boilers, a reserve of 60,000 gallons of diesel fuel is maintained as backup fuel should there be a loss of natural gas supply to the Ellensburg area. Improvements in the boiler industry have been driven by demand for greater fuel efficiency and reduced air emissions for both natural gas and diesel fuel. CWU anticipates a 2-percent to 3-percent improvement in combustion efficiency with new boilers.
The project will reduce air emissions, particularly Nox emissions, which are the most critical regulated pollutant, by as much as 10 percent. Reduction of carbon dioxide emissions will also be realized by 2 percent to 3 percent as result of the above improved combustion efficiency. All of these improvements help CWU meet its goal of improving energy efficiency, reducing air emissions, and working toward greater sustainability.

Location

City: Ellensburg **County:** Kittitas **Legislative District:** 013

Project Type

Infrastructure (Major Projects)

Growth Management impacts

Central Washington University (CWU) is required to adhere to the State Environmental Policy Act (SEPA). The SEPA process is where growth management act impacts are considered. CWU coordinates planning efforts with all applicable city and county jurisdictions.

Funding

			Expenditures		2019-21 Fiscal Period	
Acct Code	Account Title	Estimated Total	Prior Biennium	Current Biennium	Reapprops	New Approps
057-1	State Bldg Constr-State	4,656,000				4,656,000
	Total	**4,656,000**	**0**	**0**	**0**	**4,656,000**

Future Fiscal Periods

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375 - Central Washington University
Capital Project Request
2019-21 Biennium

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Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:35PM

Project Number: 40000076
Project Title: Boiler Replacement
Project Class: Preservation

Funding

		2021-23	2023-25	2025-27	2027-29
057-1	State Bldg Constr-State				
	Total	**0**	**0**	**0**	**0**

Schedule and Statistics

	Start Date	End Date
Predesign		
Design	3/1/2020	8/1/2020
Construction	9/1/2020	5/1/2021

	Total
Gross Square Feet:	0
Usable Square Feet:	0
Efficiency:	
Escalated MACC Cost per Sq. Ft.:	0
Construction Type:	Heating and Power Plants
Is this a remodel?	No
A/E Fee Class:	A
A/E Fee Percentage:	10.56%

Cost Summary

		Escalated Cost	% of Project
Acquisition Costs Total		**0**	**0.0%**
Consultant Services			
Pre-Schematic Design Services		0	0.0%
Construction Documents		0	0.0%
Extra Services		0	0.0%
Other Services		0	0.0%
Design Services Contingency		19,404	0.4%
Consultant Services Total		**402,271**	**8.6%**
Maximum Allowable Construction Cost(MACC)	**3,500,000**		
Site work		0	0.0%
Related Project Costs		0	0.0%
Facility Construction		3,500,000	75.2%
GCCM Risk Contingency		0	0.0%
GCCM or Design Build Costs		0	0.0%
Construction Contingencies		175,001	3.8%
Non Taxable Items		0	0.0%
Sales Tax		305,025	6.6%

375 - Central Washington University
Capital Project Request

2019-21 Biennium

*

Version: SF CWU Supplemental Capital Submitted

Report Number: CBS002
Date Run: 9/19/2019 12:35PM

Project Number: 40000076
Project Title: Boiler Replacement
Project Class: Preservation

Cost Summary

	Escalated Cost	% of Project
Construction Contracts Total	**3,980,026**	**85.5%**
Equipment		
Equipment	0	0.0%
Non Taxable Items	0	0.0%
Sales Tax	0	0.0%
Equipment Total	**0**	**0.0%**
Art Work Total	**0**	**0.0%**
Other Costs Total	**5,160**	**0.1%**
Project Management Total	**268,153**	**5.8%**
Grand Total Escalated Costs	**4,655,610**	
Rounded Grand Total Escalated Costs	**4,656,000**	

Operating Impacts

Total one time start up and ongoing operating costs

Capital Project Request

2019-21 Biennium

*

Parameter	Entered As	Interpreted As
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000076	40000076
Sort Order	Project Class	Project Class
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

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Cost Estimate Number: 184
Cost Estimate Title: Boiler Replacement

Report Number: CBS003
Date Run: 9/19/2019 12:38PM

Version: SF CWU Supplemental Capital Submitted
Agency Preferred: Yes
Project Number: 40000076
Project Title: Boiler Replacement
Project Phase Title:

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:	0
Usable Sq. Ft.:	0
Space Efficiency:	
MACC Cost per Sq. Ft.:	0
Escalated MACC Cost per Sq. Ft.:	0
Remodel?	No
Construction Type:	Heating and Power Plants
A/E Fee Class:	A
A/E Fee Percentage:	10.56%

Schedule

	Start Date	End Date
Predesign:		
Design:	03-2020	08-2020
Construction:	09-2020	05-2021
Duration of Construction (Months):	8	

Cost Summary Escalated

Acquisition Costs Total			**0**
Pre-Schematic Design Services		0	
Construction Documents		0	
Extra Services		0	
Other Services		0	
Design Services Contingency		19,404	
Consultant Services Total			**402,271**
Site work		0	
Related Project Costs		0	
Facility Construction		3,500,000	
Construction Contingencies		175,001	
Non Taxable Items		0	
Sales Tax		305,025	
Construction Contracts Total			**3,980,026**
Maximum Allowable Construction Cost(MACC)	**3,500,000**		
Equipment		0	
Non Taxable Items		0	
Sales Tax		0	
Equipment Total			**0**
Art Work Total			**0**
Other Costs Total			**5,160**
Project Management Total			**268,153**
Grand Total Escalated Costs			**4,655,610**
Rounded Grand Total Escalated Costs			**4,656,000**

Additional Details

Alternative Public Works Project: No

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375 - Central Washington University
Cost Estimate Summary
2019-21 Biennium

*

Cost Estimate Number: 184
Cost Estimate Title: Boiler Replacement

Report Number: CBS003
Date Run: 9/19/2019 12:38PM

Version: SF CWU Supplemental Capital Submitted
Agency Preferred: Yes
Project Number: 40000076
Project Title: Boiler Replacement
Project Phase Title:

Contact Info
Contact Name: Steve DuPont
Contact Number: 509.963.2111

Additional Details

State Construction Inflation Rate:	3.18%
Base Month and Year:	09-2019
Project Administration By:	AGY
Project Admin Impact to DES that is NOT Included in Project Total:	$0

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375 - Central Washington University
Cost Estimate Detail
2019-21 Biennium

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Cost Estimate Number: 184 **Analysis Date:** September 18, 2019

Cost Estimate Title: Boiler Replacement

Detail Title: Main Page
Project Number: 40000076
Project Title: Boiler Replacement
Project Phase Title:
Location:

Contact Info **Contact Name:** Steve DuPont **Contact Number:** 509.963.2111

Statistics

Gross Sq. Ft.:
Usable Sq. Ft.:
Rentable Sq. Ft.:
Space Efficiency:
Escalated MACC Cost per Sq. Ft.:
Escalated Cost per S. F. Explanation

Construction Type:	Heating and Power Plants
Remodel?	No
A/E Fee Class:	A
A/E Fee Percentage:	10.56%
Contingency Rate:	5.00%
Contingency Explanation	

Projected Life of Asset (Years):	20
Location Used for Tax Rate:	
Tax Rate:	8.30%
Art Requirement Applies:	No
Project Administration by:	AGY
Higher Education Institution?:	Yes
Alternative Public Works?:	No

Project Schedule

Project Schedule	Start Date	End Date
Predesign:		
Design:	03-2020	08-2020
Construction:	09-2020	05-2021
Duration of Construction (Months):	8	
State Construction Inflation Rate:	3.18%	
Base Month and Year:	9-2019	

Project Cost Summary

MACC:	$ 3,356,670
MACC (Escalated):	$ 3,500,000
Current Project Total:	$ 4,470,006
Rounded Current Project Total:	$ 4,470,000
Escalated Project Total:	$ 4,004,590
Rounded Escalated Project Total:	$ 4,005,000

ITEM	Base Amount	Sub Total	Escalation Factor	Escalated Cost
CONSULTANT SERVICES				
Construction Documents				
A/E Basic Design Services				256,809
SubTotal: Construction Documents				**0**
Other Services				
Bid/Construction/Closeout				115,378
SubTotal: Other Services				**0**
Design Services Contingency				
Design Services Contingency	18,609			
SubTotal: Design Services Contingency		**18,609**	1.0427	**19,404**
Total: Consultant Services		**390,796**	1.0294	**402,271**
CONSTRUCTION CONTRACTS				
Facility Construction				
D30 - HVAC Systems	3,356,670			
SubTotal: Facility Construction		**3,356,670**	1.0427	**3,500,000**
Construction Contingencies				
Allowance for Change Orders	167,834			
SubTotal: Construction Contingencies		**167,834**	1.0427	**175,001**
Sales Tax		**292,534**	1.0427	**305,025**
Total: Construction Contracts		**3,817,038**	1.0427	**3,980,026**
Maximum Allowable Construction Cost (MACC)		**3,356,670**	1.0400	**3,500,000**
OTHER COSTS				
Permits	5,000			
Total: Other Costs		**5,000**	1.0320	**5,160**
PROJECT MANAGEMENT				
Agency Project Management	257,172			
Total: Project Management		**257,172**	1.0427	**268,153**

OFM

Cost Estimate Summary and Detail

2019-21 Biennium

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Cost Estimate Number: 184
Cost Estimate Title: Boiler Replacement

Report Number: CBS003
Date Run: 9/19/2019 12:38PM

Parameter	Entered As	Interpreted As
Associated or Unassociated	Associated	Associated
Biennium	2019-21	2019-21
Agency	375	375
Version	SF-A	SF-A
Project Classification	*	All Project Classifications
Capital Project Number	40000076	40000076
Cost Estimate Number	184	184
Sort Order	Cost Estimate Number	Number
Include Page Numbers	Y	Yes
For Word or Excel	N	N
User Group	Agency Budget	Agency Budget
User Id	*	All User Ids

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Expected Use of Bond/COP Proceeds

Agency No:	**375**	**Agency Name**	**Central Washington University**
Contact Name:	**Steve DuPont**		
Phone:	**509.963.2111**	**Fax:**	
Fund(s) Number:	**057**	**Fund Name:**	**State Building Construction Account**
Project Number:	**40000076**	**Project Title:**	**Boiler Replacement**

Agencies are required to submit this form for all projects funded with Bonds or COPs, as applicable. OFM will collect and forward the forms to the Office of the State Treasurer.

1. Will any portion of the project or asset ever be owned by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
2. Will any portion of the project or asset ever be leased to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
3. Will any portion of the project or asset ever be managed or operated by any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
4. Will any portion of the project or asset be used to perform sponsored research under an agreement with a nongovernmental entity (business, non-profit entity, or the federal government), including any federal department or agency? ☐ Yes ☒ No
5. Does the project involve a public/private venture, or will any entity other than the state or one of its agencies or departments ever have a special priority or other right to use any portion of the project or asset to purchase or otherwise acquire any output of the project or asset such as electric power or water supply? ☐ Yes ☒ No
6. Will any portion of the Bond/COP proceeds be granted or transferred to nongovernmental entities (businesses, non-profit entities, or the federal government) or granted or transferred to other governmental entities which will use the grant for nongovernmental purposes? ☐ Yes ☒ No
7. If you have answered "Yes" to any of the questions above, will your agency or any other state agency receive any payments from any nongovernmental entity, for the use of, or in connection with, the project or assets? A nongovernmental entity is defined as ☐ Yes ☒ No
    a. any person or private entity, such as a corporation, partnership, limited liability company, or association;
    b. any nonprofit corporation (including any 501(c)(3) organization); or
    c. the federal governmental (including any federal department or agency).
8. Is any portion of the project or asset, or rights to any portion of the project or asset, expected to be sold to any entity other than the state or one of its agencies or departments? ☐ Yes ☒ No
9. Will any portion of the Bond/COP proceeds be loaned to nongovernmental entities or loaned to other governmental entities that will use the loan for nongovernmental purposes? ☐ Yes ☒ No
10. Will any portion of the Bond/COP proceeds be used for staff costs for tasks not directly related to a financed project(s)? ☐ Yes ☒ No

If all of the answers to the questions above are "No," request tax-exempt funding. If the answer to any of the questions is "Yes," contact your OFM capital analyst for further review.

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