CENTRAL CAMPUS CHILLED WATER PLANT

FEASIBILITY STUDY

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EXECUTIVE SUMMARY

The purpose of this study is to evaluate the feasibility of constructing a Central Chilled Water Plant in connection with the USTAR project and to determine if other existing and future buildings in the central area of the campus should be connected to the plant. The study is to investigate the feasibility of a Central Plant verses distributed chiller plants in each building.

The scope of the study is the central zone of the lower campus which is defined on Map CHW1 in the Appendix with the study area shown in yellow.

The study includes cooling loads and chiller data for all existing buildings in the study area and estimated loads for all potential future buildings that were identified by the University. The projected connected cooling load for all existing and future buildings is estimated at 12,244 tons of cooling.

A substantial diversity of loads can be expected when multiple buildings are connected to a common plant. The East Campus Chilled Water Plant, constructed in the year 2000, has a demonstrated diversity of 73%. Similar diversity experience has been demonstrated on the Chemistry/Biology Chilled Water Loop on the lower campus. A Central Plant with such diversity will support more building space from a given tonnage than will decentralized chiller plants. The study used diversity in the analysis.

Two independent cooling loops exist at the South End of the study area, one serving the HPER Complex of buildings and one that serves the Fine Arts Building and the Business Buildings. There is a 1200 ton chiller plant at the HPER Complex and a 646 Ton Chiller Plant in the Fine Arts Building.

The advantages of a Central Plant over decentralized chiller plants is discussed at length in the study. It is estimated that the University will save $425,962.00 in annual operations and maintenance costs and $1,432,132.00 in initial construction costs by constructing a Central Chiller Water Plant in lieu of replacing existing chillers in place and installing chiller plants in all new buildings.

Several options were investigated for serving the area. Option 1 considers a plant that would support the entire area under study and would replace the existing plants at HPER and Fine Arts. Option 2 considers retaining and expanding the existing loops at HPER and Fine Arts and construction of a new Central Chilled Water Plant to serve the rest of the area. The USTAR project and several other existing buildings would be connected to the new Central Plant initially. A chilled water plant to support the HPER Loop would be installed in the Eccles School of Business Project. See Map CHW2 in the Appendix.

It is recommended that Option 2 be adopted and implemented in three phases. See Maps CHW2-A-1,2 in the Appendix.

Phase I

1. Construct a New Central Chilled Water Plant of 3000 tons to be located west of Campus Drive, South of the Warnock Engineering Buildng with an estimated first cost of $7,538,010.00. Provide piping as shown on Map CHW2-A-1. Part of this cost should come from the USTAR project and part from the replacement costs of existing chillers.

2. Construct a new 640 ton chiller plant in the new Eccles School of Business (ESB) project with an estimated cost of $1,991,742.00. Extend piping as shown on Map CHW2-A-1. This cost should be part of the ESB project and will not need new funding.

Phase II would expand the Central Chilled Water Plant 4000 tons to a total of 7000 tons, add a 320 ton chiller in the ESB bringing this plant to 960 tons and extend piping as shown on Map CHW2-A-2. Estimated costs for Phase II are $8,578,741.00. The timing of this phase is subject to the construction of future buildings.

Phase III would expand the Central Chilled Water Plant 2000 tons to a total of 9000 tons and would provide a redundant chiller. Estimated costs for Phase III are $4,200,000.00. No additional piping is required in this phase. The timing of this phase is subject to the final construction of all projected buildings.

PURPOSE AND SCOPE

The purpose of this study is to evaluate the feasibility of constructing a Central Chilled Water Plant in connection with the USTAR project and to determine what other existing and projected future buildings could and should be connected to the plant. The study is to consider the feasibility of a Central Plant verses distributed chiller plants in each building.

The scope of the study is to consider present and future buildings in the central zone of the campus, below Medical Drive and the buildings fronting Campus Drive between North Campus Drive and South Campus Drive. See Map CHW1 in the Appendix. The area in yellow is the area under study.

BACKGROUND, EXISTING CHILLED WATER SYSTEMS

Chilled water systems on the Campus have traditionally been dedicated to chiller plants for each building. In the early 1970's a small central chilled water plant was installed as part of the HPER complex and served six buildings. In 1995 a chilled water loop was installed between the Chemistry and Biology Buildings and several other buildings were later connected to the loop. The Biology Research Building was later connected into this loop. In 1996 a chilled water plant was installed in Kingsbury Hall and the chilled water loop was extended to the remodel and addition of Gardner Hall. In 1998 the chilled water loop in the new Fine Arts Building was extended to the business buildings. In the year 2000, a new central chilled water plant was constructed on the Medical Campus to which all buildings on the Medical Campus are connected. All other buildings on the campus that are air conditioned have dedicated chilled water plants.

The maintenance staff has noted many problems with chillers in the following buildings: Bldg. 49, Language and Communication; Buildings 51 and 52 have continual problems; Bldg. 56, 57 chillers are at end of useful life; Bldg. 64 Merrill Engineering Building has multiple problems with the 290 ton machine and air locks are a continual problem with machines in Bldg. 96 HPER.

Previous experience on the University with the centralization of chilled water has demonstrated that there are distinct advantages over decentralized chiller plants in each building.

- Maintenance costs are lower.
- Diversity of loads allows greater use of the available capacity.
- Operating costs are lower.
- Central Plant Water side economizers for winter operation reduces chiller running costs.

See Map CHW1 in Appendix which shows the existing chilled water centralization loops.

BUILDINGS AND COOLING CAPACITIES INCLUDED IN THE STUDY

Table 1 on the following page, notes the existing buildings that are included in this study together with future buildings that have been identified by the University as future projects. The Table 1 includes the following:

- University Building Number
- Building Name
- Building Status, E (Existing) - Red, P (Programming) - Blue, F (Future) - Yellow
- Gross Area, Existing or Projected
- Age of Chillers in the Existing Building
- The tons of cooling actually installed or estimated for future buildings
- The type of refrigerant in the existing chillers

With the exception of the chillers in the Fine Arts Museum, which have R-134A refrigerant, all other chillers have R-22 or R-123. Production of R-22 is scheduled to be totally phased out by 2020 with no new equipment being made with R-22 after 2010. Production of R-123 is scheduled to be totally phased out by 2030 with no new equipment being made after 2020. Refrigerants subject to phase out will become more expensive as time goes and replacement refrigerant for leaks and repairs will be more difficult to obtain.

BUILDING SUMMARY

COOLING CAPACITIES							
BLDG NO.	BLDG. STATUS E,P,D,F	BUILDING NAME	GROSS SQ.FT.	AGE OF CHILLERS	ASSUMED SQ.FT. /TON	TONS	Refrigerant
	P	NBTRB PHASE 1	200,000		200	1,000	
	P	ECCLES SCHOOL OF BUSINESS	200,000		300	667	
51	E	STERLING W. SILL CENTER	13,107	11		60	R-22
52	E	ALUMNI HOUSE	16,720	14		70	R-22
56	E	HEDCO ENERGY AND MINING	197,300	23		75	R-22
57	E	HEDCO ENERGY AND MINING	28,252			30	R-22
	F	UTAH MUSEUM OF FINE ARTS	45,000		300	150	
	F	COLLEGE EDUCATION	78,000		300	260	
49	E	LANGUAGE AND COMMUNICATIONS	100,732	13		340	R-22
64	E	MERRILL ENGINEERING BUILDING	268,173	14		340	R-22
	F	NBTRB PHASE 2	300,000		225	1,333	
	E	MERRILL ENGINEERING BUILDING		4		350	R-123
	F	STUDENT LIFE CENTER	157,500		275	573	
	F	FUTURE BUILDINGS (INTERD.CORRIDOR)	500,000		225	2,222	
	F	HEALTH PHYS. ED WEST ADDITION	60000		250	240	
	F	MERRILL ENGINEERING BUILDING EXPAN.	100000		250	400	
	F	MORAN EYE PHASE 2	200000		250	800	
54	E	ORSON SPENCER HALL	116,148	9		415	
	F	MILTON BENNION HALL EXPANSION	112000		350	320	
53	E	A. RAY OLPIN UNION	68,000		250	272	
61	E	ENERGY AND MINERAL RESEARCH	51,611	3		150	
35	E	FINE ARTS MUSEUM	73,792	9		646	
74	E	BUSINESS CLASSROOM (Served from F.A.)	49,222				
75	E	KEN GARFF BUS.OFF.(Served from F.A.)	32,884				
76	E	ARMSTRONG MADSEN (Served from F.A.)	23,727				
77	E	CHRISTENSEN CENTER (Served from F.A.)	42,000				
96	E	HPER		11		1,200	R-123
	E	HUNTSMAN CENTER					
	E	HEALTH PHYS. ED. EAST					
	E	HEALTH PHYS. ED. NORTH					
	E	HEALTH PHYS. ED. SO. NATATORIUM					
	E	BURBIDGE ATHLETIC CENTER					
	E	RANDALL TURPIN UNVERSITY SERVICES					
	E	MILTON BENNION HALL					
62	E	WARNOCK ENGINEERING BUILDING	125,000	1		640	R-123
63	E	ENERGY AND MINES CLASSROOM	59,872				
TOTALS:			3,219,040			12,244	-

Table 1

Table 1 shows a full buildout connected load for the plant at 12,244 tons.

It is safe to assume, however, that there will be some diversity in the usage of this projected tonnage. The documented experience at the East Campus Plant, demonstrates a diversity of 73% (See Table 9, Diversity in the Appendix). The Lower Campus chilled water loop between Biology, Chemistry and several smaller buildings, has a demonstrated diversity of between 68% and 76%. Based on campus experience it would be conservative to assume the new plant could achieve an 80% diversity in its full built out condition.

Assuming a conservative number of 80%, and12,244 tons connected load a 9,795 ton plant could support the connected load. The following analysis will be directed toward the 12,244 ton connected load with an 80% diversity for the plant. The plant would be sized for 10,000 tons. If the University wants a redundant chiller, the ultimate size of the plant should be 12,000 tons.

SYSTEM EFFICIENCY ANALYSIS

System efficiency is a function of the equipment which generates the chilled water, the method with which the chilled water is distributed to the terminal equipment and the running time of each component in the system. Elements of design which affect system efficiency:

1. Energy consumption of full and part load operation of chillers.
2. Primary/Secondary pumping systems.
3. Water side economizers
4. Cooling Towers
5. Automation
6. Central Plant

Chiller Efficiency:

The current array of existing chillers are a mix of air cooled chillers and water cooled systems, most of which have refrigerants which will be phased out the next thirteen to twenty years. Air cooled chillers traditionally consume twice as much energy per ton of cooling (1.2 kw/ton) as water cooled systems (0.5 kw/ton) and therefore should be phased out from the campus as soon as possible. Recent development of variable speed drives for large chillers increases the operational efficiency of these chillers and many chillers presently can be designed to give efficiencies of less than 0.40 kw/ton. The variable speed technology greatly improves plant efficiency and thus is a marked improvement over the constant speed machines found in existing buildings.

Primary/Secondary Pumping Systems:

This scheme provides for a low head pump for each chiller, to pump water around a local chilled water loop in the chiller room. A secondary variable speed pump draws water from this local loop and distributes the water to various buildings. The advantage of this system over the constant flow arrangement presently used is that the secondary variable speed pump only pumps the volume of water that is required in the system. In other words, in the low load times of the year the actual flow relates directly to the actual demand, thus saving pumping horsepower. In addition, the local loop chilled water pumps only operate when their respective chiller is on and guarantee constant flow through each chiller when it is operating.

Water Side Economizer:

Due to our cold winter season, the opportunity exists to utilize cooling towers to generate cold enough water in conjunction with a plate and frame heat exchanger to supply chilled water during the winter season. This approach will allow the chillers to remain “off,” saving electrical energy. Buildings which do not use air side economizers for free cooling can benefit from the water side economizer approach.

Specifically, buildings in the Interdisciplinary Quad may require humidity control in the sensitive Nanotechnology Areas and other lab areas which would negate the use of air side economizers. The water side economizer is then a good solution to provide cooling in the cold winter months while leaving the chillers off. A schematic of this system is shown in Drawing M-1 in the Appendix.

In order for this scheme to be most effective, all local chilled water coil pumps at air handlers should be eliminated and the three way coil valves should be converted to two valves so that each cooling coil becomes a variable flow device, maximizing the chilled water temperature rise rather than run constant flow with lower chilled water rises. Building chilled water pumps in each building should be converted to variable flow pumps.

System Automation:

Automation of any function in a mechanical process is a step toward reducing dependence on manpower and the desire to effect a more efficient Plant operation. In a time when all businesses are seeking ways to streamline operations and save money, it becomes prudent to seek alternate operating methods to the current methods of operation. Automation systems have the capacity to monitor temperatures and pressures, collect data, analyze inputs from multiple sources and then make decisions based on preset parameters as to how the system components should respond. If current operating personnel can be relieved from the laborious tasks of data collection and monitoring duties, their time can be redirected to more cost effective areas of operations such as preventive maintenance functions. Twice a week in the Central Campus, eight manual separate entries are made on log sheets for each chiller, totaling approximately 300 manual log entries per week. At five seconds per entry, plus the time to travel to each building, personnel spend approximately six hours per week recording data. This a 0.15 FTE to just record data. An automated system could pay for itself in five to seven years and free up maintenance personnel for more critical tasks.

Automation systems are on the market today which are capable of managing entire chilled water systems. These systems have been rigorously tested and many installations are performing successfully. Based on the input from monitored temperatures and pressures, the central computer can decide which machine should come on to satisfy the cooling demands. If primary/secondary pumping systems are being used, the differential pressures provide input to the variable frequency drive for the secondary pumps, thus allowing only the quantity of water to be pumped that is required, rather than a constant full flow of water. In addition, to the chilled water side of the system, the computer will monitor the condenser, cooling tower loop and adjust valving and fans to provide the coolest condenser water that the system chillers can accept to allow the chillers to operate at the their most efficient operating points. The lower the condenser water, the lower the electrical input per ton of cooling, thus lower overall operating costs. In addition, automation systems have the capability to accept some chiller operating conditions, such as head pressure, oil pressures, evaporator and condenser operating temperatures and chiller KW per ton input. Systems can be automatically programmed for weekends and holidays and any night time setback conditions that may be desired.

Automation systems are particularly effective when multiple chillers feed into the same piping system.

It is estimated that an automation system for a central Plant will cost between $30,000 and $80,000 installed**.**

Central Plant:

The concept of a Central Plant is especially appealing for this Central Campus since the buildings are in close proximity to each other and the loads will not necessarily coincide. The basic advantages of a Central Plant include capacity diversity to be used for redundant capacity, centralization for maintenance, and incorporation of energy conserving pumping and water side economizer features. A more detailed discussion of this concept can be found in this study under the heading "CENTRALIZED CHILLER PLANT VS. INDIVIDUAL PLANT ANALYSIS."

CENTRALIZED CHILLER PLANT VS. INDIVIDUAL PLANT ANALYSIS

The concept of a Central Plant provides the best opportunity to maximize the efficiency concepts that have been discussed above. A central Plant would included multiple chillers piped in a primary/secondary arrangement and would include one redundant chiller to support down times and emergency breakdowns of one chiller. The Plant would include the provisions of water side economizers and a complete automation system. The advantages and disadvantages of a central Plant are as follows:

Advantages:

- New Plant with state-of-the-art high efficiency chillers.
- New Plant without CFC liability.
- Redundancy available.
- One location for maintenance and operations.
- Primary/Secondary pumping to conserve pumping energy.
- Water side economizer for winter chilled water system.
- Central Plant for 25-30 year life.
- Smaller Plant size due to diversity of loads.
- Ease of expansion.
- More efficient operation at part loads.

Disadvantages:

- Capital investment.
- Piping costs between Plant and buildings.
- Funding priorities may not match load priorities.

One of the advantages of a centralized Plant is the ability to operate the chillers at a more efficient point on the performance curve than for individual Plants. Constant Flow Chillers typically become inefficient around 30% of capacity and below.

If the minimum load for several buildings could be combined for one chiller, then its operating point will be higher than individual machines. Multiple buildings connected to a Plant can let the Plant operate at 20-30% capacity, which could translate to one machine at 40 - 50%, which is well within the efficient range, of the proposed variable flow chillers.

A properly designed central Plant can expand to meet the demands of additional buildings. Each time a new building is added to a Central Plant the diversity goes up. The sum of the individual loads in buildings will always be greater than the diversified load from a central Plant. This is because each building does not peak at the same time. Experience on the East Campus of the University with their new chilled water loop is that there is a diversity between 73% and 76%. See Table 9 in the Appendix.

Due to the age of some of the chillers in the existing system these machines will require replacement in the very near future. The decision, therefore, on the viability and funding of a Central Plant is of paramount importance before the replacement of these chillers begins. Typical life of air cooled equipment is 20 years. Typical life of cooling towers used for water cooled chillers is 20 years. Centrifugal chillers have an expected life of 23 years. The two air cooled chillers in the Hedco Buildings 56 & 57 are twenty three years old. The air cooled chillers in the Sill Center Building 51 and the Alumni House Building 52 are eleven and fourteen years old, respectively, and the 290 ton chiller in Merrill Engineering Building 64 is fourteen years old. University maintenance has reported many problems with these chillers. These buildings could be brought on to a new Central Plant before the chillers fail.

With Phase I of the USTAR project now in programming, and Phase II to be expected within the next few years, and the need of replacement chillers noted above, the concept of a Central Campus Central Chilled Water Plant should be considered. This Plant could be the backbone of a major Central Plant for the Interdisciplinary Quad and the Central Campus that could be expanded as future projects come on line. This Plant could be designed and constructed on a modular basis with the expansion modules close in size to the future needs. A suggested phasing of this Plant is discussed in a later section.

CODE ISSUES

When considering whether to replace existing chillers, or to build a Central Plant, code issues must be addressed.

The 2006 International Building Code requires machinery to be located in a Refrigeration Machinery Room with designated exits, special dedicated exhaust systems, refrigerant vapor alarm systems and separation from other areas of the building, Buildings with sprinkler systems in refrigeration room must be separated from other areas of the building. Buildings without sprinkler systems must be separated from other areas of the building with a one hour wall. This means that any existing refrigeration room that does not now comply must be brought up to code when chillers are replaced. The chillers in HEDCO, Sill Center, and Alumni House are air cooled and are outside, so they are not affected. All other buildings however, if constructed earlier than the past six years probably fall under this code requirement. Following is the code relative to the above comment:

> **508.2.2.1 Construction.** Where Table 508.2 requires a fire-resistance-rated separation, the incidental use area shall be separated from the remainder of the building by a fire barrier constructed in accordance with Section 06 or a horizontal assembly constructed in accordance with Section 711, or both. Where Table 508.2 permits an automatic fire-extinguishing system without a fire barrier, the incidental use area shall be separated from the remainder of the building by construction capable of resisting the passage of smoke. The partitions shall extend from the floor to the underside of the fire-resistance-rated floor/ceiling assembly or fire-resistance-rated roof/ceiling assembly above or to the underside of the floor or roof sheathing, or sub deck above. Doors shall be self- or automatic closing upon detection of smoke. Doors shall not have air transfer openings and shall not be undercut in excess of the clearance permitted in accordance with NFPA 80.

The impact of this code requirement is that chiller rooms in buildings that do not meet this code need to be upgraded when a replacement chiller is installed.

CENTRAL PLANT LOCATION

A central Plant for the Central Campus should be located as close to the center of the projected loads as possible. See Map CHW1 in Appendix for a representation where the centroid of the loads is.

It is apparent from this map that the centroid of the load is the Interdisciplinary Quad. The Plant theoretically should be as close to the area as possible to reduce distribution piping costs. Three sites, “A”, “B”, and “C” were investigated and are shown on map CHW1 in the Appendix. Each of these sites were analyzed in depth with cost estimates for plant and piping distribution. Each site and the options investigated are presented in subsequent section of the study.

Initial cost estimates confirmed our original hypothesis that the plant should be located as close as possible to the Interdisciplinary Quad. Further analysis was conducted with SOM, the Campus Master Planning Team, Architectural Nexus and LAS, the USTAR programming Architects and representatives from the University and the Health Sciences Campus. Some concern had been expressed that a Central Plant located at Sites “B” or “C” would not be a good entrance to the Interdisciplinary Quad. After much discussion it has been concluded that site “A” is the preferred site for a new Central Chilled Water Plant. The following reasoning led to this conclusion:

1. Sites “A” would remove the plant from a very prominent location for traffic coming from the North to the Campus and the Interdisciplinary Quad (I.Q.).
2. Site “A” reduced the impact on roads and services in and around the I.Q.
3. Site “A” does not impact existing parking, north of the I.Q.
4. Site “A” does not impact future flexibility and use of the proposed area, north of the I.Q.
5. Site “A” does not locate a utility building on the prominent site of the I.Q.
6. Site “A” locates the plant in an existing area that is more in keeping with industrial utility type buildings.
7. The size and height of the plant at Site “A” blends better with the existing landscape from either sites “B” or “C.”

The only significant drawback to Site “A” is the piping distribution costs, which will be in excess of $250,000.00 more than the costs at Site “B”.

Based on the above reasoning this study recommends the plant be at Site “A”.

OPTIONS FOR CENTRALIZATION OF CHILLED WATER

OPTION 1

This option considers a plant that encompasses all buildings in the central zone of the campus. See Map CHW1 in the Appendix, which shows in yellow the area for this option. The peak capacity for this option is 12,244 tons of cooling. See Table 2 in the Appendix which identifies each building, the size of the building, the actual or estimated tons required and the time when it is expected that these loads would be added to the plant. The Central Plant associated with the HPER Complex would be phased out as chillers fail and this building would be available for other uses. The chillers in the Fine Arts Building would be removed as soon as they fail and this building would be connected to the new plant.

Three sites were considered for the siting of these options. See maps CHW1-A, CHW1-B, CHW1-C in the Appendix. These maps identify the Central Chilled Water Plant and show possible piping routes and associated pipe sizes.

Cost Estimates were prepared for this option for each of the proposed plant sites. A, B, & C Estimates can be found in the Appendix under Cost Estimates. Piping distribution costs were estimated and are added to the Central plant costs for this option. As noted in the previous section, Site "A" is the preferred site for the plant as discussed with the Campus Master Planning Team.

Option 1, Site "A"

Estimated Costs:	Plant:	$15,743,911.00
	Piping:	$3,940,888.00
Total:		**$19,684,799.00**

Option 1, Site "B"

Estimated Costs:	Plant:	$15,743,911.00
	Piping:	$4,055,123.00
Total:		**$19,799,034.00**

Option 1, Site "C"

Estimated Costs:	Plant:	$15,743,911.00
	Piping:	$4,332,900.00
Total:		**$20,076,011.00**

It quickly became apparent as costs were developed that the piping costs for this option were extremely high. The practicality of pumping water from the Northern part of this Central Campus area to the HPER Mall area appears to be prohibitive. Locating the plant at the Southern part of this central area would require much larger piping to send water back to the North where the majority of the load will exist and the costs would be even higher.

The analysis of costs associated with this option led to a second option that is presented herein.

OPTION 2

Under this option the Central Area of the Campus would be split in two areas. See map CHW-2 in the Appendix where all areas in yellow would be connected to the new Central Chilled Water Plant in the vicinity of the Interdisciplinary Quad. An expanded chilled water loop would be created from the existing HPER Loop and the Fine Arts Loop shown in pink. See Table 3 in the Appendix, which identifies what buildings would be on the New Central Chilled Water Plant and Table 4 in the Appendix, which identifies what buildings would be on the HPER Loop. The tables are color coded to indicate the time table when the loads would be connected to the respective systems.

New Chilled Water Plant
Interdisciplinary Quad (I.Q.)

The new proposed plant would be 7,000 tons, which would support the 8748 tons estimated for the buildings. A diversity of 82% has been used which would allow the 7,000 ton plant to support the entire projected load. If the University wants a redundant chiller to replace a potential repair on one of the other chillers, then the plant should be planned for 9,000 tons. All costs in this study relate to the 7,000 ton plant. The plant can be phased as outlined below.
See Maps CHW2-A and CHW2-B for plant locations A & B and piping.

Expanded HPER Loop
New Chilled Water Plant in Eccles School of Business (ESB)

The existing 1200 ton chiller plant associated with the HPER Complex is in good condition and the chillers are only 11 years old. It is recommended that this plant be retained as the major contributor to a chilled water loop encompassing the existing connected buildings, the future Student Life Center, the Eccles School of Business Complex of buildings and the Fine Arts building. The chillers in the Fine Arts building will remain as a chilled water contributor to the loop and a new chilled water plant will be added in the new ESB, which is presently in the planning stages, and will provide chilled water to the loop. The existing line between the HPER plant and Milton Bennion Hall will be replaced with a larger line. Once the ESB chillers are on line, the chilled water that is being sent to Milton Bennion Hall can be reserved for the Student Life Center. Since all buildings will be interconnected with the loop, if any of the chillers go down, back up capacity is available from the other plants. The total connected capacity of this loop would be 3746 tons. The Huntsman Center consumes approximately 1000-1200 tons alone, but this is a very sporadic load and generally does not peak at the same time as the other buildings thus freeing up this capacity for the other buildings. It is therefore reasonable to assume that the diversity for this loop could be 60-65%. Assuming 65%, the connected load could be supported from a 2435 ton plant.

It is suggested that the ESB include a chilled water plant of 960 tons which would bring the capacity of this loop to 2806 tons, and a 75% diversity for the loop. It is recommended that the two chillers in the Warnock Building (640 tons) be relocated to ESB and a new 320 ton chiller be added, bringing the total capacity to 960 tons. This would complete the HPER loop. Phasing of this work is outlined below.

Option 2, Site "A", 7000 Ton Plant (I.Q.)

Estimated Costs:	Plant:	$11,319,818.00
	Piping:	$2,631,915.00
Total:		**$13,954,733.00**

Option 2, Site "B", 7000 Ton Plant (I.Q.)

Estimated Costs:	Plant:	$11,319,818.00
	Piping:	$2,345,970.00
Total:		**$13,665,788.00**

Option 2, HPER Loop, 960 Ton Plant (ESB)

Estimated Costs:	**Plant**	**$1,998,032.00**

See detail for costs estimates in the Appendix under COST ESTIMATES.

The costs for the ESB Plant will be part of the ESB project and are given here as information only. These costs include the chiller plant, dedicated building costs for the plant, contractor's fees, a 5% contingency, and the cost to relocate the chillers from Warnock to ESB.

PHASING OF CENTRAL PLANT, OPTION 2

Since all of the needs for a central Plant are not immediate, it is prudent to consider phasing the Plant. The initial phase should include all of the immediate loads with planning for future needs. The piping distribution system should anticipate the future loads and be sized and installed accordingly so that connections need only be made in the future.

Phase 1

New Chilled Water Plant (I.Q.)

Construct a new 3,000 ton chilled water plant at site “A” with provisions to expand the plant as the future loads dictate. This plant would serve all projected loads for the next eight years. See Table 3 in the Appendix for loads to be connected to the plant immediately. It is suggested that mains be extended from the plant to the USTAR Phase I and Warnock Building, the Sill Center, Alumni House and the Mines and Minerals Buildings. It is suggested that the existing chillers in Warnock be relocated to ESB and that the Warnock Building be connected to the chilled water plant. The reduced cost of these two chillers in ESB could be used toward the piping distribution cost to the Warnock Building. With this pipe in place, the main could be extended to the Merrill Engineering Building and this building could be connected as soon as chiller replacements are needed. See map CHW2-A-1 in Appendix.

The new plant serving the Interdisciplinary Quad should be planned to accommodate Phases I, II, and III, with Land reserved for future Plant expansion. See Central Plant Proposal Drawing M-1 in the Appendix.

Estimated Costs:		Plant:	$6,300,462.00
		Piping:	$1,237,528.00
	Total:		$7,538,010.00

Expanded HPER Loop (ESB)

Relocate the two 320 ton chillers from the Warnock Building and install in the Eccles School of Business Building. Provide space in the building to add a third 320 ton chiller in the future. Phase I capacity of this plant would be 640 tons. Space should be provided for a third cooling tower. Connect to the existing chilled water loop from the Fine Arts Building. The relocated Warnock chillers of 640 tons together with one new 320 ton chiller will eventually bring the ESB plant total to 960 tons.

Estimated Costs:		Plant:	$1,867,167.00
		Piping:	$124,575.00
	Total:		$1,991,742.00

The suggested phasing would provide the following:

Phase I - Completion 2009	Capacity
New Central Plant & Distribution Piping:	3000 tons
(Interdisciplinary Quad)	
Expanded HPER Loop	640 tons
(Chiller Plant in ESB)	
Existing HPER Plant	1200 tons
Existing Fine Art Plant	646 tons
Total:	2486 tons

The 3000 tons for the I.Q. Plant exceeds the immediate needs of 1875 tons noted in Table 3 and will provide a redundant chiller.

The 2486 ton for HPER, ESB loop exceeds the immediate 2204 tons noted in Table 4.

Phase II – 4000 tons			
Chilled Water Plant I.Q.			
Estimated Costs:		Plant:	$6,675,531.00
		Piping:	$943,828.00
	Total:		$7,619,359.00
Expanded HPER Loop 320 tons			
(Chiller in ESB)			
Estimated Costs:		Plant:	$424,728.00
		Piping:	$534,600.00
	Total:		$959,328.00
Phase III (If desired) 2000 tons			
Chilled Water Plant I.Q.			
Estimated Costs:	Total:		$4,200,000.00

COSTS, ESTIMATES, DECENTRALIZED VS. CENTRAL PLANT

The following estimates identify the costs associated with replacing existing chillers in place with new chillers and costs for a central chilled water Plant. The replacement costs include replacement of chillers and cooling towers, and upgrading the chiller room to current codes.

Replacement Chiller Costs vs. Central Plant Costs.

Replacement of Existing Chillers

Air Cooled Chillers

Bldg. 51, Sterling Sill Center, Bldg. 52, Alumni House, Bldg. 56, 57, HEDCO.

Estimated Replacement Costs: $141,000.00

Water Cooled Chillers

Bldg. 49, Language & Communications, Bldg. 53, A. Ray Olpin Union, Bldg. 54, Orson Spencer Hall, Bldg. 61, Mines and Minerals, Bldg. 64, Merrill Engineering, Warnock Bldg.

Estimated Replacement Costs: $1,452,740.00

Estimated Building Code Upgrades $167,625.00

ESTIMATED TOTAL REPLACEMENT COSTS $1,761,375.00

Piping Costs to Existing Buildings

These costs relate to the cost to bring chilled water piping to the existing buildings from a new chilled water plant at the Interdisciplinary Quad site.

CHILLED WATER MAINS.......... $856,680.00

BRANCH PIPING TO: $471,840.00

Bldg. 64 Merrill Engineering, Warnock Bldg., Bldg. 56,57,61 HEDCO, Bldg. 51 Sterling Sill, Bldg. 52 Alumni House, Bldg. 54 A. Ray Olpin Union, Bldg. 47 Language & Communications

INTERNAL PIPING IN BUILDINGS.......... $185,250.00

ESTIMATED TOTAL COST TO CONNECT TO CENTRAL PLANT $1,515,720.00

SAVINGS TO CONNECT TO CENTRAL PLANT.......... $247,605.00

These costs consider only the buildings that would be connected to the New Central Chilled Water Plant at the Interdisciplinary Quad. The HPER Loop would still have several individual chiller plants and no savings can be expected from operations and maintenance on that Loop.

OPERATING AND MAINTENANCE COST COMPARISIONS

The existing chiller plants in the existing buildings consist of machines manufactured in the 1990's with efficiencies of 0.49 – 1.2 KW/ton and higher. Many of these machines run throughout the year, winter and summer, and none of these systems have water side economizers. The systems have constant flow pumping.

A new chiller Plant is proposed that will incorporate energy conservation features aimed toward reducing operating costs. These features will include one variable speed chiller, a water side economizer for winter operation, decoupled chilled water pumping with primary chilled water pumps for each chiller and variable speed system pumps and new high efficiency chillers that will operate at 0.40 KW/ton.

Data has been collected from the University Maintenance Department to assist in the analysis of the current operating costs. Based on the data collected, for the past two years, and the analysis that was made, the University spends $22.50/ton/year on repairs and maintenance and it takes 1.25 FTE of labor for the existing chillers and towers (2320 tons). The East Campus Chilled Water Plant by contrast spends $6.50/ton/year in maintenance and repair and uses 0.75 FTE of labor for the 8000 ton plant. Tables 6 & 7 in Appendix outline the operating and maintenance savings that can be expected with a Central Plant versus decentralized plants.

If decentralized individual plants are used for the future projected load of 6178 tons (8498 tons total, less 2320 tons existing, Table 3 Appendix) the O.M. costs are projected as noted below.

Table 8 in the Appendix includes the details and assumptions used in calculating the operating costs for the existing systems as well as the costs for replacing the existing system in place and for a Central Plant delivering the same ton hours of cooling and Tables 6 & 7 give the detailed calculations.
A summary of these costs are:

	Individual Plants	Central Plant
Existing O & M Annual Costs	$231,970.00	
(Existing 2320 tons)		
Estimated O & M Annual Costs		$115,680.00
(Existing 2320 tons)		
Estimated Future O & M Annual Costs	$617,720.00	$308,048.00
(For new 6178 tons)		
Subtotal	$849,690.00	$423,728.00

Annual O & M Savings for a Central Plant..$425,962.00

INITIAL COST COMPARISONS

From the above analysis it has been shown that the Option 2, full connected load will be 12,244 tons, 8498 tons at the Interdisciplinary Quad site and 3746 tons at the HPER Loop. For the new Interdisciplinary Quad Central Plant, the plant is proposed for 7000 ton, to serve a connected load of 8498 tons for a savings of 1498 tons. The HPER loop is proposed for 2800 tons to serve a connected load of 3746 tons, for a savings of 946 tons.

The following cost analysis pertains only to the present (2320 tons) and future (6178 tons) buildings that are in the area proposed to be served by the New Chilled Water Plant in the vicinity of the Interdisciplinary Quad.

The comparison shows the difference between the cost to replace all existing chillers with new chillers, and to install individual chillers in all of the new buildings as opposed to connecting all present and future buildings to a Central Chilled Water Plant.

Initial Costs Summary	Individual Building Chiller Plants	New Central Plant Option 2
Replace Existing Chillers (2320 tons)	$1,761,375.00*	
New Building Chiller Plants (6178 tons)	$13,622,490.00**	
New Central Plant (7000 tons)		$11,319,818.00
Piping Distribution to all Existing & New Buildings		$2,631,951.00
Totals	$15,383,865.00	$13,951,733.00

SAVINGS FOR CENTRAL PLANT OVER INDIVIDUAL CHILLERS IN EACH BUILDING...$1,432,132.00

See Cost Estimates in the Appendix for details.

* See Table 10 in the Appendix.

** Based on $2,205.00 per ton, which includes chiller plant, electrical, dedicated building costs for the plant, contractor's fees and a 5% contingency.

CONCLUSIONS

The following conclusions have been reached from the foregoing analysis of the chilled water systems for the Central Campus.

1. The existing systems are operated on a manual basis and there is no automation of the systems from a central location.
2. There are no energy conserving features in the system to allow the chillers to remain off during the cold winter months. A lack of air side or water side economizer systems in the buildings dictate the need for winter chiller operation. Replacement of existing old machines with new higher efficiency machines coupled with water side economizers will save operating costs throughout the life of the systems.
3. The maintenance staff has noted many problems with chillers in the following buildings: Bldg. 49, Language and Communication; Buildings 51 and 52 have continual problems; Bldg. 56, 57 chillers are at end of useful life; Bldg. 64 Merrill Engineering Building has multiple problems with the 290 ton machine and air locks are a continual problem with machines in Bldg. 96 HPER.
4. A central chilled water Plant in lieu of the present decentralized Plants would be advantageous for the owner in terms of maintenance, operations, energy savings and expansion capability.
5. The existing chiller and piping arrangements do not lend themselves to a primary/secondary pumping scheme for maximum energy conservation. A central Plant would allow this approach to be implemented.
6. Existing chiller installations do not conform to present codes. Replacement of these chillers should comply with codes, which means replacement in the same location is not possible without major remodeling.
7. The chiller plant in Building 96, serving the HPER complex should be left in place and upgraded with primary/secondary pumping and the valves in all connected buildings should be changed from three way valves to two way valves.
8. The HPER chilled water loop should be expanded as noted in the study as the new Eccles School of Business and the Student Life Buildings come on line.
9. Constructing a Central Chilled Water Plant connecting multiple buildings will allow diversity, which will allow more building space to be served from the Central Plant tonnage without increasing the plant size.
10. The first phase of the I.Q. plant should be constructed to address the immediate and short term needs for the next eight years. Chilled water requirements beyond the eight years should be addressed with expansion of the plant building and capacity.
11. A new central plant will save the University $116,290.00 per year now in operating and maintenance costs and will save an additional $309,672.00 when future buildings come on line.

12. A new Central Chilled Water Plant will save the University $1,432,132.00 in initial construction costs over decentralized chillers in existing and future buildings.

RECOMMENDATIONS

The following recommendations are being made after consideration of the above conclusions and after consultation with the owner in terms of priorities and long term expectations of the University and the Master Plan for the Campus:

Phase I

1. Construct a new Central Chilled Water Plant close to the Interdisciplinary Quad site on the west edge of Campus Drive. See map CHW2-A-1. Construct the building for the Plant in phases of sufficient size to eventually accommodate 10,000 tons of cooling. The initial size of this Plant is recommended to be 3,000 tons.
2. Construct a piping distribution system to the center of the Interdisciplinary Quad of sufficient capacity to support all present and future buildings in the quad and the future Moran building scheduled for east of the quad.
3. Extend the piping to the North side of Warnock and connect Warnock to the plant.
5. Remove the chillers from Warnock and install them in the new Eccles School of Business Building and extend piping out to the existing chilled water loop from Fine Arts.

Phase II, 2015-2022

1. Expand the I.Q. Central Chilled Water Plant by 4000 tons.
2. Extend piping to Language and Communications Building.
3. Add the third 320 ton chiller in the Eccles School of Business Building and extend piping to the HPER Loop and to the Student Life Building.

Phase III, 2025

1. Expand the I.Q. Central Chilled Water Plant by 2000 tons.

APPENDIX:

CAPACITY TABLES

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

9/12/2007

PROPOSED CENTRAL CAMPUS CENTRAL CHILLED WATER PLANT
UNIVERSITY OF UTAH

PLANT CAPACITY PROJECTIONS
AUG. 1, 2007

BLDG NO.	BUILDING STATUS E,P,D,F	BUILDING NAME	GROSS SQ.FT.	AGE OF CHILLERS	ACTUAL OR ESTIMATED LOADS: ASSUMED SQ.FT./TON	TONS	GPM @14 DEL.	ESTIMATED LOADS TONS: IMMEDIATE	IMMEDIATE FUTURE WITHIN 8 YEARS	PROJECTED FUTURE 8-15 YEARS	FUTURE 20+ YEARS
	P	NBTRB PHASE 1	200,000		200	1,000	1,714	1,000			
	P	ECCLES SCHOOL OF BUSINESS	200,000		300	667	1,143	667			
51	E	STERLING W. SILL CENTER	13,107	11		60	103	60			
52	E	ALUMNI HOUSE	16,720	14		70	120	70			
56	E	HEDCO ENERGY AND MINING	197,300	23		75	129	75			
57	E	HEDCO ENERGY AND MINING	28,252			30	51	30			
	F	UTAH MUSEUM OF FINE ARTS	45,000		300	150	257		150		
	F	COLLEGE EDUCATION	78,000		300	260	446		260		
49	E	LANGUAGE AND COMMUNICATIONS	100,732	13		340	583		340		
64	E	MERRILL ENGINEERING BUILDING	268,173	14		290	497		290		
	F	NBTRB PHASE 2	300,000		225	1,333	2,286		1,333		
	E	MERRILL ENGINEERING BUILDING		4		400	686			400	
	F	STUDENT LIFE CENTER	157,500		275	573	982			573	
	F	FUTURE BUILDINGS (INTERD.CORRIDOR)	500,000		225	2,222	3,810			2,222	
	F	HEALTH PHYS. ED WEST ADDITION	60000		250	240	411			240	
	F	MERRILL ENGINEERING BUILDING EXPAN.	100000		250	400	686			400	
	F	MORAN EYE PHASE 2	200000		250	800	1,371			800	
54	E	ORSON SPENCER HALL	116,148	9		415	711			415	
	F	MILTON BENNION HALL EXPANSION	112000		350	320	549			320	
53	E	A. RAY OLPIN UNION	68,000		250	272	466			272	
61	E	ENERGY AND MINERAL RESEARCH	51,611	3		150	257			150	
35	E	FINE ARTS MUSEUM	73,792	9		646	1,107			646	
74	E	BUSINESS CLASSROOM (Served from F.A.)	49,222			-144				-144	
75	E	KEN GARFF BUS.OFF.(Served from F.A.)	32,884			-96				-96	
76	E	ARMSTRONG MADSEN (Served from F.A.)	23,727			-69				-69	
77	E	CHRISTENSEN CENTER (Served from F.A.)	42,000								
96	E	HPER		11		1,200	2,057			1,200	
	E	HUNTSMAN CENTER									
	E	HEALTH PHYS. ED. EAST									
	E	HEALTH PHYS. ED. NORTH]									
	E	HEALTH PHYS. ED. SO. NATATORIUM									
	E	BURBIDGE ATHLETIC CENTER									
	E	RANDALL TURPIN UNVERSITY SERVICES									
	E	MILTON BENNION HALL									
62	E	WARNOCK ENGINEERING BUILDING	125,000	1		640	1,097				640
63	E	ENERGY AND MINES CLASSROOM	59,872				0				
TOTALS:			3,219,040			12,244	21,519	1,902	2,373	7,329	640

ACCUMULATED TOTAL FOR PLANT:		1,902	4,275	11,604	12,244

RECOMMENDED PLANT CAPACITY,10,000 TONS

PHASE I PLANT SIZE 4000 TONS JULY 2009

Plant size: # Tons		► ► ►				
Estimated Load with Diversity:	100%	► ► ►	1,902			
(Diversity is based on a design day when the outside air temperature is 96°F or lower.)	92%	► ► ►	1,750	3,933		
	85%		1,616	3,634		
Standby capacity based on Phase I, 4000 Ton Plant			2,098	67		

PHASE II, EXPAND PLANT TO 10,000 TONS JULY 2015

Plant size: # Tons						
	90%				10,444	11,020
Estimated Load with Diversity:	82%	► ► ►	►	►	9,515	10,040
Standby capacity based on Phase II, 10,000 Ton Plant					485	-40

ESTIMATED YEAR WHEN LOAD WILL OCCUR:	2009	2012	BEYOND 2015	

MACHINE CAPACITY USAGE: 2000 TON MACHINES # Tons

2000 TON MACHINE	1000	1500	2000	2000
PERCENT LOADED:	50%	75%	100%	100%
2000 TON MACHINE	800	1500	2000	2000
PERCENT LOADED:	40%	75%	100%	100%
2000 TON MACHINE	0	1500	2000	2000
PERCENT LOADED:	0%	75%	100%	100%
2000 TON MACHINE	0	0	2000	2000
PERCENT LOADED:	0%	0%	100%	100%
2000 TON MACHINE	0	0	2000	2000
PERCENT LOADED:	0%	0%	100%	100%
CAPACITY USED:	1800	4500	10000	10000

Note: *EXISTING (E) + PROGRAM (P) + DESIGN (D) + FUTURE (F) - CENTRAL CAMPUS (GOLF COURSE)*

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

9/12/2007

OPTION 1, ALL CENTRAL CAMPUS AND HPER ON ONE PLANT

PROPOSED CENTRAL CAMPUS CENTRAL CHILLED WATER PLANT
UNIVERSITY OF UTAH

PLANT CAPACITY PROJECTIONS
AUG. 1, 2007

BLDG NO.	BUILDING STATUS E,P,D,F	BUILDING NAME	GROSS SQ.FT.	AGE OF CHILLERS	ASSUMED SQ.FT./TON	ACTUAL OR CALCULATED TONS	IMMEDIATE	IMMEDIATE FUTURE WITHIN 8 YEARS	PROJECTED FUTURE 8-15 YEARS	FUTURE 20+ YEARS
	P	NBTRB PHASE 1	200,000		200	1,000	1,000			
	P	ECCLES SCHOOL OF BUSINESS	200,000		300	667	667			
51	E	STERLING W. SILL CENTER	13,107	11*		60	60			
52	E	ALUMNI HOUSE	16,720	14*		70	70			
56	E	HEDCO ENERGY AND MINING	197,300	22*		75	75			
57	E	HEDCO ENERGY AND MINING	28,252	23*		30	30			
	F	UTAH MUSEUM OF FINE ARTS	45,000		300	150		150		
	F	COLLEGE EDUCATION	78,000		300	260		260		
49	E	LANGUAGE AND COMMUNICATIONS	100,732	13		340		340		
64	E	MERRILL ENGINEERING BUILDING	268,173	14		290		290		
		NBTRB PHASE II	300,000		225	1,333		1,333		
		MERRILL ENGINEERING BUILDING		4		400			400	
	F	STUDENT LIFE CENTER	157,500		275	573			573	
	F	FUTURE BUILDINGS (INTERD.CORRIDOR)	500,000		225	2,222			2,222	
94	F	HEALTH PHYS. ED. WEST ADDITION	60,000		250	240			240	
62.1	F	MERRILL ENGINEERING BUILDING EXPANSION	100,000		250	400			400	
	F	MORAN EYE PHASE 2	200,000		250	800			800	
54	E	ORSON SPENCER HALL	116,148	9		415			415	
65.1	F	MILTON BENNION HALL EXPANSION	112,000		350	320			320	
53	E	A. RAY OLPIN UNION	68,000		250	272			272	
61	E	ENERGY AND MINERAL RESEARCH	51,611	3		150			150	
35	E	FINE ARTS MUSEUM	73,792	9		646			646	
74	E	BUSINESS CLASSROOM (Served from F.A.)**	49,222		343	-144			-144	
75	E	KEN GARFF BUS.OFF.(Served from F.A.)**	32,884		343	-96			-96	
76	E	ARMSTRONG MADSEN (Served from F.A.)**	23,727		343	-69			-69	
77	E	CHRISTENSEN CENTER (Served from F.A.)	42,000							
96	E	HPER		11		1,200			1,200	
90	E	HUNTSMAN CENTER	201,301							
91	E	HEALTH PHYS.ED. EAST	80,627							
92	E	HEALTH PHYS. ED. NORTH ADDITION	52,532							
93	E	HEALTH PHYS. ED. SO. NATATORIUM	35,806							
98	E	BURBIDGE ATHLETIC CENTER	14,833							
350	E	RANDALL TURPIN UNIVERSITY SERVICES	71,906							
65	E	MILTON BENNION HALL	78,158							
62	E	WARNOCK ENGINEERING BUILDING	125,000	1		640	640			
63	E	ENERGY AND MINES CLASSROOM	59,872							
TOTALS:			3,754,203			12,244	2,542	2,373	7,329	
ACCUMULATED TOTAL FOR PLANT:							2,542	4,915	12,244	

* Note: These chillers are air cooled chillers and are very inefficient and should be replaced with more efficient machines.
** Note: These buildings and their respective capacities will be replaced with the new Eccles School of Business noted above at 200,000 sf.

TABLE 2

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

9/12/2007

OPTION 2, CENTRAL CAMPUS PLANT CAPACITY

PROPOSED CENTRAL CAMPUS CENTRAL CHILLED WATER PLANT
UNIVERSITY OF UTAH

PLANT CAPACITY PROJECTIONS
AUG. 1, 2007

BLDG NO.	BUILDING STATUS E,P,D,F	BUILDING NAME	GROSS SQ.FT.	AGE OF CHILLERS	ASSUMED SQ.FT./TON	ACTUAL OR CALCULATED TONS	IMMEDIATE	IMMEDIATE FUTURE WITHIN 8 YEARS	PROJECTED FUTURE 8-15 YEARS	FUTURE 20+ YEARS
	P	NBTRB PHASE 1	200,000		200	1,000	1,000			
	P	ECCLES SCHOOL OF BUSINESS	200,000		300					
51	E	STERLING W. SILL CENTER	13,107	11*		60	60			
52	E	ALUMNI HOUSE	16,720	14*		70	70			
56	E	HEDCO ENERGY AND MINING	197,300	22*		75	75			
57	E	HEDCO ENERGY AND MINING	28,252	23*		30	30			
	F	UTAH MUSEUM OF FINE ARTS	45,000		300					
	F	COLLEGE EDUCATION	78,000		300					
49	E	LANGUAGE AND COMMUNICATIONS	100,732	13		340		340		
64	E	MERRILL ENGINEERING BUILDING	268,173	14		290		290		
	F	NBTRB PHASE II	300,000		225	1,333		1,333		
64	E	MERRILL ENGINEERING BUILDING		4		400			400	
	F	STUDENT LIFE CENTER	157,500							
	F	FUTURE BUILDINGS (INTERD.CORRIDOR)	500,000		225	2,222			2,222	
94	F	HEALTH PHYS. ED. WEST ADDITION	60,000		250	240			240	
62.1	F	MERRILL ENGINEERING BUILDING EXPANSION	100,000		250	400			400	
	F	MORAN EYE PHASE 2	200,000		250	800			800	
53	E	A. RAY OLPIN UNION	68,000		250	272			272	
61	E	ENERGY AND MINERAL RESEARCH	51,611	3		150			150	
54	E	ORSON SPENCER HALL	116,148	9		415			415	
65.1	F	MILTON BENNION HALL EXPANSION	112,000		350					
35	E	FINE ARTS MUSEUM	73,792	9						
74	E	BUSINESS CLASSROOM (Served from F.A.)	49,222							
75	E	KEN GARFF BUS.OFF.(Served from F.A.)	32,884							
76	E	ARMSTRONG MADSEN (Served from F.A.)	23,727							
77	E	CHRISTENSEN CENTER (Served from F.A.)	42,000							
96	E	HPER		11						
90	E	HUNTSMAN CENTER	201,301							
91	E	HEALTH PHYS.ED. EAST	80,627							
92	E	HEALTH PHYS. ED. NORTH ADDITION	52,532							
93	E	HEALTH PHYS. ED. SO. NATATORIUM	35,806							
98	E	BURBIDGE ATHLETIC CENTER	14,833							
350	E	RANDALL TURPIN UNIVERSITY SERVICES	71,906							
65	E	MILTON BENNION HALL	78,158							
62	E	WARNOCK ENGINEERING BUILDING	125,000	1		640	640			
63	E	ENERGY AND MINES CLASSROOM	59,872							
TOTALS:			3,754,203			8,498	1,875	1,963	4,659	
ACCUMULATED TOTAL FOR PLANT:							1,875	3,838	8,498	

* Note: These chillers are air cooled chillers and are very inefficient and should be replaced with more efficient machines.

ACCUMULATED TOTAL FOR PLANT: 3,838 8,498

RECOMMENDED PLANT CAPACITY,7,000 TONS

PHASE I PLANT SIZE 3000 TONS JULY 2009

	Plant size: # Tons	3000				
Estimated Load with Diversity:	100%		▶	▶	1,875	
(Diversity is based on a design day when the outside air temperature is 96°F or lower.)	92%		▶	▶	1,725	3,531
	85%				1,594	3,263
Standby capacity based on Phase I, 3000 Ton Plant, 92% diversity.					1,275	-531

PHASE II, EXPAND PLANT TO 7,000 TONS JULY 2015

	Plant size: # Tons	7000					
	90%						7,648
Estimated Load with Diversity:	82%		▶	▶	▶		6,968
Standby capacity based on Phase II, 7,000 Ton Plant, 82% diversity.							32

Note: *EXISTING (E) + PROGRAM (P) + DESIGN (D) + FUTURE (F) - CENTRAL CAMPUS (GOLF COURSE)*

TABLE 3

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

9/12/2007

OPTION 2 HPER LOOP CAPACITY

PROPOSED CENTRAL CAMPUS CENTRAL CHILLED WATER PLANT
UNIVERSITY OF UTAH

PLANT CAPACITY PROJECTIONS
AUG. 1, 2007

BLDG NO.	BUILDING STATUS E,P,D,F	BUILDING NAME	GROSS SQ.FT.	AGE OF CHILLERS	ASSUMED SQ.FT./TON	ACTUAL OR CALCULATED TONS	IMMEDIATE	IMMEDIATE FUTURE WITHIN 8 YEARS	PROJECTED FUTURE 8-15 YEARS	FUTURE 20+ YEARS
	P	NBTRB PHASE 1	200,000		200					
	P	ECCLES SCHOOL OF BUSINESS	200,000		300	667	667			
51	E	STERLING W. SILL CENTER	13,107	11*						
52	E	ALUMNI HOUSE	16,720	14*						
56	E	HEDCO ENERGY AND MINING	197,300	22*						
57	E	HEDCO ENERGY AND MINING	28,252	23*						
	F	UTAH MUSEUM OF FINE ARTS	45,000		300	150		150		
	F	COLLEGE EDUCATION	78,000		300	260		260		
49	E	LANGUAGE AND COMMUNICATIONS	100,732	13						
64	E	MERRILL ENGINEERING BUILDING	268,173	14						
	F	NBTRB PHASE II	300,000		225					
64	E	MERRILL ENGINEERING BUILDING		4						
	F	STUDENT LIFE CENTER	157,500		275	573			573	
	F	FUTURE BUILDINGS (INTERD.CORRIDOR)	500,000		225					
94	F	HEALTH PHYS. ED. WEST ADDITION	60,000		250	240			240	
62.1	F	MERRILL ENGINEERING BUILDING EXPANSION	100,000		250					
	F	MORAN EYE PHASE 2	200,000		250					
53	E	A. RAY OLPIN UNION	68,000		250					
61	E	ENERGY AND MINERAL RESEARCH	51,611	3						
54	E	ORSON SPENCER HALL	116,148	9						
65.1	F	MILTON BENNION HALL EXPANSION	112,000		350	320			320	
35	E	FINE ARTS MUSEUM	73,792	9	250	646	646			
74	E	BUSINESS CLASSROOM (Served from F.A.)**	49,222			-144	-144			
75	E	KEN GARFF BUS.OFF.(Served from F.A.)**	32,884			-96	-96			
76	E	ARMSTRONG MADSEN (Served from F.A.)**	23,727		343	-69	-69			
77	E	CHRISTENSEN CENTER (Served from F.A.)	42,000		343					
96	E	HPER		11	343	1,200	1,200			
90	E	HUNTSMAN CENTER	201,301							
91	E	HEALTH PHYS.ED. EAST	80,627							
92	E	HEALTH PHYS. ED. NORTH ADDITION	52,532							
93	E	HEALTH PHYS. ED. SO. NATATORIUM	35,806							
98	E	BURBIDGE ATHLETIC CENTER	14,833							
350	E	RANDALL TURPIN UNIVERSITY SERVICES	71,906							
65	E	MILTON BENNION HALL	78,158							
62	E	WARNOCK ENGINEERING BUILDING	125,000	1						
63	E	ENERGY AND MINES CLASSROOM	59,872							
TOTALS:			3,754,203			3,746	2,204	410	1,133	
ACCUMULATED TOTAL FOR PLANT:							2,204	2,614	3,746	

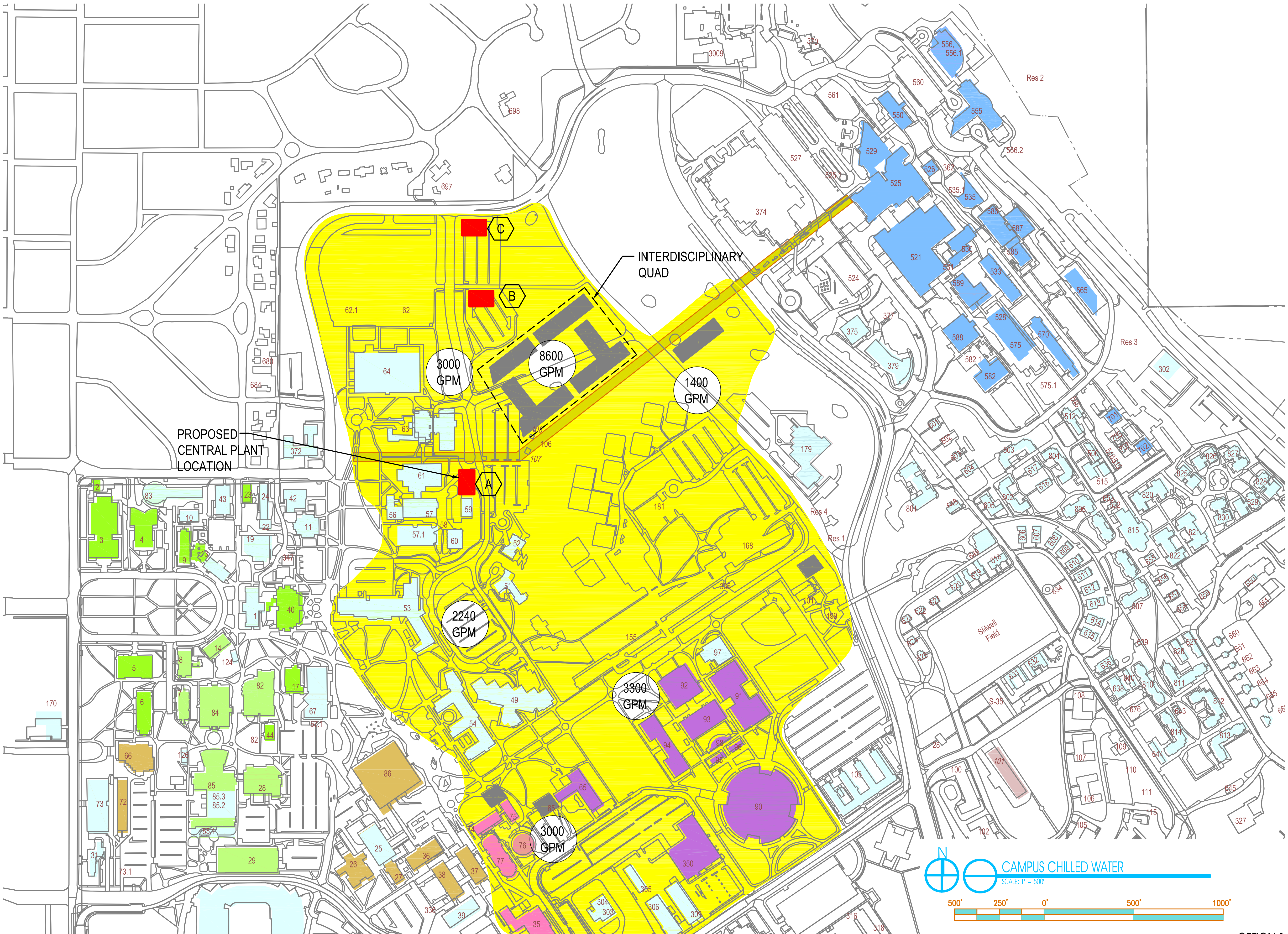
* Note: These chillers are air cooled chillers and are very inefficient and should be replaced with more efficient machines.

**** Note: These buildings and their respective capacities will be replaced with the new Eccles School of Business noted above at 200,000 sf.**

TABLE 4

APPENDIX:

MAPS



OPTION 1

UNIVERSITY OF UTAH
CHILLER PLANT FEASIBILITY STUDY

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS
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Salt Lake City, UT 84111 801.530.3150 F

CONSULTANTS

LEGEND
- NEW CHW - PHASE I
- FUTURE MAINS - PHASE II
- EXISTING MAINS
- FUTURE BUILDINGS
- EXISTING BUILDINGS
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- CHEM/BIOLOGY CHILLED WATER LOOP
- HYPER CHILLED WATER LOOP
- FINE ARTS MUSEUM LOOP
- PROPOSED CHILLED WATER PLANT
- DEDICATED COOLING

REVISIONS

VBFA PROJECT #:	7318
CHECKED BY:	
DRAWN BY:	DL
DATE:	09-11-07

SHEET CONTENTS
CAMPUS CHILLED WATER

CHW1

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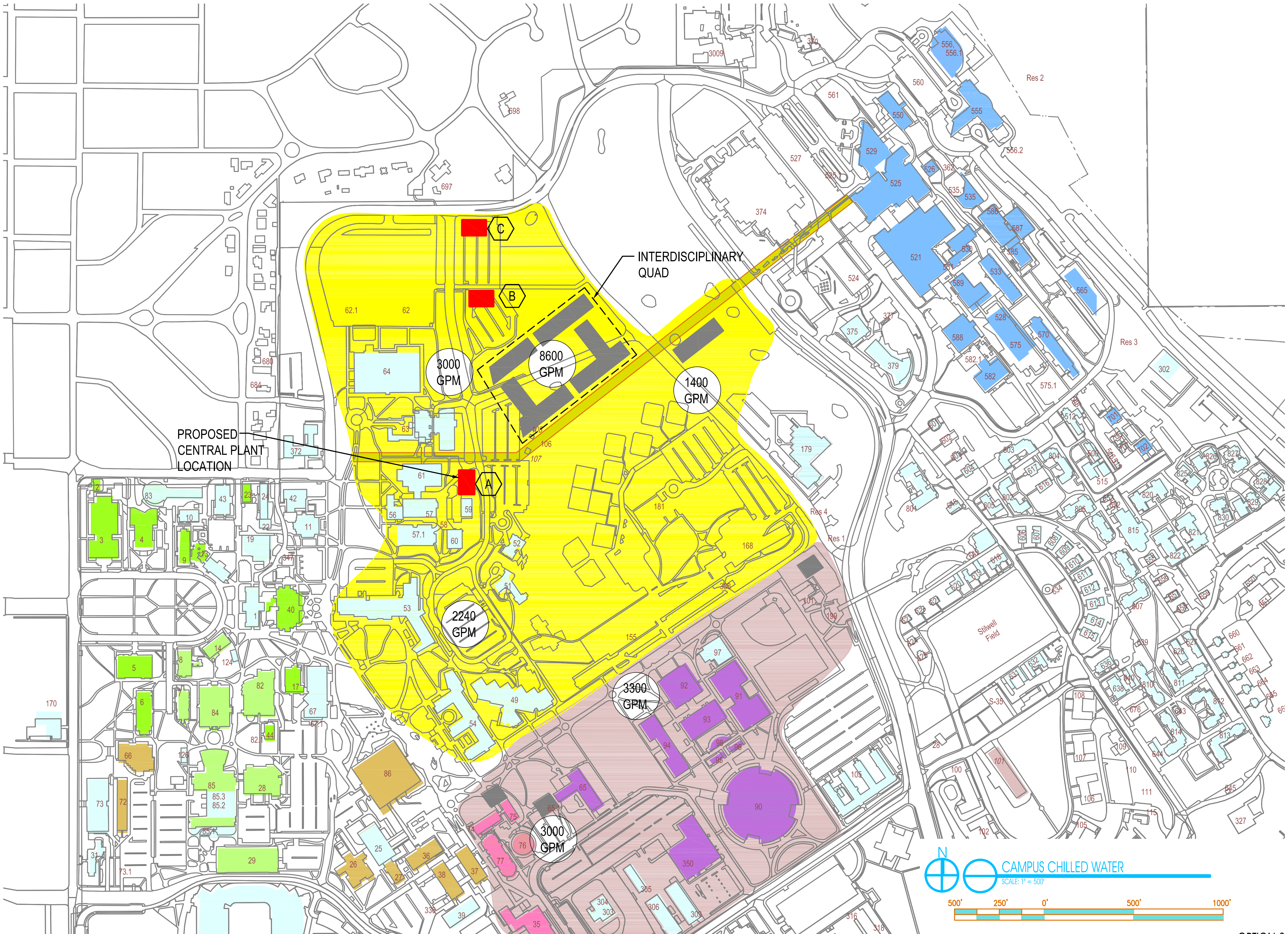

OPTION 2

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REVISIONS

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SHEET CONTENTS

CAMPUS CHILLED WATER

CHW2

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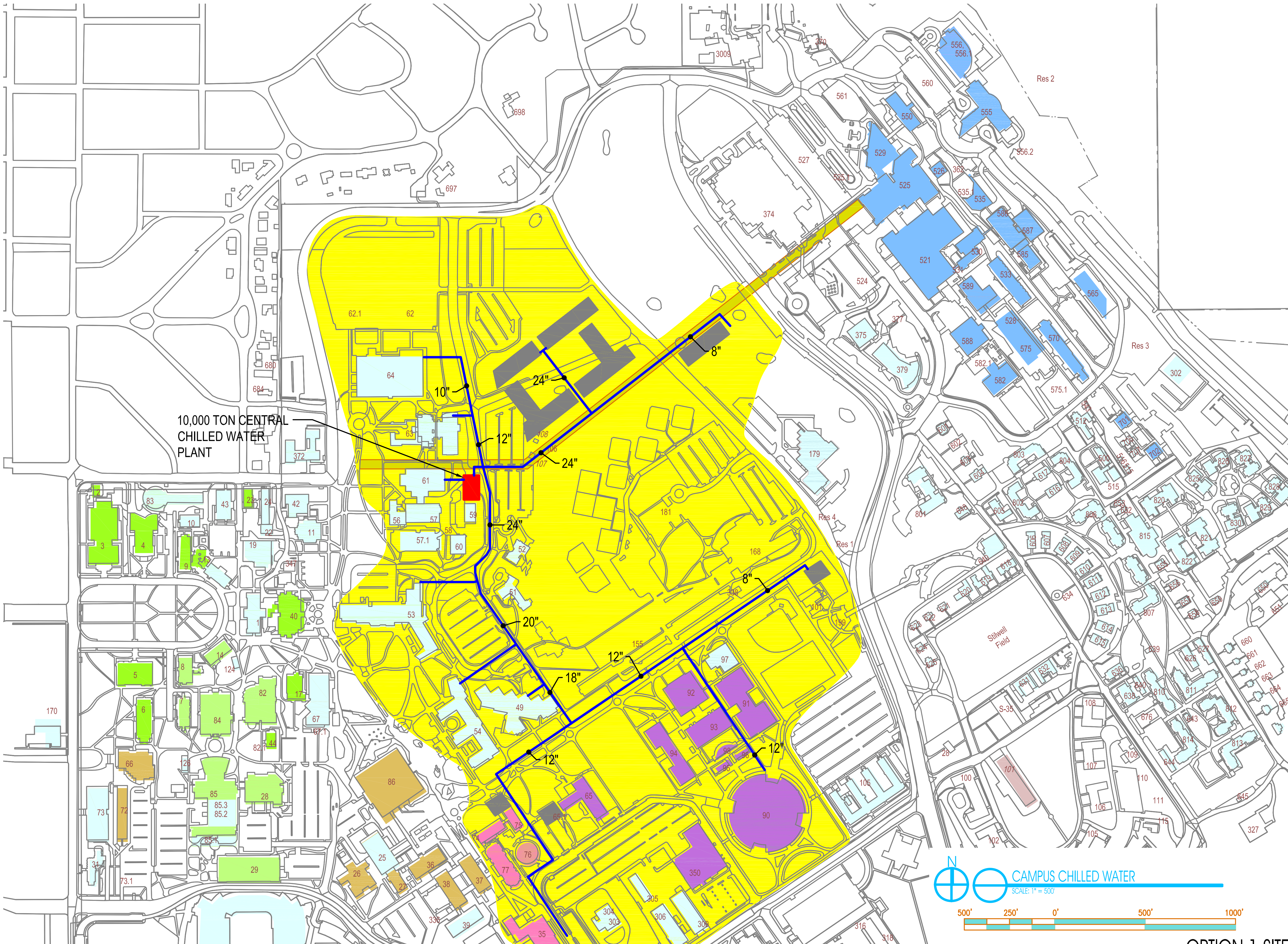

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REVISIONS

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SHEET CONTENTS

CAMPUS CHILLED WATER

OPTION 1 SITE A

CHW1-A

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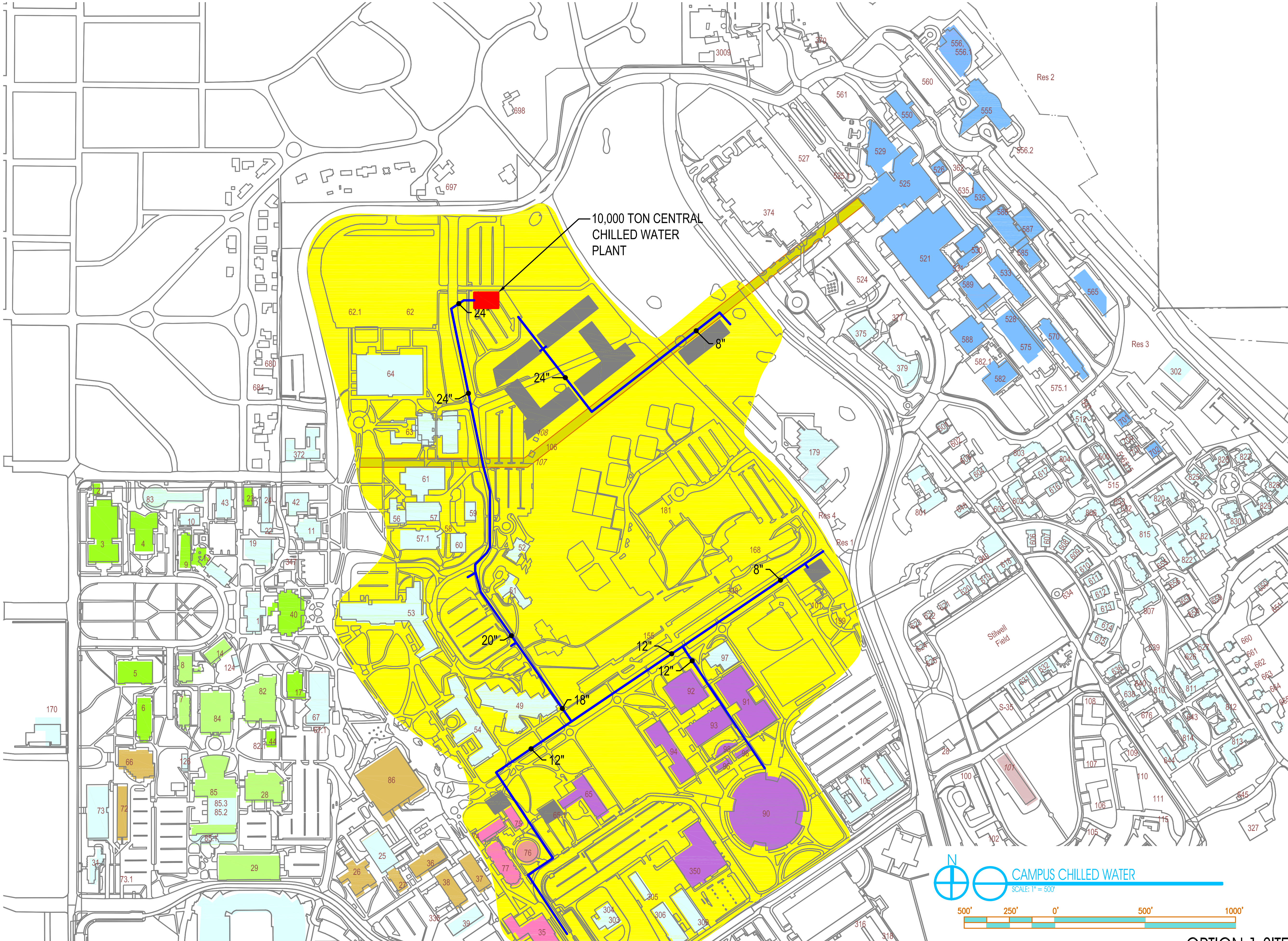

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REVISIONS

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SHEET CONTENTS
CAMPUS CHILLED WATER

OPTION 1 SITE B

CHW1-B

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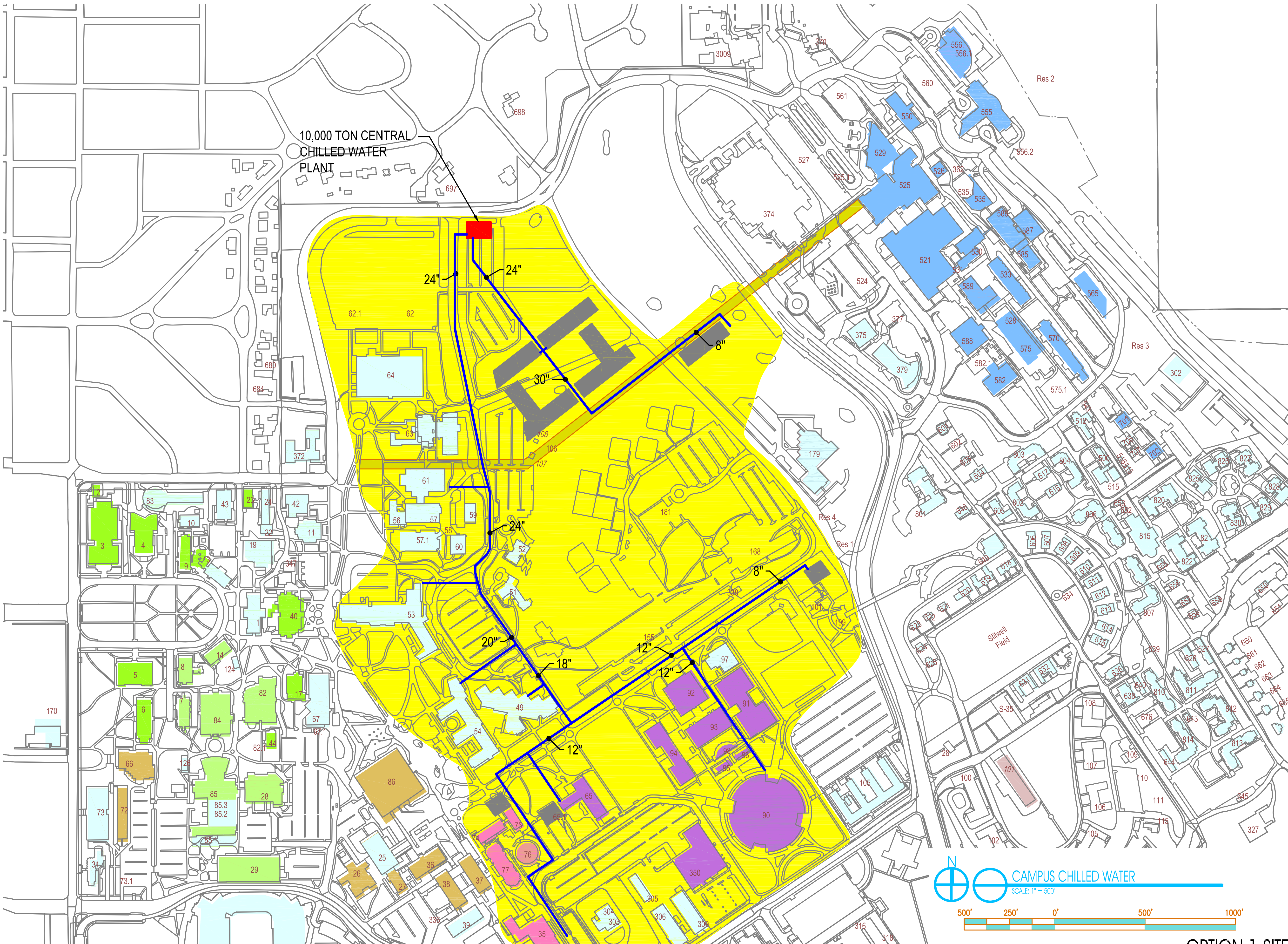

LEGEND

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REVISIONS

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DATE: 09-11-07

SHEET CONTENTS
CAMPUS CHILLED WATER

OPTION 1 SITE C

CHW1-C

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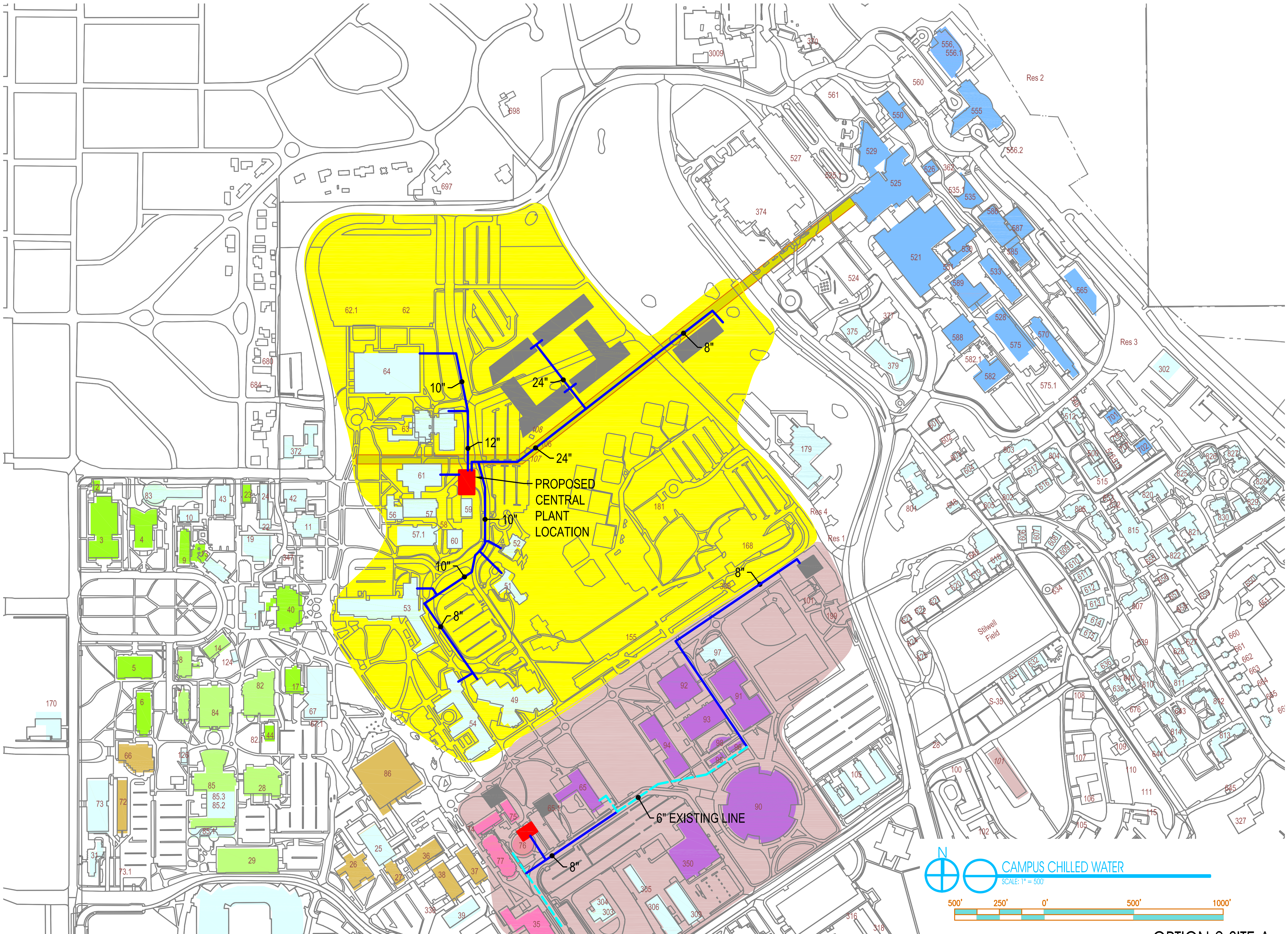

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SHEET CONTENTS
CAMPUS CHILLED WATER

CAMPUS CHILLED WATER
SCALE: 1" = 500'
500' 250' 0' 500' 1000'

OPTION 2 SITE A

CHW2-A

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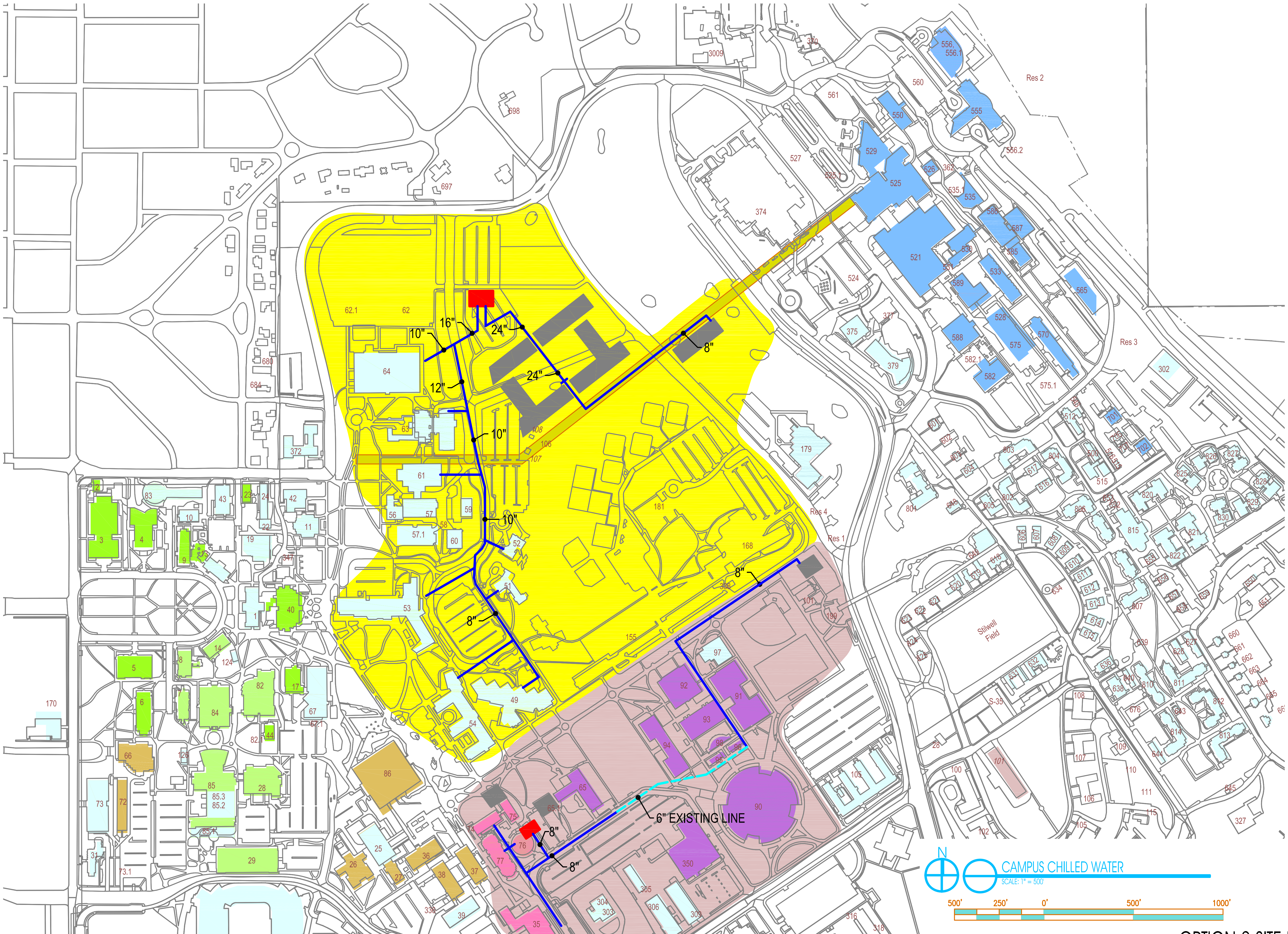

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SHEET CONTENTS

CAMPUS CHILLED WATER

OPTION 2 SITE B

CHW2-B

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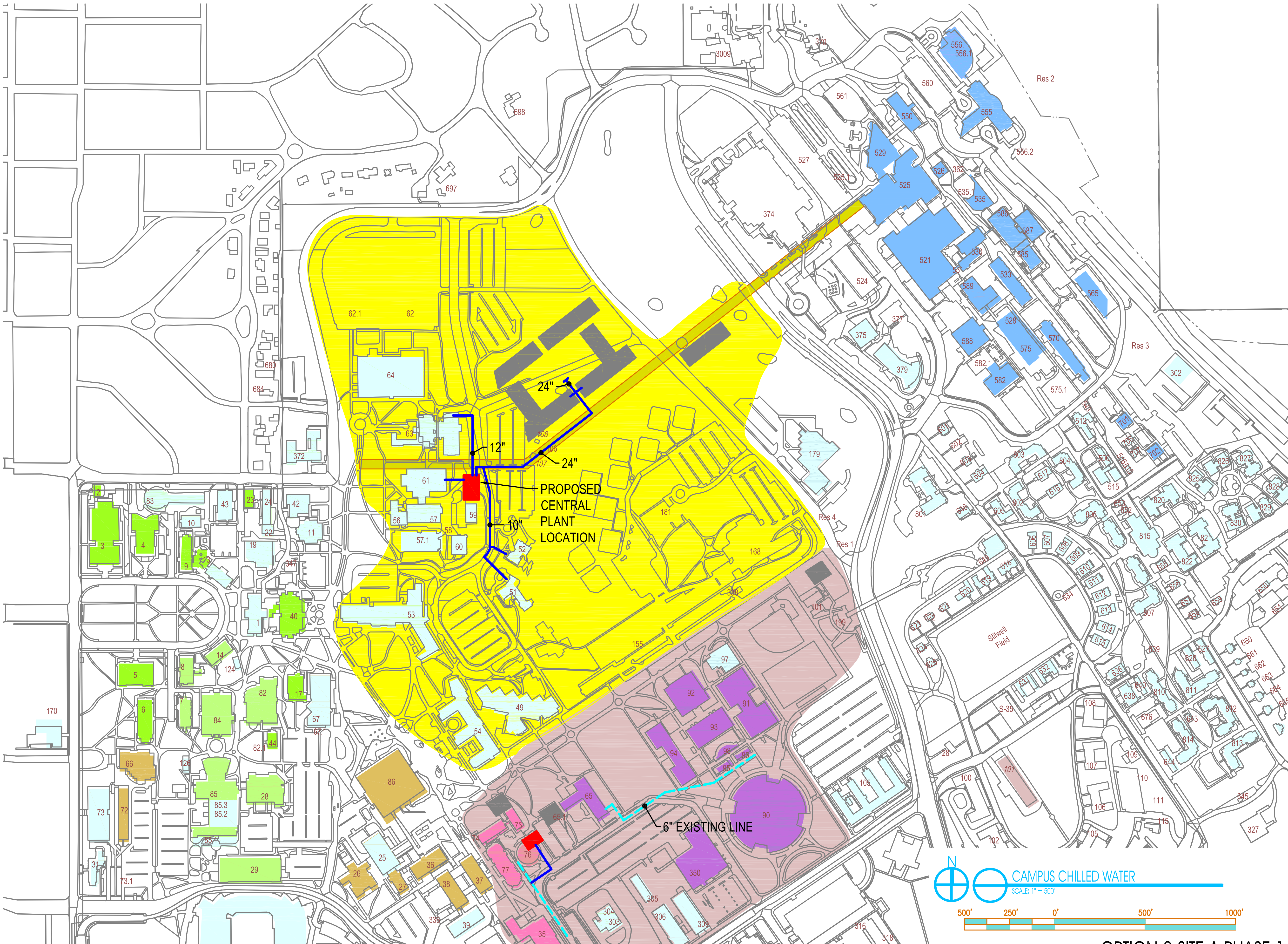

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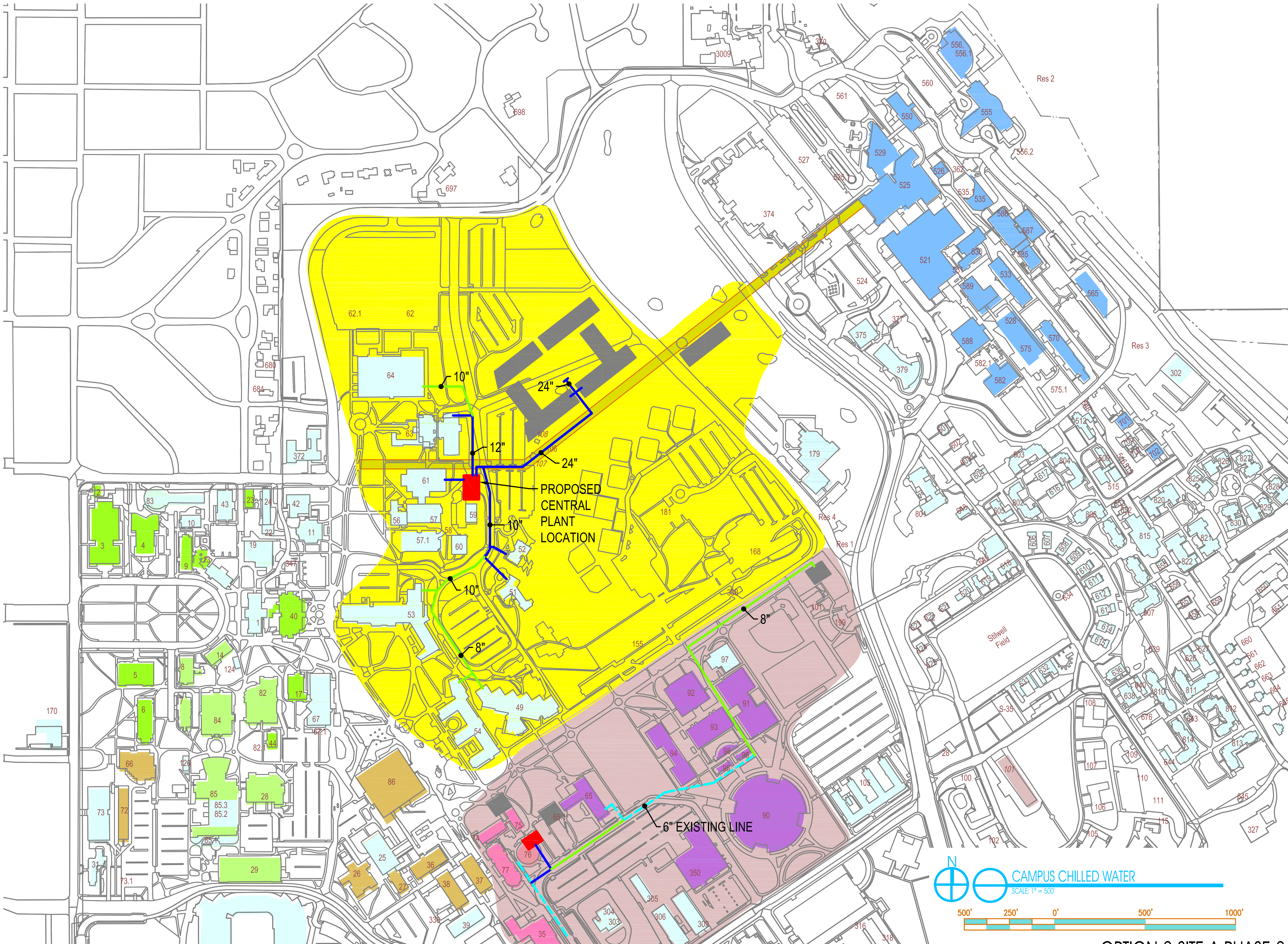
SHEET CONTENTS

CAMPUS CHILLED WATER OPTION 2 SITE A PHASE 1

OPTION 2 SITE A PHASE 1

CHW2-A-1



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CHILLER PLANT FEASIBILITY STUDY

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CONSULTANTS

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REVISIONS

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SHEET CONTENTS
CAMPUS CHILLED WATER OPTION 2 SITE A PHASE 2

OPTION 2 SITE A PHASE 2

CHW2-A-2

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APPENDIX:

COST ESTIMATES

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 1 Sites A, B, & C

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 10,000 TONS

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
2000 ton Chiller		5	ea	$475,000	$2,375,000
Cooling Tower		10000	tons	$125	$1,250,000
New Condenser Water Pump		5	ea	$35,000	$175,000
New Primary Chilled Water Pump		5	ea	$26,000	$130,000
New Secondary Chilled Water Pumps		4	ea	$38,000	$152,000
Installation of Chiller		5	ea	$32,000	$160,000
Installation of Pumps		14	ea	$20,000	$280,000
Controls for chiller, pumps		1	lot	$230,000	$230,000
Piping for pumps and chiller		1	lot	$2,000,000	$2,000,000
Building		10000	sf	$225	$2,250,000
Fire Protection in building		10000	sf	$3	$25,000
Valves		1	lot	$350,000	$350,000
Misc. supports, pads, seismic, inslutaton, etc.		1	lot	$460,000	$460,000
Plumbing		10000	ea	$5	$50,000
Electrical for chiller and pumps		1	lot	$2,670,000	$2,670,000
Site Improvements		1	lot	$280,000	$280,000
Water Treatment		1	lot	$25,000	$25,000
Contractor mark up on equipment	15%	1	lot	$612,300	$612,300
Sub total					**$13,474,300**
Piping		**1**	**lot**		**$0**
Sub total					**$13,474,300**
Contingency	**5%**				**$673,715**
Sub total					**$14,148,015**
General Contractors Fees	**4%**				**$565,921**
Sub total					**$14,713,936**
Escalation to be added beyond Aug. 2007		**0%**			**$14,713,936**
Sub total					
Engineering	**7%**				**$1,029,975**
Total					**$15,743,911**

Cost of Mech.	$8,609,265
Cost per ton:	$861
Cost per ton:	$1,574.39

file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2 Sites A & B

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 7,000 TONS

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
2000 ton Chiller		2	ea	$475,000	$950,000
1500 ton Chiller		2	ea	$367,500	$735,000
Cooling Tower		7000	tons	$125	$875,000
New Condenser Water Pump		4	ea	$35,000	$140,000
New Primary Chilled Water Pump		4	ea	$26,000	$104,000
New Secondary Chilled Water Pumps		4	ea	$38,000	$152,000
Installation of Chiller		4	ea	$32,000	$128,000
Installation of Pumps		12	ea	$20,000	$240,000
Controls for chiller, pumps		1	lot	$185,000	$185,000
Piping for pumps and chiller		1	lot	$1,550,000	$1,550,000
Building, including HVAC & Electrical		7200	sf	$225	$1,620,000
Fire Protection in building		7200	sf	$3	$18,000
Valves		1	lot	$280,000	$280,000
Misc. supports, pads, seismic, inslation, etc.		1	lot	$390,000	$390,000
Plumbing		7200	sf	$5	$36,000
Electrical for chiller and pumps		1	lot	$1,686,825	$1,686,825
Site Improvements		1	lot	$240,000	$240,000
Water Treatment		1	lot	$25,000	$25,000
Contractor mark up on equipment	15%	1	lot	$333,150	$333,150
Sub total					**$9,687,975**
Piping		**1**	**lot**	**0**	$0
Sub total					**$9,687,975**
Contingency	**5%**				**$484,399**
Sub total					**$10,172,374**
General Contractors Fees	**4%**				**$406,895**
Sub total					**$10,579,269**
Escalation to be added beyond Aug. 2007		**0%**			**$10,579,269**
Sub total					
Engineering	**7%**				**$740,549**
Total					**$11,319,818**

Cost of Mech.	$5,619,786
Cost per ton mech.	$803
Cost per ton total:	$1,617.12

file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2 Site B

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 7,000 TONS

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
2000 ton Chiller		2	ea	$475,000	$950,000
1500 ton Chiller		2	ea	$367,500	$735,000
Cooling Tower		7000	tons	$125	$875,000
New Condenser Water Pump		4	ea	$35,000	$140,000
New Primary Chilled Water Pump		4	ea	$26,000	$104,000
New Secondary Chilled Water Pumps		4	ea	$38,000	$152,000
Installation of Chiller		4	ea	$32,000	$128,000
Installation of Pumps		12	ea	$20,000	$240,000
Controls for chiller, pumps		1	lot	$185,000	$185,000
Piping for pumps and chiller		1	lot	$1,550,000	$1,550,000
Building, including HVAC & Electrical		7200	sf	$225	$1,620,000
Fire Protection in building		7200	sf	$3	$18,000
Valves		1	lot	$280,000	$280,000
Misc. supports, pads, seismic, inslation, etc.		1	lot	$390,000	$390,000
Plumbing		7200	sf	$5	$36,000
Electrical for chiller and pumps		1	lot	$1,686,825	$1,686,825
Site Improvements		1	lot	$240,000	$240,000
Water Treatment		1	lot	$25,000	$25,000
Contractor mark up on equipment	15%	1	lot	$333,150	$333,150
Sub total					**$9,687,975**
Piping		**1**	**lot**	**0**	$0
Sub total					**$9,687,975**
Contingency	**5%**				**$484,399**
Sub total					**$10,172,374**
General Contractors Fees	**4%**				**$406,895**
Sub total					**$10,579,269**
Escalation to be added beyond Aug. 2007		**0%**			**$10,579,269**
Sub total					
Engineering	**7%**				**$740,549**
Total					**$11,319,818**

Cost of Mech.	Mech.	$5,619,786
Cost per ton:	Mech.	$803
Cost per ton:		$1,617.12

file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 960 TONS

Plant to be in Eccles School of Business

Cost Estimate

ITEM		Quantity	Unit	Unit Cost	Total
320 ton Chiller, relocate from Warnock Building		2	ea	$10,000	$20,000
320 ton Chiller		1	ea	$66,000	$66,000
Cooling Tower		960	tons	$125	$120,000
Relocated Condenser Water Pumps from Warnock Building		2	ea	$3,000	$6,000
New Condenser Water Pump		1	ea	$12,000	$12,000
New Primary Chilled Water Pump		3	ea	$10,000	$30,000
New Secondary Chilled Water Pumps		2	ea	$22,000	$44,000
Installation of Chiller		3	ea	$12,000	$36,000
Installation of Pumps		6	ea	$8,000	$48,000
Controls for chiller, pumps		1	lot	$50,000	$50,000
Piping for pumps and chiller		1	lot	$325,000	$325,000
Building, including HVAC & Electrical		2000	sf	$225	$450,000
Fire Protection in building		2000	sf	$3	$5,000
Valves		1	lot	$45,000	$45,000
Misc. supports, pads, seismic, insulation, etc.		1	lot	$50,000	$50,000
Plumbing		2000	sf	$5	$10,000
Electrical for chiller and pumps		1	lot	$350,000	$350,000
Site Improvements		0	lot	$180,000	$0
Water Treatment		1	lot	$10,000	$10,000
Contractor mark up on equipment	15%	1	lot	$33,000	$33,000
Sub total					**$1,710,000**
Piping		**1**	**lot**	**0**	**$0**
Sub total					**$1,710,000**
Contingency, Design	**5%**				**$85,500**
Sub total					**$1,795,500**
General Contractors Fees	**4%**				**$71,820**
Sub total					**$1,867,320**
Escalation to be added beyond Aug. 2007		**0%**			**$1,867,320**
Sub total					
Engineering	**7%**				**$130,712**
Total					**$1,998,032**

Cost of Mech. Mech.	$857,878
Cost per ton mech.	$894
Cost per ton total:	$2,081.28

Cost saving to Eccles Business School Project: The cost of two chillers at $220/ton x 640 ton = $140,800.00 plus two pumps at $24,000.00 , less cost of relocation estimated at $26,000.00. Net savings: $138,800.00, Phase 1.
One new chiller however is recommended to be added at a cost of $66,000.00
Net savings after Phase 2 would be $138,800-$66,000 = $72,800.00
file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2 Phase I

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 3,000 TONS

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
1500 ton Chiller		2	ea	$367,500	$735,000
Cooling Tower		3000	tons	$125	$375,000
New Condenser Water Pump		2	ea	$35,000	$70,000
New Primary Chilled Water Pump		2	ea	$26,000	$52,000
New Secondary Chilled Water Pumps		2	ea	$38,000	$76,000
Installation of Chiller		2	ea	$32,000	$64,000
Installation of Pumps		6	ea	$20,000	$120,000
Controls for chiller, pumps		1	lot	$100,000	$100,000
Piping for pumps and chiller		1	lot	$725,000	$725,000
Building, including HVAC & Electrical		5200	sf	$225	$1,170,000
Fire Protection in building		5200	sf	$3	$13,000
Valves		1	lot	$180,000	$180,000
Misc. supports, pads, seismic, insulation, etc.		1	lot	$195,000	$195,000
Plumbing		5200	sf	$5	$26,000
Electrical for chiller and pumps		1	lot	$1,095,000	$1,095,000
Site Improvements		1	lot	$180,000	$180,000
Water Treatment		1	lot	$20,000	$20,000
Contractor mark up on equipment	15%	1	lot	$196,200	$196,200
Sub total					**$5,392,200**
Piping		**1**	**lot**	**0**	**$0**
Sub total					**$5,392,200**
Contingency, Design	**5%**				**$269,610**
Sub total					**$5,661,810**
General Contractors Fees	**4%**				**$226,472**
Sub total					**$5,888,282**
Escalation to be added beyond Aug. 2007		**0%**			**$5,888,282**
Sub total					
Engineering	**7%**				**$412,180**
Total					**$6,300,462**

Cost of Mech.	Mech.	$3,053,638
Cost per ton:	Mech.	$1,018
Cost per ton:		$2,100.15

file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2 Phase I

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 640 TONS

Plant to be in Eccles School of Business

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
320 ton Chiller, relocate from Warnock Building		2	ea	$10,000	$20,000
Cooling Tower		640	tons	$125	$80,000
Relocated Condenser Water Pumps from Warnock Building		2	ea	$3,000	$6,000
New Condenser Water Pump		1	ea	$12,000	$12,000
New Primary Chilled Water Pump		3	ea	$10,000	$30,000
New Secondary Chilled Water Pumps		2	ea	$22,000	$44,000
Installation of Chiller		3	ea	$12,000	$36,000
Installation of Pumps		6	ea	$8,000	$48,000
Controls for chiller, pumps		1	lot	$50,000	$50,000
Piping for pumps and chiller		1	lot	$325,000	$325,000
Building, including HVAC & Electrical		2000	sf	$225	$450,000
Fire Protection in building		2000	sf	$3	$5,000
Valves		1	lot	$45,000	$45,000
Misc. supports, pads, seismic, insulation, etc.		1	lot	$50,000	$50,000
Plumbing		2000	sf	$5	$10,000
Electrical for chiller and pumps		1	lot	$350,000	$350,000
Site Improvements		0	lot	$180,000	$0
Water Treatment		1	lot	$10,000	$10,000
Contractor mark up on equipment	15%	1	lot	$27,000	$27,000
Sub total					**$1,598,000**
Piping		**1**	**lot**	**0**	**$0**
Sub total					**$1,598,000**
Contingency, Design	**5%**				**$79,900**
Sub total					**$1,677,900**
General Contractors Fees	**4%**				**$67,116**
Sub total					**$1,745,016**
Escalation to be added beyond Aug. 2007		**0%**			**$1,745,016**
Sub total					
Engineering	**7%**				**$122,151**
Total					**$1,867,167**

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
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Option 2 Phase 2

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 4,000 TONS

Cost Estimate

ITEM		Quantity	Unit	Unit Cost	Total
2000 ton Chiller		2	ea	$475,000	$950,000
Cooling Tower		4000	tons	$125	$500,000
New Condenser Water Pump		2	ea	$35,000	$70,000
New Primary Chilled Water Pump		2	ea	$26,000	$52,000
New Secondary Chilled Water Pumps		2	ea	$38,000	$76,000
Installation of Chiller		2	ea	$32,000	$64,000
Installation of Pumps		6	ea	$20,000	$120,000
Controls for chiller, pumps		1	lot	$120,000	$120,000
Piping for pumps and chiller		1	lot	$970,000	$970,000
Building, including HVAC & Electrical		2800	sf	$225	$630,000
Fire Protection in building		2800	sf	$3	$7,000
Valves		1	lot	$180,000	$180,000
Misc. supports, pads, seismic, insulation, etc.		1	lot	$220,000	$220,000
Plumbing		2800	sf	$5	$14,000
Electrical for chiller and pumps		1	lot	$1,460,000	$1,460,000
Site Improvements		1	lot	$13,000	$13,000
Water Treatment		1	lot	$20,000	$20,000
Contractor mark up on equipment	15%	1	lot	$247,200	$247,200
Sub total					**$5,713,200**
Piping		**1**	**lot**	**0**	**$0**
Sub total					**$5,713,200**
Contingency, Design	**5%**				**$285,660**
Sub total					**$5,998,860**
General Contractors Fees	**4%**				**$239,954**
Sub total					**$6,238,814**
Escalation to be added beyond Aug. 2007		**0%**			**$6,238,814**
Sub total					
Engineering	**7%**				**$436,717**
Total					**$6,675,531**

Cost of Mech.	$3,768,688
Cost per ton mech.	$942
Cost per ton total:	$1,668.88

file: n:/7000/7300/7318/UU Golf Course chiller Plant Cost Estimate 1

19-Sep-07

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Option 2 Phase 2

Project: **Golf Course Chiller Water Plant, University of Utah**
Subject: **Cost Estimate**

NEW CHILLED WATER PLANT, 320 TONS

Plant to be in Eccles School of Business

Cost Estimate					
ITEM		**Quantity**	**Unit**	**Unit Cost**	**Total**
320 ton Chiller, relocate from Warnock Building		1	ea	$66,000	$66,000
Cooling Tower		320	tons	$125	$40,000
New Condenser Water Pump		1	ea	$12,000	$12,000
New Primary Chilled Water Pump		1	ea	$10,000	$10,000
New Secondary Chilled Water Pumps		1	ea	$22,000	$22,000
Installation of Chiller		1	ea	$12,000	$12,000
Installation of Pumps		3	ea	$8,000	$24,000
Controls for chiller, pumps		1	lot	$20,000	$20,000
Piping for pumps and chiller		1	lot	$45,000	$45,000
Valves		1	lot	$45,000	$45,000
Misc. supports, pads, seismic, insulation, etc.		1	lot	$10,000	$10,000
Electrical for chiller and pumps		1	lot	$35,000	$35,000
Contractor mark up on equipment	15%	1	lot	$22,500	$22,500
Sub total					**$363,500**
Piping		**1**	**lot**	**0**	**$0**
Sub total					**$363,500**
Contingency, Design	**5%**				**$18,175**
Sub total					**$381,675**
General Contractors Fees	**4%**				**$15,267**
Sub total					**$396,942**
Escalation to be added beyond Aug. 2007		**0%**			**$396,942**
Sub total					
Engineering	**7%**				**$27,786**
Total					**$424,728**

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File: N:/7000/7300/7318/Cost Estimates
Project: UU Central Campus Chilled Water Plant Feasbility Study
Subject: Cost Estimates

Option No. 1 Site A

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot $**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
30"	100	100	550	100	18	6.5	$121,700
24"	1600	1600	285	1600	16	6.5	$1,078,400
20"	550	550	255	550	14	6.5	$330,550
18"	600	600	208	600	12	6.5	$296,400
16"					12	6.5	$0
12"	2300	2300	110	2300	11	6.5	$670,450
10"	700	700	98	700	10.5	6.5	$184,975
8"	900	900	74	900	10	6.5	$191,700
6"	550	550	64	550	9	6.5	$102,575
5"	500	500	60	500	8	6.5	$86,000
4"	250	250	57	250	7	6.5	$39,875
							$3,102,625
Valve Boxes	8	60000					$480,000
Sub total Cost:							**$3,582,625**
Contingency:	**10%**						**$358,263**
Total Cost:							**$3,940,888**

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File: N:/7000/7300/7318/Cost Estimates
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Option No. 1 Site B

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot $**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
30"	0	0	550	0	18	6.5	$0
24"	2000	2000	285	2000	16	6.5	$1,348,000
20"	550	550	255	550	14	6.5	$330,550
18"	600	600	208	600	12	6.5	$296,400
16"					12	6.5	$0
12"	2000	2000	110	2000	11	6.5	$583,000
10"	300	300	98	300	10.5	6.5	$79,275
8"	1600	1600	74	1600	10	6.5	$340,800
6"	550	550	64	550	9	6.5	$102,575
5"	500	500	60	500	8	6.5	$86,000
4"	250	250	57	250	7	6.5	$39,875
							$3,206,475
Valve Boxes	8	60000					$480,000
Sub total Cost:							**$3,686,475**
Contingency:	**10%**						**$368,648**
Total Cost:							**$4,055,123**

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Project: UU Central Campus Chilled Water Plant Feasbility Study
Subject: Cost Estimates

Option No. 1 Site C

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
30"	0	0	550	0	18	4	$0
24"	2600	2600	285	2600	16	4	$1,648,400
20"	550	550	255	550	14	4	$311,300
18"	600	600	208	600	12	4	$278,400
16"	0	0		0	12	4	$0
12"	2000	2000	110	2000	11	4	$528,000
10"	800	800	98	800	10.5	4	$190,400
8"	1600	1600	74	1600	10	4	$300,800
6"	550	550	64	550	9	4	$90,200
5"	500	500	60	500	8	4	$76,000
4"	250	250	57	250	7	4	$35,500
				9450			$3,459,000
Valve Boxes	**8**	**$60,000**					**$480,000**
Sub total Cost:							**$3,939,000**
Contingency:	**10%**						**$393,900**
Total Cost:							**$4,332,900**

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File: N:/7000/7300/7318/Cost Estimates
Project: UU Central Campus Chilled Water Plant Feasbility Study
Subject: Cost Estimates

Option No. 2 7000 Ton Plant, Site A

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
24"	1300	1300	285	1300	16	6.5	$876,200
12"	300	300	110	300	11	6.5	$87,450
10"	1200	1200	98	1200	10.5	6.5	$317,100
8"	3450	3450	74	3450	10	6.5	$734,850
6"	300	300	64	300	9	6.5	$55,950
5"	150	150	60	500	8	6.5	$44,000
3"	350	350	40	350	4	6.5	$37,100
				7050			$2,152,650
Valve Boxes	**4**	**$60,000**					**$240,000**
Sub total Cost:							**$2,392,650**
Contingency:	**10%**						**$239,265**
Total Cost:							**$2,631,915**

Option 2 7000 Ton Plant, Site B

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
24"	700	700	285	700	16	6.5	$471,800
16"	150	150	177	150	12		$53,100
12"	400	400	110	400	11	6.5	$116,600
10"	900	900	98	900	10.5		$176,400
8"	3200	3200	74	3200	10	6.5	$681,600
							$1,499,500
Branches:							
Bldg. 64: 10"	300	300	74	300	10	6.5	$63,900
Bldg. : 8"	200	200	74	200	10	6.5	$42,600
Bldg. 56,57: 4"	400	400	54	400	6	6.5	$58,800
Bldg. 51: 3"	150	150	40	150	4	6.5	$15,900
Bldg. 52: 3"	200	200	40	200	4	6.5	$21,200
Bldg. 53 : 6"	500	500	62	500	8	6.5	$88,000
Bldg. 54: 8"	400	400	74	400	10	6.5	$85,200
Bldg. 49: 6"	100	100	62	100	8	6.5	$17,600
Sub Total Branch:							$393,200
				7600			
Valve Boxes	**4**	**$60,000**					**$240,000**
Sub total Cost:							**$2,132,700**
Contingency:	**10%**						**$213,270**
Total Cost:							**$2,345,970**

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Project: UU Central Campus Chilled Water Plant Feasbility Study
Subject: Cost Estimates

Option No. 2 **Phase 1, Site A**

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
24"	1000	1000	285	1000	16	6.5	$674,000
12"	300	300	110	300	11	6.5	$87,450
10"	600	600	98	300	10.5	6.5	$138,075
Bldg. 51: 3"	150	150	40	150	4	6.5	$15,900
Bldg. 52: 3"	200	200	40	200	4	6.5	$21,200
Bldg. 61 5"	150	150	60	150	8	6.5	$25,800
Bldg. : 8"	200	200	74	200	10	6.5	$42,600
							$1,005,025
Valve Boxes	**2**	**$60,000**					**$120,000**
Sub total Cost:							**$1,125,025**
Contingency:	**10%**						**$112,503**
Total Cost:							**$1,237,528**

Option No. 2 **Phase 1, Site B**

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
24"	700	700	285	700	16	6.5	$471,800
16"	150	150	177	150	12	6.5	$64,800
12"	400	400	110	400	11	6.5	$116,600
8"	300	300	74	300	10	6.5	$63,900
Sub Total Mains:							$717,100
Valve Boxes	**1**	**$60,000**					**$60,000**
Sub total Cost:							**$777,100**
Contingency:	**10%**						**$77,710**
Total Cost:							**$854,810**

VAN BOERUM & FRANK ASSOCIATES INC. CONSULTING ENGINEERS

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Project: UU Central Campus Chilled Water Plant Feasbility Study
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Option No. 2 **Phase 2, Site A, 7000 Ton Plant**

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
24"	300	300	285	300	16	6.5	$202,200
10"	900	900	98	900	10.5	6.5	$237,825
8"	800	800	74	800	10	6.5	$170,400
Bldg. 49: 6"	100	100	62	100	4	6.5	$15,000
Bldg. 53: 6"	200	200	62	200	4	6.5	$30,000
Bldg. 54 8"	200	200	74	200	8	6.5	$40,000
Bldg. : 8"	200	200	74	200	10	6.5	$42,600
							$738,025
Valve Boxes	**2**	**$60,000**					**$120,000**
Sub total Cost:							**$858,025**
Contingency:	**10%**						**$85,803**
Total Cost:							**$943,828**

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File: N:/7000/7300/7318/Cost Estimates
Project: UU Central Campus Chilled Water Plant Feasbility Study
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Option No. 2 Phase 1, Link between Business ,Fine Arts and HPER Loop

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
8"	250	250	74	250 250	10	6.5	53250 53250
Valve Boxes	**1**	**$60,000**					**$60,000**
Sub total Cost:							**$113,250**
Contingency:	**10%**						**$11,325**
Total Cost:							**$124,575**

This cost will eliminate a chiller plant in the Student Life Center of 525 tons at an estimated cost of $1800.00 per ton, $945,000.00, which cost inlcudes the chiller plant and the space it takes to locate it in a building.
This piping cost proposes a new chilled water plant in the Eccles School of Business which would b tied to loop between Fine Arts and HPER. This plant would support the Business Building and it would be sized large enough to support the expansion of Milton Bennion Hall and would provide some back up to the HPER plant through the existing connection. The excess capacity now going to Milton Bennion Hall would be diverted to the new Student Life Building. The first Phase would include only the new link between Business and Fine Arts

Option No. 2 Phase 2, Pipe to Student Life Center, Pipe between ESB and Milton Bennion

PIPE COST ESTIMATE							
Pipe Size	**CWS feet**	**CWR feet**	**Cost per foot**	**Trench Length**	**Trench Width feet**	**Surface Repair $/sf**	**Installed Cost**
8"	2000	2000	74	2000 2000	10	6.5	426000 426000
Valve Boxes	**1**	**$60,000**					**$60,000**
Sub total Cost:							**$486,000**
Contingency:	**10%**						**$48,600**
Total Cost:							**$534,600**

VAN BOERUM & FRANK ASSOCIATES INC.
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COST ESTIMATE FOR REPLACING EXISTING CHILLERS				
	Tons	Replacement Cost Per Ton		Total
Air Cooled Chillers	235	$600		$141,000
Water Cooled Chillers				
Chillers, Towers	2235	$650		$1,452,750
Code Upgrades	2235	$75		$167,625
Total:				**$1,761,375**

TABLE 10

APPENDIX:

OPERATION AND MAINTENANCE COSTS

VAN BOERUM & FRANK ASSOCIATES INC. CONSULTING ENGINEERS

OPERATING AND MAINTENANCE COSTS
FOR CHILLERS DISTRIBUTED IN EXISTING BUILDINGS
Exisiting Conditions

EXISTING DISTRIBUTED CHILLERS

CHILLERS	CAPACITY TONS	Average Load %	Annual Operating Hours	Full Load] Efficiency kw/ton	Estimated Annual Cooling (ton-hrs)	Annual Electric Consumption (kw-hrs)
Language	300	0.7	1800	0.47	378,000	177,660
Language	40	0.9	1800	0.83	64,800	53,784
Sill Center	60	0.75	1800	1.2	81,000	97,200
Alumni House	70	0.75	1800	1.2	94,500	113,400
Orson Spencer Hall	415	0.65	1800	0.47	485,550	228,209
Energy Mines	105	0.65	1800	1.2	122,850	147,420
Warnock	640	0.7	1800	0.49	806,400	395,136
Merrill Engineering Building	350	0.8	1800	0.5	504,000	252,000
Merrill Engineering Building	50	0.8	1800	1	72,000	72,000
Merrill Engineering Building	290	0.8	1800	0.51	417,600	212,976
Chiller Totals:	2,320				3,026,700	1,749,785

PUMPS	Flow GPM	Estimated Head (ft)	Annual Operating Hours	Pump Efficiency (%)	Motor Efficiency (%)	Annual Electric Consumption (kw-hrs)
Chiller Water	6960	75	1800	0.75	0.88	117,137
Condenser Water	6960	85	1800	0.78	0.88	138,065
Pump Totals:						255,202

COOLING TOWERS	Capacity Tons	Estimated Motor Size hp	Annual Operating Hours		Motor Efficiency (%)	Annual Electric Consumption (kw-hrs)
Cooling Tower Fans	2,320	150	1800		0.88	177,725
Tower Totals:						177,725

ELECTRICAL COSTS:				
Chillers:	1,749,785 kwh/yr		0.048 $/kwh	$83,990
Pumps:	255,202 kwh/yr		0.048 $/kwh	$12,250
Towers:	177,725 kwh/yr		0.048 $/kwh	$8,531
Sub Total:				**$104,770**
			Cost/ton/yr	$45.16
MAINTENANCE COSTS:				
U of U Personnel		1.25 man-years	$60,000 per year	$75,000
Vendor Maintenance		2,320 tons	$22.50 per ton/year	$52,200
Sub Total:				**$127,200**
			Cost/ton/yr	$54.83
Existing Distributed Chiller Annual O. & M. Costs:				**$231,970**
			Cost/ton/yr	$99.99

Estimated cost per year for the 6178 tons of new decentralized chillers: **6178 tons** **$617,720**

TABLE 6

VAN BOERUM & FRANK ASSOCIATES INC. CONSULTING ENGINEERS

OPERATING AND MAINTENANCE COSTS
FOR CHILLERS IN A NEW CENTRAL PLANT

PROPOSED NEW CENTRAL CHILLED WATER PLANT

CHILLERS	CAPACITY TONS	Average Load %	Annual Operating Hours	Part Load] Efficiency kw/ton	Estimated Annual Cooling (ton-hrs)	Annual Electric Consumption (kw-hrs)
New Chiller	2000	0.43	1800	0.4	1,548,000	619200
New Chiller	2000	0.41	1800	0.4	1,476,000	590400

Chiller Totals:	4,000				3,024,000	1,209,600
Tons Used:	2320					

PUMPS	Flow GPM	Estimated Head (ft)	Annual Operating Hours	Pump Efficiency (%)	Motor Efficiency (%)	Annual Electric Consumption (kw-hrs)
Chiller Water, Primary, CP	4640	30	1800	0.82	0.92	35,704
Chiller Water, VV Secondary,CP	4640	60	1800	0.82	0.92	71,408
Condenser Water, Central Plant	6960	85	1800	0.82	0.92	151,743
Building Chiller Water Pumps	6960	55	1800	0.75	0.88	85,900

Pump Totals: 425,091

COOLING TOWERS	Capacity Tons	Estimated Motor Size hp	Annual Operating Hours		Motor Efficiency (%)	Annual Electric Consumption (kw-hrs)
Cooling Tower Fans	2,320	120	1800		0.92	148,643

Tower Totals: 148,643

ELECTRICAL COSTS:			
Chillers:	1,209,600 kwh/yr	0.048 $/kwh	$58,061
Pumps:	425,091 kwh/yr	0.048 $/kwh	$20,404
Towers:	148,643 kwh/yr	0.048 $/kwh	$7,135
Sub Total:			**$85,600**
MAINTENANCE COSTS:			
U of U Personnel	0.25 man-years	$60,000 per year	$15,000
Vendor Maintenance	2,320 tons	$6.50 per ton/year	$15,080
Sub Total:			**$30,080**
Central Chiller Plant Annual O. & M. Costs:			**$115,680**
		Cost/ton/yr.	$49.86
Estimated cost per year for the new 6178 tons in a central plant:		**6178 tons**	**$308,048**

TABLE 7

ASSUMPTIONS MADE IN CALCULATING OPERATING AND MAINTENANCE COSTS OF A CENTRAL CHILLER PLANT AND OF CHILLERS IN THE INIDVIUAL BUILDINGS

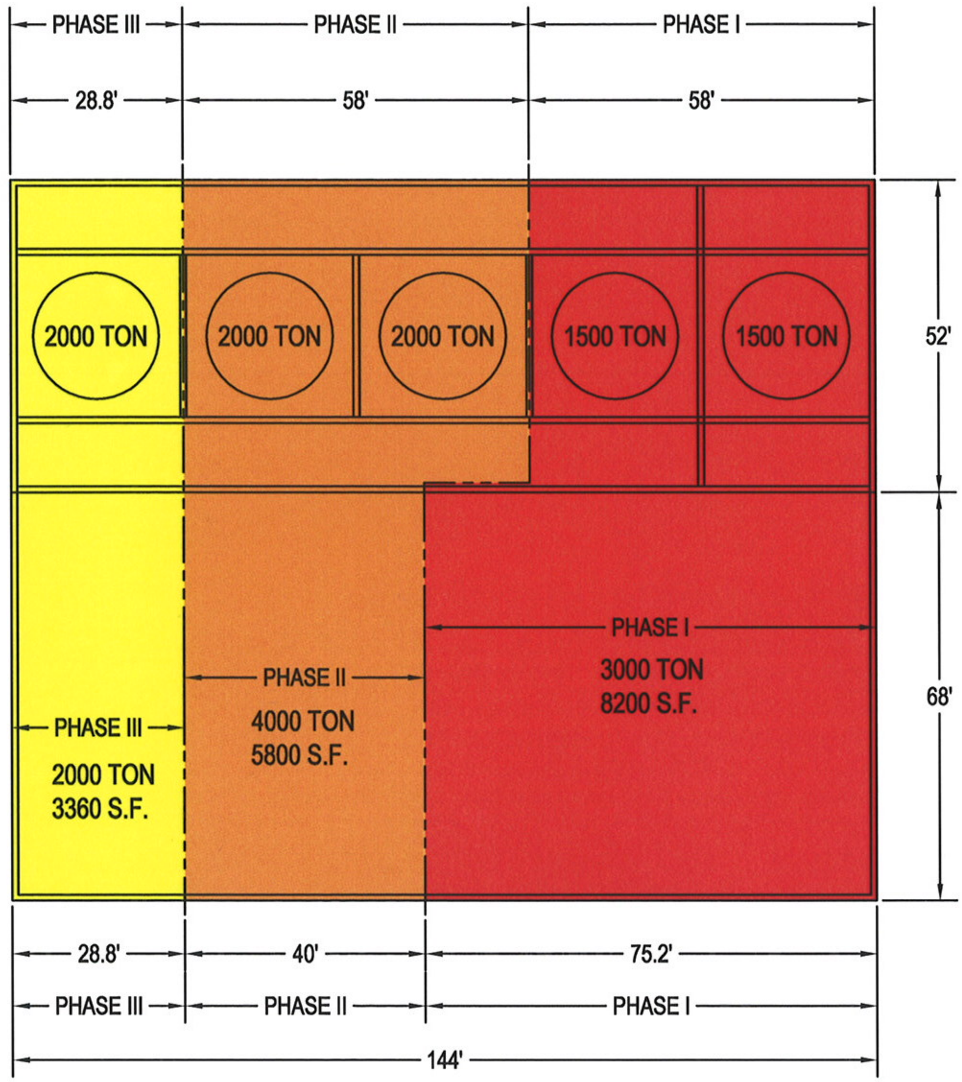
1. The cost of electricity including demand charge is $0.048 per kwh.
2. Approximate existing chiller run-times were estimated.
3. Existing chiller average load as a percentage of full load was estimated from previous operating logs furnished by the University.
4. Existing chiller full load kw was provided by university personnel.
5. Pump head and flows were estimated based on previous reports.
6. Condenser and chiller pump operating hours are equal to chiller operating hours.
7. Pump efficiencies were estimated from catalog date on similar pumps.
8. Existing motor efficiencies were estimated from ASHRAE HVAC Systems and Equipment 2004, Chapter 40. New high efficient motors were estimated for the new plant.
9. Chiller kwh = chiller capacity in tons x average fraction loading x annual operating hours x full load operating efficiency in kw/ton.
10. Pump kwh = [pump GPM x pump head in feet x annual operating hours x 0.746 kw/hp] divided by [pump efficiency x motor efficiency x 3960 GPM•feet/hp]
11. Operating hours of chillers in new central plant were estimated. The average fraction loading was calculated so that the new central plant cooling ton-hours per year are the same as the distributed (existing) cooling ton-hours per year.
12. Average distribution pump fraction loading was calculated to deliver the cooling ton-hours at a 14ºF difference between return and supply.
13. Maintenance costs were provided by the University for two years for the chillers in the study. Costs included hours spent and materials purchased. Costs were reduced to costs/ton/year and for time equivalent hours per year.
14. The central plant chillers were assumed to be 10% more efficient than new distributed chillers because they operated nearer peak efficiencies.
15. U of U personnel savings were estimated to be 1/2 man-years
16. Material maintenance savings were calculated as the difference between the distributed chiller cost per ton and the central plant. This difference is $16.00 per ton annually.

TABLE 8

APPENDIX:

CENTRAL PLANT PROPOSAL DRAWING, M-1

3,000 TON PLANT - 8200 S.F.
7,000 TON PLANT - 14,000 S.F.
9,000 TON PLANT - 17,360 S.F.



PROPOSED PHASED CHILLER WATER PLANT

SCALE: 1/32"=1'-0"

VAN BOERUM
& FRANK
ASSOCIATES INC.
CONSULTING ENGINEERS
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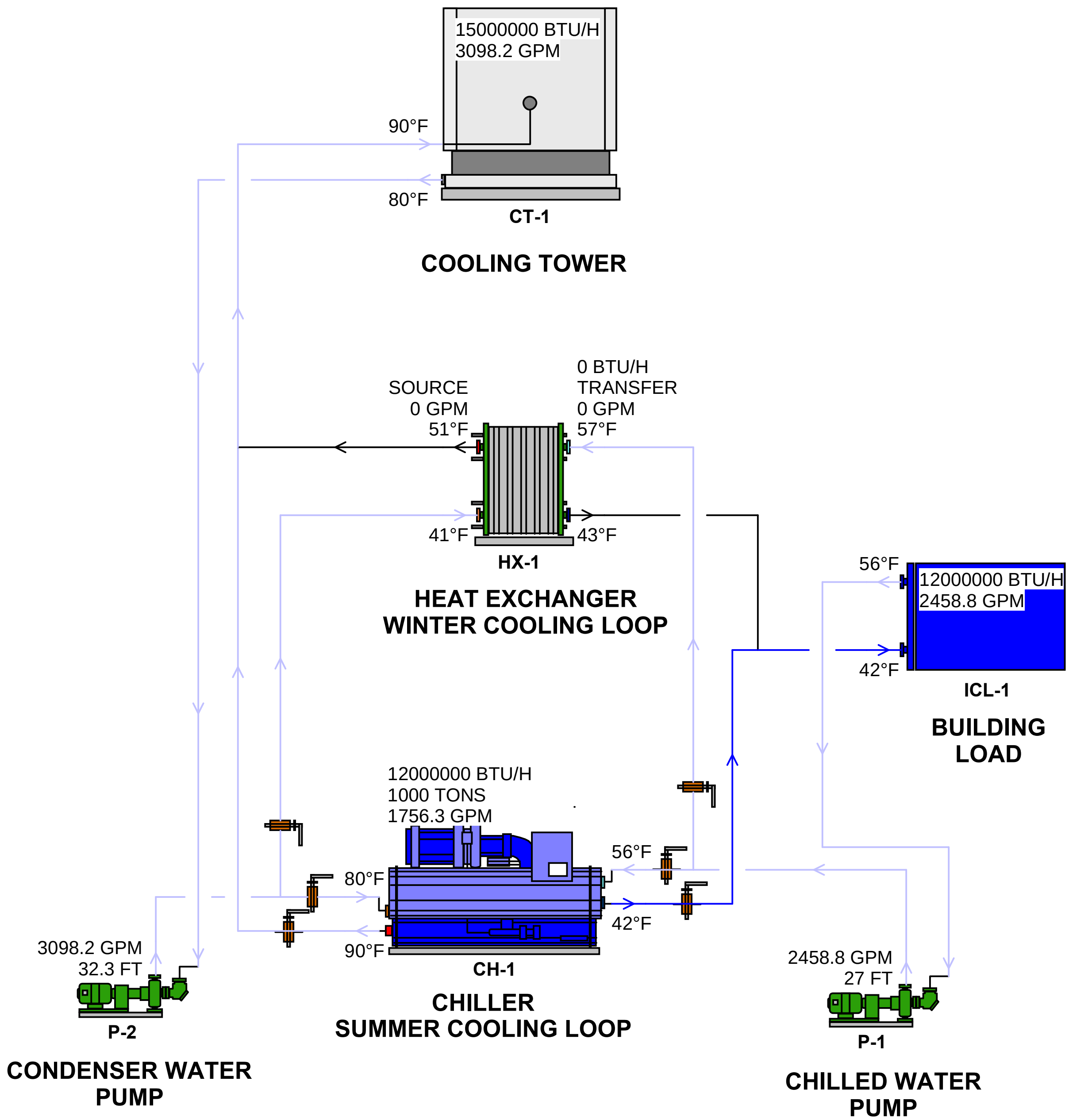
330 South 300 East 801.530.3148 T
Salt Lake City, UT 84111 801.530.3150 F

M-1

APPENDIX:

WATER SIDE ECONOMIZER DRAWING, M-2



WATER SIDE ECONOMIZER SCHEMATIC

APPENDIX:

DIVERSITY

VAN BOERUM & FRANK ASSOCIATES INC.
CONSULTING ENGINEERS

Aug. 2, 2007

File: N:\07\07300\07318 chiller plant feasibility stury\East Chiller Plant Performance
Project: Chilled Water Plant Feasibility Study 7318
Subject: East Campus Chiller Water Plant Performance

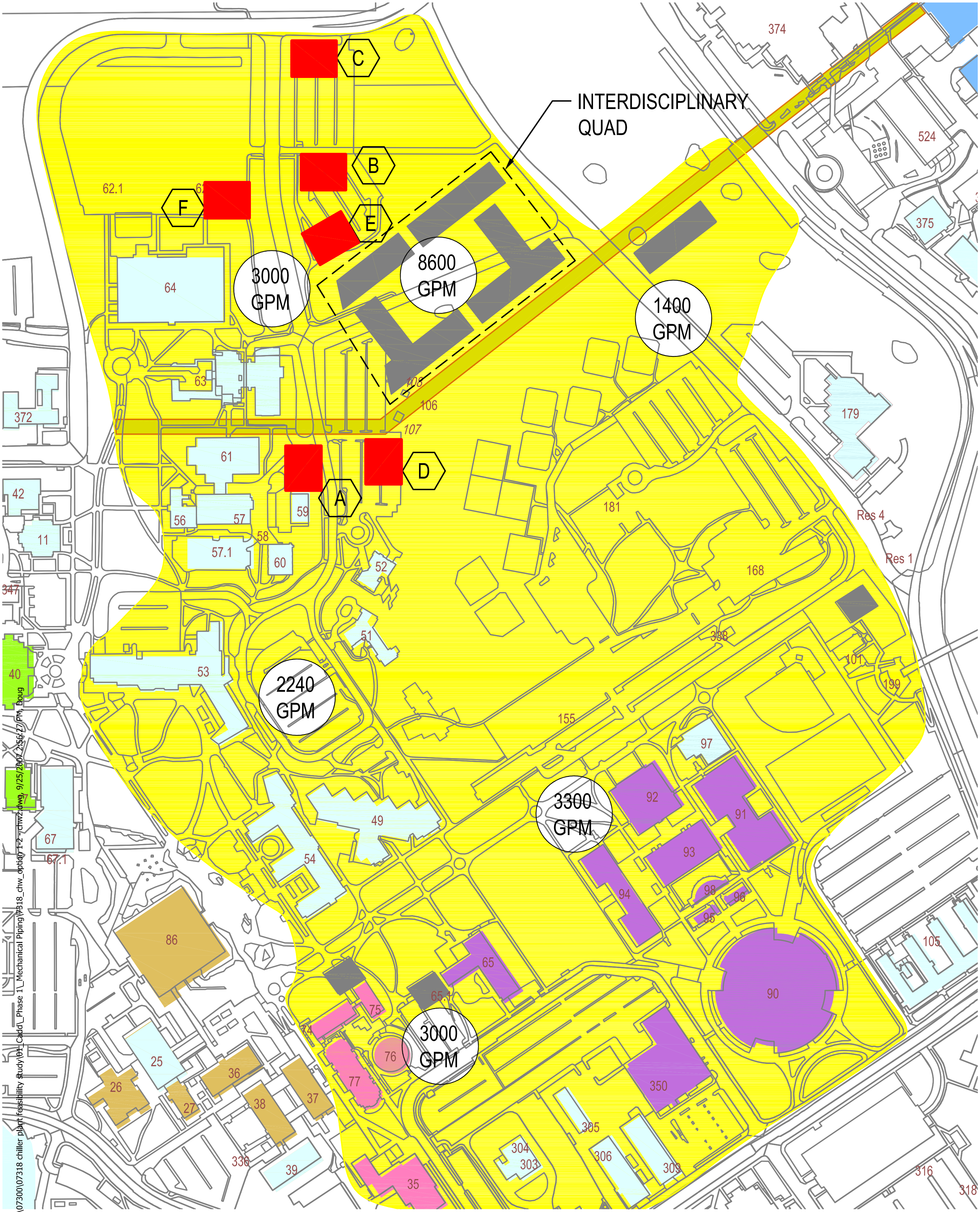
TIME: 3:00PM
Load percentage attributed to outside air temperatures: 55%
Connected Tons: 8443
Tons Available: 8000

CHILLER PLANT PERFORMANCE TABLE

Date	O.A. Temp. ° F	CWS Temp. ° F	CWR Temp. ° F	GPM	Δ T ° F	Delivered Load Tons	Temperature Adjusted Connected Tons	Connected Load Tons	Calculated Plant Diversity	Excess Tons Available
9-Jul	98.535	41.406	50.375	14048	8.969	5,250	8,613	8,443	60.95%	2,750
10-Jul	99.182	41.563	52.188	14800	10.625	6,552	8,684	8,443	75.45%	1,448
11-Jul	101.066	41.406	52.719	12320	11.313	5,807	8,893	8,443	65.31%	2,193
12-Jul	88.779	41.250	49.781	14960	8.531	5,318	7,534	8,443	70.58%	2,682
13-Jul	98.310	41.563	50.875	14752	9.312	5,724	8,588	8,443	66.65%	2,276
14-Jul	101.066	41.344	50.500	14976	9.156	5,713	8,893	8,443	64.25%	2,287
15-Jul	104.974	41.563	50.563	14280	9	5,355	9,325	8,443	57.43%	2,645
16-Jul	95.892	41.344	50.813	14088	9.469	5,558	8,320	8,443	66.80%	2,442
17-Jul	91.169	41.250	50.438	14392	9.188	5,510	7,798	8,443	70.65%	2,490
18-Jul	101.010	41.344	50.500	15392	9.156	5,872	8,886	8,443	66.08%	2,128
19-Jul	98.564	41.344	51.000	14968	9.656	6,022	8,616	8,443	69.90%	1,978
20-Jul	99.941	41.406	50.563	14880	9.157	5,677	8,768	8,443	64.75%	2,323
21-Jul	99.969	41.188	50.219	14784	9.031	5,563	8,771	8,443	63.42%	2,437
22-Jul	100.616	41.188	50.656	15160	9.468	5,981	8,843	8,443	67.63%	2,019
23-Jul	98.901	41.406	51.000	14512	9.594	5,801	8,653	8,443	67.04%	2,199
24-Jul	87.907	41.250	50.500	14952	9.25	5,763	7,438	8,443	77.48%	2,237
25-Jul	86.895	41.188	51.750	13800	10.562	6,073	7,326	8,443	82.90%	1,927
26-Jul	88.779	41.406	52.188	14448	10.782	6,491	7,534	8,443	86.15%	1,509
27-Jul	90.016	41.406	51.438	14264	10.032	5,962	7,671	8,443	77.73%	2,038
28-Jul	95.049	41.406	51.531	13424	10.125	5,663	8,227	8,443	68.83%	2,337
29-Jul	98.282	41.406	51.875	12800	10.469	5,583	8,585	8,443	65.04%	2,417
30-Jul	98.676	41.844	51.375	14472	9.531	5,747	8,628	8,443	66.61%	2,253
31-Jul	94.346	42.688	51.875	15120	9.187	5,788	8,150	8,443	71.02%	2,212
1-Aug	92.743	40.000	51.094	14728	11.094	6,808	7,972	8,443	85.40%	1,192

Average: **72.96%** **2,279**

TABLE 9



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