Kansas State University

Chilled Water Master Plan

Manhattan, Kansas

Final

March 2013

Stanley Consultants INC.

A Stanley Group Company

Engineering, Environmental and Construction Services - Worldwide

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Executive Summary

General

This Chilled Water Master Plan investigates the chilled water system on the campus of Kansas State University (KSU) in Manhattan, Kansas. The University has selected Stanley Consultants to investigate the current campus chilled water system and provide options for growth of these systems as the campus continues to expand in size and number of students. Planning includes short term growth (through year 2017) and long term growth (through year 2025). Growth projections are described in Section 3, tabulated in Appendix A, and shown graphically on the drawings in Appendix B.

Chilled Water Capacity

As discussed in Section 2, there is currently adequate chiller capacity at the Cooling Plant to provide sufficient N+1 capacity to campus at peak cooling load. However, recent projects such as the East Stadium Welcome Center and West Stadium Theatre have added cooling loads to the Cooling Plant and now, prior to adding any additional loads, it is necessary to increase cooling capacity in order to maintain N+1 capacity.

An additional 4,000 tons of cooling is anticipated to provide for additional loads through the year 2017. A new chiller plant located near the Wind Erosion Laboratory with two 2,000 ton chillers and accommodations for two additional 2,000 ton chillers is recommended. This site was selected in coordination with KSU and the Campus Master Plan to minimize disturbances to existing and proposed campus buildings, to avoid costly customization, and to minimize the costs involved with bringing additional electrical power to the plant. Refer to the Electrical Utility Master Plan for new substation location and associated electrical project costs.

The estimated cost includes a chiller plant with two 2,000 ton chillers and space for two future chillers. Buried 24” CHW piping from the plant to the existing north loop piping is included. Excluded are electrical utility costs. Refer to Electrical Utility Master Plan.

New 4,000 ton Chiller Plant near Wind Erosion Laboratory: $15.3 million

Cross-connection (Chem-Biochem with North Loop)

It is recommended that cross-connections be added between the different loops in the chilled water system. Each will add needed redundancy to the system, help to ensure a reliable chilled water supply, and improve operational flexibility to isolate sections of the system without compromising delivery to the rest of the loop. Suggested routings and sizes for these proposed cross-connections are shown on the drawings provided in Appendix B.

The cross-connection between the Chem-Biochem Loop and the North Loop is proposed to run from the corner of Claflin Road and Mid-Campus Drive to the chem-biochem loop near Shellenberger Hall. Parts of the existing Chem-Biochem loop piping are undersized (less than 18" diameter) for the proposed cross-connection, and will need to be replaced. This work should be coordinated with the installation of the new CHW piping for the new plant.

Cross-connect Chem-Biochem with North Loop: $570,000

Current Projects

Engineering Complex Phase IV: The engineering complex buildings are currently cooled by the central plant. The expansion project should include the cost of up-sizing the CHW supply and return mains to accommodate the expansion.

College of Business Administration: A new classroom building is planned near the corner of Manhattan Ave. and Lover's Lane. The building project should include provisions for CHW cooling and the CHW supply and return mains.

East Stadium: The East Stadium Welcome Center Project is now complete and adds a cooling load of approximately 116 tons to the south loop.

West Stadium: The West Stadium Theatre Project is now complete and adds a cooling load of approximately 102 tons to the south loop.

Seaton Hall College of Architecture: Currently about half of Seaton Hall is on the CHW loop. The College of Architecture addition should include up-sizing the existing CHW piping. Approximately 109,000 square feet of space would need to be converted for CHW loop cooling. This work should be included in the current project.

Kramer Complex: Kramer, Marlatt, and Goodnow are currently on the north loop. The renovation of this complex will provide local chillers. The existing CHW piping will remain in place, but will normally be closed.

Justin Hall: An expansion is planned for Justin Hall. This building is currently cooled by the Chem-Biochem CHW loop, and the CHW supply and return lines are of sufficient size for the expansion.

Vet-Med Complex: Master plans for the new Vet-Med Complex include utilizing local chillers. With that in mind, it is not economical to provide any CHW loop piping north of Call Hall at this time. In the future, consideration should be given to utilizing those chillers (and possibly expanding capacity) as another satellite plant by connecting to the north loop.

Existing Building Conversions

Existing buildings that do not utilize the CHW loop should be considered for conversion of their existing systems and connecting to the loop. The projected loads in this study reflect future projects and adding existing buildings to the loop.

Certain buildings can be converted to central cooling without an extensive amount of modifications to the distribution piping. These building are either already connected to or near existing distribution lines. Also, buildings with local chilled water systems in place would require a minimal amount of work to convert to the loop system as compared to buildings with no cooling or with only window units.

Window units are relatively inefficient when compared to central cooling. However, buildings with only window units would require an extensive amount of work within the building to convert to chilled water. Ductwork and piping would need to be routed throughout the building. This may be considered if the building is due for a significant renovation. If KSU chooses not to convert these buildings within the timeframe of this study (2025), the projected peak cooling load is reduced by nearly the capacity of one 2,000 ton chiller.

Each building is listed in Section 4 of this report, describing their current systems and conversion costs. Cost estimates for converting existing buildings to utilize the central CHW loop are based on the buildings' occupancy types, current cooling systems (if any), and square footage. These estimates are intended to provide a high level look at what buildings should be considered for the CHW loop.

An in-depth study is recommended for each building to be considered. A building study should include a thorough investigation of the building's existing systems, detailed costs involved with converting it to CHW, and a cost-benefit analysis including possible energy savings.

Install Additional Chilled Water Capacity

In order to maintain N+1 capacity to future loads beyond the year 2018, additional chilled water production must be installed. An additional 4,000 tons of cooling is anticipated to provide for additional loads through the year 2023. This will provide adequate N+1 capacity during the time (2020) that chillers #5 and #6 would be taken out of service. If the plant was installed with space available for the new chillers, the cost is estimated to be:

Two new 2,000 ton chillers: $9.4 million

Cross-connection (Chem-Biochem with South Loop)

The cross-connection between the Chem-Biochem Loop and the South Loop includes increasing the pipe size in the tunnel below 17th Street, installing buried pipe south to Anderson Avenue, east to the Beach Art Museum, north along Butterfly Drive and Mid-campus Drive to the Chem-Biochem loop. Parts of the existing Chem-Biochem loop piping are undersized (less than 18" diameter) for the proposed cross-connection, and will need to be replaced.

Cross-connect Chem-Biochem with South Loop: $3.0 million

Replace Chiller No. 5

In order to maintain N+1 capacity to future loads beyond the year 2025, replace existing Chiller #5 in the Cooling Plant in 2023 with a chiller of equal or greater capacity (1,250 tons). As stated earlier, it is anticipated that this chiller will reach the end of its service life and be taken out of service by year 2020.

Chiller No. 5 Replacement (1,250 tons): $1.4 million

Cost Estimates

The cost estimates are consistent with a study level of detail. They are not based on a quantity takeoff from a detailed design. Actual costs may vary with the actual scope determined by the design process. Cost estimates are given in 2012 dollars representing present value and do not incorporate inflation. Cost estimates given below include margin for undeveloped design details (25%), overhead (15%), profit (10%), and construction contingencies (10%).

Existing System Considerations

Several pieces of equipment in the existing chilled water system are at or near the end of their useful service life and may require replacement within the timeframe of this study. This is summarized below.

- In the Cooling Plant, Chiller #5 will be nearing the end of its useful service life by 2020.
- In the Power Plant, Chiller #6 will be nearing the end of its useful service life by 2020.
- In the Power Plant, Chiller #7 will be nearing end of its useful service life by 2025.
- The chilled water pumps have an estimated median service life of 20 years. These may require replacement or refurbishment within the timeframe of this study and should be evaluated regularly to verify reliable operation.
- The fill and/or mechanical internals of some cooling towers may require replacement before 2025. The tower performance and internal equipment should be evaluated regularly to verify reliable operation.
- At Ackert Hall, the local chiller and cooling tower have reached the end of their useful service life and are in need of replacement. Replace these units with roof top units to provide emergency air conditioning for animals.
- Utilize the recently-installed building metering system to monitor chilled water usage for the individual buildings. Developing historical data will help identify inefficiencies in specific buildings.

Central vs. Local Cooling

Local chillers can be noisy and produce vibration, which is a concern with most of the campus buildings. Mechanical rooms and systems can be designed to minimize the amount of vibration and noise transferred to the occupied parts of the building, but there are additional costs associated with that and it can be difficult to implement on existing buildings. Additionally, KSU has expressed concern with the appearance of cooling towers on campus and the plume they can produce. Again, this can be minimized by custom designed towers or architectural structures, but at a higher cost. Refer to Appendix D for general options for cooling towers.

It is recommended that KSU continue to pursue utilizing the central chilled water loops for cooling new and existing buildings. A centrally located system is typically more efficient and provides redundancy and reliability across the entire loop. Energy and maintenance costs are also typically lower than utilizing smaller, local units. With much of the infrastructure already in place (central plant, pumps, and distribution lines), several campus buildings can be added to the CHW loop by extending branch lines from the mains to the buildings. Whether or not it is an economical decision primarily depends on the distance from the mains and the current type of mechanical system in the building. An in-depth study is recommended for each building to be considered.

Outsourcing Utility Systems

As an alternative to utilizing in-house staff for operation and maintenance of the chilled water production, the work could be outsourced to a contractor who in turn would provide chilled water to the campus for a fee based on usage. A contract must be set up in a detailed manner and must be written in a manner to protect the university's assets. The contractor may be responsible for the chiller plant only, or their scope may include the distribution system also. However the contract is written, an accurate metering system is required.

Outsourcing may relieve the University of their plant O&M responsibilities; however, there are several concerns of which to be aware. Providers are in business to make a profit. They do not always work in the long term best interest of the university. Even if the contract is set up in a very detailed manner, operations and maintenance firms can try to skew the operations and maintenance of the facilities to maximize profits and minimize costs. University staff will still be needed to monitor the work, making sure that contractual agreements are met.

Based on our knowledge of other client experiences, we have found that in most cases universities are dissatisfied with these types of contracts. We recommend KSU continue to operate and maintain their chilled water production with in-house staff.

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Section 1

Introduction

General

This Chilled Water Master Plan investigates the current chilled water system on the campus of Kansas State University (KSU) in Manhattan, Kansas. The University has selected Stanley Consultants to investigate the current campus chilled water system and provide options for growth of these systems as the campus continues to expand in size and number of students. The team will use its expertise to lead the effort to review, revise, and make both tactical and strategic recommendations to support the Chilled Water Master Plan development.

Scope

The objective of the Chilled Water Master Plan is to develop sufficient information allowing the University to make future utility infrastructure planning decisions related to campus growth; creative solutions, including sustainability considerations; central or satellite utility services; operational efficiencies; life cycle cost of distribution; and reliability.

Project Tasks

The University's Chilled Water Master Plan project is broken down into task level requirements:

Task 1

Task 1 is the Site Data Gathering Visit. This includes meeting with the Facilities Management Group of KSU. This data collection effort is critical to the development of the Master Plan. Specific tasks include the following:

- Meet with the facilities staff to identify the existing loads and chilled water plant capacity.

- Site data collection on chilled water system, drawings and review of the existing system.

- Review of the facilities management system snapshots of the chilled water system for each building.

Task 2

Develop a set of overall parameters, constraints, and guidelines for the short term and long term Chilled Water Master Plan. Specific tasks include the following:

- Develop a set of parameters for use in Master Plan development. These parameters will include short term and long term items needed to develop effective cost models and methodologies.
- Develop a Master Plan template that can be used for future project evaluation.

Task 3

Prepare recommendations on the approaches for campus chilled water production facilities and distribution systems. Specific tasks include the following:

- Compare current production capacities and future demand requirements.
- Highlight “break points” where the University must make substantial capital commitments to meet future demand loads.
- Develop options to meet future demand.

Section 2

Existing Chilled Water Systems

Chilled Water Production

The campus has one main Cooling Plant located on 17th Street just north of the Power Plant. The Cooling Plant houses five chillers; four electric motor-driven centrifugal chillers and one steam absorption chiller. Additionally, there is also one electric motor-driven centrifugal chiller and one steam absorption chiller located at the Power Plant which tie into the primary loop at the Cooling Plant. These seven chillers provide a capacity of 7,300 tons and an N+1 cooling capacity of 6,050 tons. Design information for the chillers, pumps, and cooling towers was obtained from construction drawings dated December 16, 2010 and field verification. A summary of the chiller information is provided in the following table.

Table 2-1 Existing Campus Loop Chillers

Name	Manufacturer	Fuel Source	Type	Capacity (tons)	Location	Year Installed
Chiller #1	York	Electric	Centrifugal	900	CHW Plant	2004
Chiller #2	York	Electric	Centrifugal	1,250	CHW Plant	2011
Chiller #3	York	Electric	Centrifugal	1,250	CHW Plant	2011
Chiller #4	York	Electric	Centrifugal	1,250	CHW Plant	2011
Chiller #5	York	Steam	Absorption	1,250	CHW Plant	1998
Chiller #6	York	Steam	Absorption	1,000	Power Plant	1997
Chiller #7	York	Electric	Centrifugal	400	Power Plant	Mid 1990s

Source: Stanley Consultants, Inc.

The installation date of each of the existing chillers is shown above. Median service life estimates for various pieces of mechanical equipment are included in Appendix C. These values are estimated using ASHRAE data as well as experience from past projects. The useful service life of centrifugal Chillers #1-4 is anticipated to last beyond the timeframe of this study. Steam absorption Chillers #5 and #6 are seldom used and will be nearing the end of their service life by 2020, most likely requiring replacement. Chiller #7 is seldom used and will be nearing end of service life by 2025, possibly requiring replacement. All chillers should be evaluated regularly to verify reliable operation.

Chilled Water Pumping

The Cooling Plant has a primary-secondary system with three sub-loops; the North Loop, the South Loop, and the Chem-Biochem Loop. The loops are fed from a common header supplied by five secondary pumps. The total pumping capacity is 14,600 gpm. The existing secondary pump configuration results in an N+1 capacity of 11,680 gpm. The existing primary pump configuration results in an N+1 capacity of 11,800 gpm. Primary and secondary chilled water pumps are summarized in the following table.

Table 2-2 Existing Chilled Water Pump Schedule

Name	Service	Manuf.	Model	Flow (gpm)	Head (ft)	Power (hp)	Location
PP-1	Primary	B & G	1510-8G	1,800	40	25	CHW Plant
PP-2	Primary	B & G	1510-8G	2,500	40	40	CHW Plant
PP-3	Primary	B & G	1510-8G	2,500	40	40	CHW Plant
PP-4	Primary	B & G	1510-8G	2,500	40	40	CHW Plant
PP-5	Primary	B & G	1510-8G	2,500	40	40	CHW Plant
PP-6	Primary	B & G	1510-8G	2,800	70	75	CHW Plant
SP-1	Secondary	B & G	1510-8G	2,920	90	100	CHW Plant
SP-2	Secondary	B & G	1510-8G	2,920	90	100	CHW Plant
SP-3	Secondary	B & G	1510-8G	2,920	90	100	CHW Plant
SP-4	Secondary	B & G	1510-8G	2,920	90	100	CHW Plant
SP-5	Secondary	B & G	1510-8G	2,920	90	100	CHW Plant

Source: Stanley Consultants, Inc.

In the existing primary and secondary pump configurations the design flow through the largest pump is larger than the design flow through the largest chiller. Therefore, if the largest pump were lost from either the primary or secondary system, the Cooling Plant would become flow limited, reducing the N+1 cooling capacity from 6,050 tons to 5,840 tons. While this is not an issue at current campus cooling loads, it could cause problems in the future. It is recommended that pump redundancy be added to each system to provide N+1 pumping capacity greater than or equal to the corresponding flow through the chillers at N+1 cooling capacity (12,100 gpm). Additionally, it is recommended that any future chiller installation have an accompanying primary and secondary pump installed as well, all with identical flow rates.

The chilled water pumps have an estimated median service life of 20 years. These may require replacement or refurbishment within the timeframe of this study and should be evaluated regularly to verify reliable operation.

Condenser Cooling Water

Ten cooling towers are used to cool the condenser water for these chillers. This equipment is summarized in the following table.

Table 2-3 Existing Campus Loop Cooling Towers

Name	Manuf.	Flow (gpm)	EWT (°F)	LWT (°F)	Capacity (tons)	Location	Last Refurbished
CT-1	TEI	3,500	95	85	1,460	CHW Plant	2011
CT-2	TEI	3,500	95	85	1,460	CHW Plant	2011
CT-3	TEI	3,500	95	85	1,460	CHW Plant	2011
CT-4	TEI	3,500	95	85	1,460	CHW Plant	2011
CT-5	TEI	2,200	95	85	918	CHW Plant	
CT-6	TEI	2,200	95	85	918	CHW Plant	
CT-7	TEI	1,168	95	85	487	Power Plant	
CT-8	TEI	1,168	95	85	487	Power Plant	
CT-9	TEI	1,168	95	85	487	Power Plant	
CT-10	TEI	1,200	95	85	501	Power Plant	

Source: Stanley Consultants, Inc.

Cooling towers 1-4 were modified in 2011. The useful service life of these cooling towers is anticipated to last beyond the timeframe of this study. Assuming the age of the remaining cooling towers is similar to Chillers #5-7, the fill and/or mechanical internals of these cooling towers may require replacement before 2025. The tower performance and internal equipment should be evaluated regularly to verify reliable operation.

The condenser water pumps have an estimated median service life of 20 years. These may require replacement or refurbishment within the timeframe of this study and should be evaluated regularly to verify reliable operation.

Chilled Water Distribution

The campus loop utilizes a primary-secondary-tertiary pumping scheme, and chilled water supply is distributed at 40°F and returned at 54°F. Based on the 2010 Facility Conservation Improvement Program report and information provided by the University staff, 31 buildings are served by these three loops. Appendix A lists all campus buildings, the year they were built, the occupancy type, and the existing type of cooling system.

Existing building cooling loads are taken from the analysis performed in the 2010 Facility Conservation Improvement Program report. If an existing building was not included in that report, square footage data was used to estimate cooling load. Since no Cooling Plant historical data or building metering data currently exists to verify these building load estimates, actual peak campus chilled water demand was estimated by interviewing campus personnel to determine chiller operation configuration during peak cooling days in 2011. A building metering project was recently completed. In the future, this metering data can be used to verify the building cooling load estimates in this report. Also, it is recommended that hourly historical data for chilled water flow and temperature be documented for each chiller electronically.

When using square footage to calculate cooling load, building occupancy type must be considered. Square footage data is taken from the Building Summary Report created on December 5, 2011 and provided by KSU. To calculate net square footage for each building, the Structural Area (ZZZ) is subtracted from the total square footage. Occupancy type is determined based on information provided in the Building Summary Report. Cooling loads used for different occupancy types are taken from ASHRAE data and provided in the table below. Refer to the building list provided in Appendix A for individual building occupancy types.

Table 2-4 Building Occupancy Types

Occupancy Type	SF/Ton
Admin/Class	285
Auditorium	300
Church	340
Dorm	320
Gym/Fieldhouse	250
Labs	205
Library	280
Museum	360
Office	360
Residence	600
Restaurant	200
Science	225
Shop	315

Source: Stanley Consultants, Inc.

The buildings currently connected to the campus chilled water loop and their corresponding cooling loads are summarized in the following tables. Refer to the complete building list provided in Appendix A for further detail.

Table 2-5 Buildings on Central Chilled Water

Property Name	Net Area (square feet)	Current Loop	Load (tons)
Ackert/Chalmers Hall	180,728	North	685
Campus Creek Complex	19,401	Chem-Biochem	70
Cardwell Hall	129,183	North	440
Chemistry/Biochemistry	85,535	Chem-Biochem	430
Durland/Rathbone/Fiedler Hall	219,238	South/North	650
English/Counseling Services	28,049	South	90
Feed Technology	17,059	North	76

Property Name	Net Area (square feet)	Current Loop	Load (tons)
Goodnow Hall	92,584	North	250
Hale-Farrell Library	298,814	Chem-Biochem	500
Holton Hall	21,894	South	70
Justin Hall	134,287	Chem-Biochem	300
Kedzie Hall	36,925	South	100
King Hall	37,062	Chem-Biochem	250
Kramer Dining Center	36,334	North	150
KSU Union	219,378	South	610
Marlatt Hall	101,488	North	250
Shellenberger Hall	44,552	Chem-Biochem	200
Throckmorton Hall	394,712	North	1,150
Ward Hall	34,304	North	260

Source: Stanley Consultants, Inc.

Table 2-6 Buildings Partially on Central Chilled Water

Property Name	Net Area (square feet)	Current Loop	Load (tons)
Anderson Hall	24,898	South	87
Burt Hall	2,930	North	65
Eisenhower Hall	4,215	South	80
Holtz Hall	622	South	20
Seaton Court	20,073	South	50
Seaton Hall + Seaton East	109,009	South	380
Waters Hall	3,108	North	14
Willard Hall	3,437	Chem Biochem	80

Source: Stanley Consultants, Inc.

The existing cooling loads total 7,307 tons. Using a diversity factor of 0.75 to account for the fact that not all buildings will be at full-load at the same time, the estimated peak load would be 5,480 tons. Campus personnel indicated that during peak days in 2011, Chillers #2, #3, #4, #5 and #7 were in operation. Assuming these chillers were all operating at rated capacity, this would indicate a campus peak demand of approximately 5,400 tons. This value is slightly less than the peak load estimate above. Chiller #6 was also used sparingly. It is assumed that Chiller #6 makes up the difference between the two load estimates. The capacity and load figures above indicate that there is sufficient N+1 capacity available on the campus chilled water loop, with an excess capacity of approximately 570 tons.

Several of the buildings currently on the campus chilled water loop are also serviced by local chillers. These chillers vary in age in condition. In particular, the chiller and cooling tower at Ackert Hall are in need of replacement. It is recommended that this local equipment at Ackert Hall be replaced by roof top units which will provide emergency air conditioning for animals in the building.

The University does not desire to use local chillers to supply the campus loop, nor are they to be considered a viable backup to the loop. Therefore, these chillers are not used to calculate loop capacity.

At design chilled water temperatures (40°F supply, 54°F return), a flow rate of 2 gpm per ton is expected. Considering a low delta-T scenario (assume 8°F), 3.5 gpm per ton can be expected. However, this would most likely occur during times of low load when the return water temperature is low. Therefore, the design case of 2 gpm per ton should be used for planning purposes. Using this flow value, it appears that nearly all existing distribution piping is sized sufficiently large, with some capacity for expansion. The 10" distribution line servicing Throckmorton Hall appears slightly undersized but should be sufficient as a branch line assuming a new header is installed to Throckmorton Hall in the future to accommodate any expansion to the north. Existing pipe routings and sizes are shown on the drawings in Appendix B.

Nearly all campus chilled water distribution piping is direct buried, with the exception of the 10" line to the KSU Union and Kedzie Hall routed through a steam tunnel. Age of the distribution piping varies from 20 years old to fairly new. The useful service life of the chilled water distribution piping is anticipated to last beyond the timeframe of this study. Per campus personnel, the chilled water distribution piping is generally considered to be in reliable condition with no known leaks.

Many spaces on campus would benefit from central air conditioning. Buildings that have been renovated with air conditioning provide a better learning and research environment. There are several buildings on campus that are not connected to the central loop. They are either not currently cooled, or they are cooled through local chillers or other means. A complete list of campus buildings and their corresponding cooling methods is included in Appendix A.

To summarize, several maintenance needs or opportunities for improvement were identified in the existing chilled water system. These are summarized below.

- Chillers #5 and #6 are seldom used and will be nearing the end of their service life by 2020, most likely requiring replacement.
- Chiller #7 is seldom used and will be nearing end of service life by 2025, possibly requiring replacement.
- The chilled water pumps have an estimated median service life of 20 years. These may require replacement or refurbishment within the timeframe of this study and should be evaluated regularly to verify reliable operation.
- The fill and/or mechanical internals of some cooling towers may require replacement before 2025. The tower performance and internal equipment should be evaluated regularly to verify reliable operation.
- Add pump redundancy to the primary and secondary chilled water systems to achieve N+1 pumping capacity greater than or equal to the corresponding flow through the chillers at N+1 cooling capacity. Accompanying primary and secondary pumps with identical flow rates should be included with any future chiller installations.

- In the future, use building metering data to verify the accuracy of the individual building cooling load estimates in this report.
- Replace local chiller and cooling tower at Ackert Hall with roof top units to provide emergency air conditioning for animals.

Section 3

Future Expansion

General Expansion Considerations

Several buildings on campus have independent cooling systems and could benefit from being connected to the central loop. Benefits of adding buildings to the loop include sharing backup capacity. One spare chiller in the Cooling Plant can provide this backup capacity for the entire loop as opposed to having a spare chiller in each independent building. Prior to adding buildings to the central loop, several factors need to be considered. The central plant must have the capacity to serve the existing plus additional cooling loads. This includes providing reliability and redundancy. The pumping capacity and distribution line sizes must be considered for adequacy. Also, location and mechanical design of the buildings will play a role in determining if adding them to the central loop is an economical option.

It is the desire of the University to maintain N+1 reliability for chilled water production. N+1 reliability is attained when the design capacity is met with the largest chiller in the system out of service. As indicated in Section 2, the current capacity of the Cooling Plant is 7,300 tons and the N+1 capacity is 6,050 tons. The central cooling loads total approximately 7,307 tons. Using a diversity factor of 0.75 to account for the fact that not all buildings will be at full-load at the same time, the estimated peak load would be approximately 5,480 tons. The capacity and load figures indicate that there is currently sufficient N+1 capacity available on the campus chilled water loop, with an excess capacity of 570 tons. Future plans for any expansion of the central chilled water system beyond 570 tons would require additional capacity to maintain N+1 reliability.

The secondary loop of the Cooling Plant has a pumping capacity of 14,600 gpm, and an N+1 capacity of 11,680 gpm. The current loads require approximately 10,960 gpm. The existing distribution line sizes were evaluated in Section 2. These sizes need to be reviewed when considering adding loads to the loop. Where new buildings are to be added, the existing distribution lines may need to be replaced with larger lines and extended out to the new buildings. These costs need to be considered in the planning stages.

The existing buildings have various types of cooling including local chillers, central A/C units, DX units, window units, or no cooling at all. The work involved with connecting one of these buildings to the central loop can vary significantly depending on the type of mechanical systems currently in the building. These costs also need to be considered in the planning stages.

Buildings selected to be added to the central chilled water loop are selected based on their proximity to existing distribution piping, proximity to other buildings, existing distribution pipe sizing, building cooling load, building modifications required to implement chilled water cooling, and other factors. Cooling loads for these buildings are calculated based on the procedure described in Section 2. Some buildings such as residence halls, or those not requiring air conditioning are not considered.

Several of the buildings being added to the campus chilled water loop are currently serviced by local chillers. The University does not desire to use these local chillers to supply the campus loop, nor are they to be considered a viable backup to the loop. Therefore, these chillers will not be used to calculate loop capacity.

2017 Expansion

Existing buildings to be considered for connection to the central chilled water loop by 2017 include those listed in the following table.

Table 3-1 Possible Central Chilled Water Loop Additions (2017)

Property Name	Net Area (square feet)	Load (tons)
Bluemont Hall	106,167	472
Bushnell Annex	1,993	10
Bushnell Hall	19,362	94
Call Hall	55,190	245
Dickens Hall	23,098	81
Dykstra Hall	35,396	106
Leadership Studies Building	31,005	109
Leasure Hall	28,690	101
General Richards B. Meyers Hall	32,288	113
International Student Center	5,057	18
Umberger Hall	40,888	143
Waters Hall Annex	14,427	64
Weber Hall	139,120	535

Source: Stanley Consultants, Inc.

Not all the buildings currently tied to the campus chilled water loop use chilled water to cool the entire building. These buildings will require some modification to convert the remainder of the building to chilled water. Existing buildings, currently tied to the campus chilled water loop, that are to be considered for conversion entirely to chilled water by 2017 include those listed in the following table.

Table 3-2 Existing Campus Users Chilled Water Expansion (2017)

Property Name	Add'l Net Area (square feet)	Add'l Load (tons)
Anderson Hall	24,898	87
Burt Hall	26,367	38
Eisenhower Hall	37,934	68
Holtz Hall	5,598	2
Seaton Court	20,073	91
Seaton Hall & Seaton East	109,009	385
Willard Hall	82,486	221

Source: Stanley Consultants, Inc.

Various building and construction projects have been completed or are expected to be completed in the near future. Some of these projects will affect buildings currently on the existing chilled water loop. The following table is a summary of funded building expansion projects expected to be completed by 2017.

Table 3-3 Funded Projects (2017)

Project Name	Add'l Net Area (square feet)	Add'l Load (tons)
Fiedler Hall - Eng. Complex Phase IV	80,000	680
College of Business Administration	140,000	491
Justin Hall - Expansion	16,376	229
East Stadium - Welcome Center	31,064	104
West Stadium - Theatre	42,216	141
College of Architecture - Seaton Hall Addition	125,000	824

Source: Stanley Consultants, Inc.

The additional load from the buildings listed above would increase the total load to approximately 11,928 tons. Using a diversity factor of 0.75 to account for the fact that not all buildings will be at full-load at the same time, the estimated peak load would be approximately 8,946 tons. Refer to the building list provided in Appendix A for further detail.

The Cooling Plant has an N+1 capacity of 6,050 tons. In order to maintain N+1 capacity through 2017, an additional 2,772 tons of capacity must be added.

2025 Expansion

Building expansion and demolition planning information was taken from the preliminary Land Development Master Plan provided by the University. No demolition projects are planned to take place within the timeframe of this study. If buildings are demolished, it is assumed that they will be replaced with new buildings of equal or greater or load.

Existing buildings to be considered for connection to the central chilled water loop by 2025 include those listed in the following table.

Table 3-4 Possible Central Chilled Water Loop Additions (2025)

Property Name	Net Area (square feet)	Load (tons)
Beach Art Museum	33,839	94
Calvin Hall	43,787	154
Danforth and All Faiths Chapels	7,883	23
Fairchild Hall	44,508	156
K-State Parking Structure	12,287	34
McCain Auditorium	94,176	314
Nichols Hall	55,523	247
President's Residence	7,901	13
Thompson Hall	21,158	94

Source: Stanley Consultants, Inc.

Existing buildings currently tied to the campus chilled water loop that are proposed to be converted entirely to chilled water by 2025 include those listed in the following table.

Table 3-5 Existing Campus Users Chilled Water Expansion (2025)

Property Name	Add'l Net Area (square feet)	Add'l Load (tons)
Waters Hall	152,289	677

Source: Stanley Consultants, Inc.

See the following table for a summary of building expansion projects expected to be completed by 2025 which will affect campus chilled water usage. This includes the expansion of existing buildings and the construction of new ones.

Table 3-6 Building Projects (2025)

Project Name	Add'l Net Area (square feet)	Add'l Load (tons)
Ackert Hall Addition	76,000	567
Cardwell Hall Expansion	16,200	206
Classroom Building	66,000	232
International Student Center	13,000	46
K-State Union Additions	89,000	590
North of Dickens Hall	10,000	35

Source: Stanley Consultants, Inc.

The additional loads from the buildings listed above would increase the total load to approximately 15,178 tons. Using a diversity factor of 0.75 to account for the fact that not all buildings will be at full-load at the same time, the estimated peak load would be approximately 11,384 tons.

In order to maintain N+1 capacity through 2025, an additional 5,334 tons of capacity must be added to the existing capacity. Refer to the building list provided in Appendix A for further detail.

Chilled Water Distribution

Using a design flow rate of 2 gpm per ton, most of the existing distribution piping is sized sufficiently large to meet the additional load requirements. Some existing chilled water lines will require an increase in size to accommodate higher flows. These lines are indicated on the drawings in Appendix B. New distribution piping will also be required to connect additional buildings to the loop. Suggested pipe routings and sizes are shown on the drawings provided in Appendix B. The line sizes and routings shown are an approximation and should be verified during detailed design when bringing buildings onto the loop.

For the line sizes indicated in Appendix B, it is assumed that all chilled water distribution piping originates from the location of the existing Cooling Plant. The Cooling Plant does not have space for any additional chillers, so the existing plant must be expanded, or a new plant must be constructed. The adjacent existing Facilities Grounds building is slated for demolition, but is small and would provide only minimal space for expansion of the existing plant. The English Counseling Services Building is a candidate for demolition. Demolition of this building would provide adequate space for a new chiller plant in a central location near the existing Cooling Plant. However, the University wishes to preserve this area as green space. Another disadvantage is the high cost to bring the additional electrical power requirements to that location. Refer to the Electrical Master Plan provided by Stanley Consultants under separate cover.

Alternatively, a satellite plant could be added elsewhere on campus. One possible location is near the Wind Erosion Laboratory. A new transformer is also proposed for this location. See the Campus Primary Electrical Distribution System Master Plan for more details. This location would co-locate electrical supply and demand, and would minimize electrical installation costs associated with a new chiller plant.

Potential chiller plant locations are shown on the drawings provided in Appendix B. The plant size shown on the drawings represents a six chiller plant with total capacity of approximately 12,000 tons. The plant should be designed to allow chillers to be installed in phases as the campus demand grows.

When selecting a site for a new chiller plant, noise, appearance and plume visibility are important considerations. These concerns primarily relate to the associated cooling towers. There are various options that can be considered to address all of these concerns:

- A custom designed tower for the application can utilize all sorts of different materials, shapes, etc. This however, can be very expensive.
- Vibration can be handled with spring isolators under the tower.

- Noise can be addressed in a few ways; oversizing the tower so the fan is smaller, using crossflow instead of counterflow (counterflow is generally louder due to the falling water noise), or you can even add noise attenuators.
- For plume, plume abatement is available.

Refer to Appendix D for general cooling tower options and some example pictures. In general, a more standard tower placed on the roof of the plant with an architectural screen would be more cost effective than going with a custom cooling tower.

It is also recommended that cross-connections be added between the North Loop and the Chem-Biochem Loop, and between the Chem-Biochem Loop and the South Loop. This will provide redundancy and improved reliability of the chilled water system. It also provides the University with the operational flexibility to isolate sections of the system without compromising delivery to the rest of the loop. Suggested routings and sizes for these proposed cross-connections are shown on the drawings provided in Appendix B.

Pump head capacity should also be explored during detailed design. Incorporating all of the above changes would significantly expand the distance from the Cooling Plant to the furthest chilled water users and frictional losses through the distribution pipe may grow to exceed the design head of the chilled water pumps. Several options are available to remedy this such as increasing the pump head, increasing distribution line sizing, and relocating some cooling capacity closer to building loads.

Overview

Based on the current chilled water loads and the resulting loads of the 2017 and 2025 proposed additions, future capacity requirements have been projected for the first five years and then for the following eight years. Where the current N+1 capacity intersects the load curve, additional capacity is required. The following graph shows the design cooling load curve versus the chilled water production capacity for the central loop from 2011 to 2025.

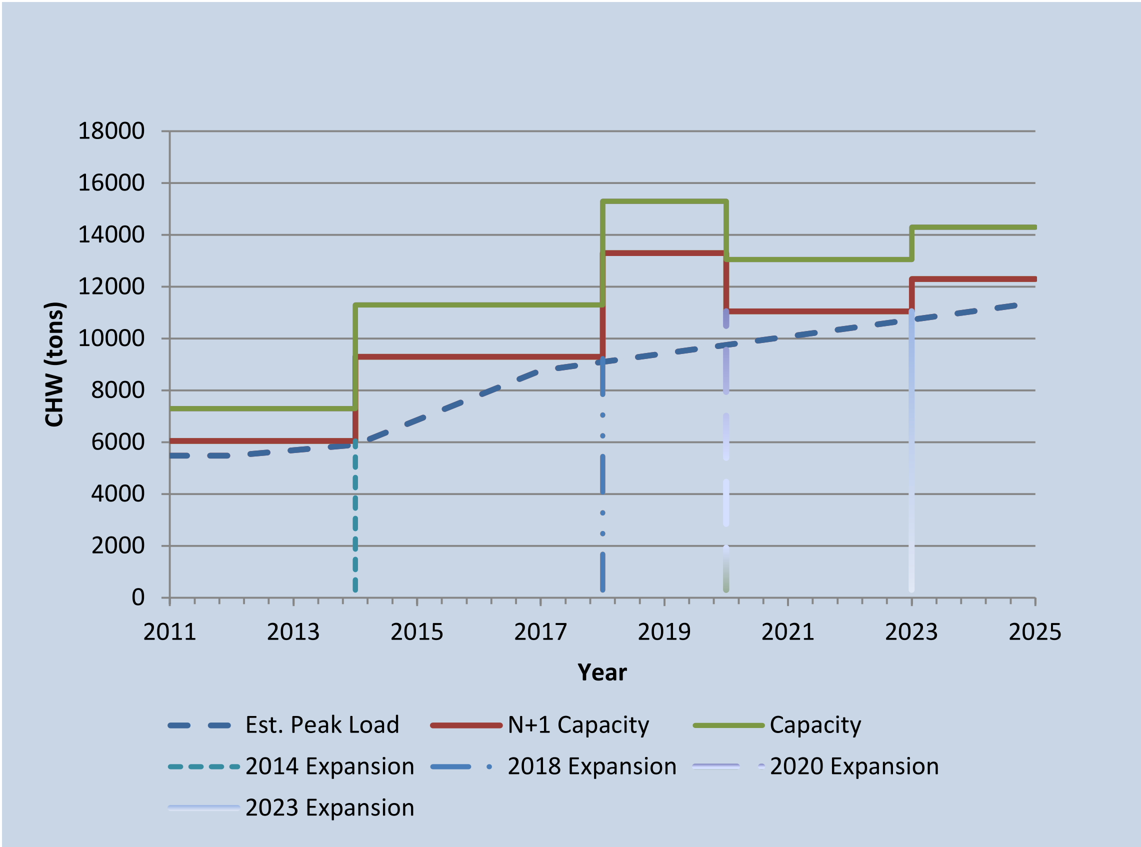


Figure 3-1: Cooling Load vs. Capacity (Scenario 1 - Chiller #5 Replacement)

As indicated in the graph above, it is assumed that 4,000 tons of chiller capacity is added in 2014 to support the proposed additions between 2012 and 2017. An additional 4,000 tons of chiller capacity is added in 2018. Between 2018 and 2020, Chillers #5 and #6 will reach the end of their service life and need to be taken out of service. By 2023, Chiller #5 will need to be replaced with a new chiller of equal capacity. Beyond 2025, as the need for capacity grows, Chiller #6 can be replaced.

A total of 5,333 additional tons of cooling will be required for N+1 reliability through year 2025. The graph above assumes total addition of 8,000 tons of new chiller capacity, as well as replacement of 1,250 tons of existing capacity. This will result in an excess cooling capacity of 917 tons in 2025, assuming the largest chiller in the system has a capacity of 2,000 tons.

Alternatively, rather than replacing the existing capacity of Chillers #5 and #6, new capacity could be added to displace the capacity lost by removing Chillers #5 and #6 from service. This capacity could potentially be added at a second chiller plant location as discussed previously. The following graph shows the design cooling load curve versus the chilled water production capacity for the central loop from 2011 to 2025, assuming this scenario.

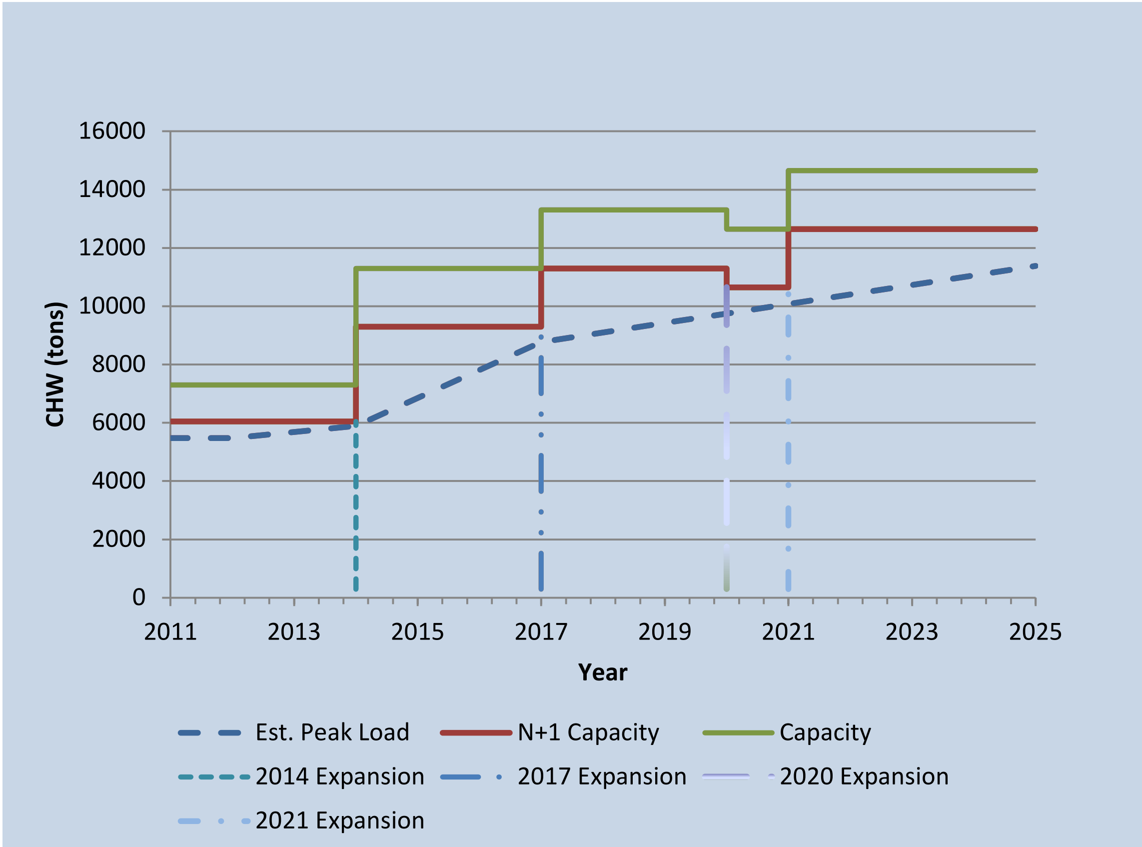


Figure 3-2: Cooling Load vs. Capacity (Scenario 2 - No Chiller Replacement)

As indicated in the graph above, it is assumed that 4,000 tons of chiller capacity is added in 2014 to support the proposed additions between 2012 and 2017. An additional 2,000 tons of chiller capacity is added in 2017. In 2020, Chillers #5, #6, and #7 are removed from service and 2,000 tons of capacity is added. In 2021, an additional 2,000 tons of capacity is added to support the proposed additions by 2025. A total of 6,600 additional tons of cooling will be required for N+1 reliability through year 2025. The graph above assumes total addition of 10,000 tons of new chiller capacity, and 2,650 tons of capacity removed from service. This will result in an excess cooling capacity of 1,267 tons in 2025, assuming the largest chiller in the system has a capacity of 2,000 tons.

All new chillers (except those replacing Chillers #5 and #6 in Scenario 1) were assumed to be 2,000 ton capacity. If the University desired to use smaller chillers (e.g. standardizing on 1,250 tons) it would require less installed capacity to maintain the same N+1 capacity. However, the number of chillers, valves, and controls would increase. Additionally, space requirements, maintenance, and capital costs per ton would most likely increase as well.

Section 4

Recommendations and Costs

Chilled Water System Summary

Evaluation of the chilled water system was performed using data gathered through site visits and information provided by University personnel. This information included building square footage data, building usage information, previous chilled water system reports, and other general information regarding the condition of the existing chilled water system. Future chilled water demand through 2025 was estimated based on factors discussed previously, including building expansion as projected in the Campus Master Plan.

As discussed in Section 2, there is currently adequate chiller capacity at the Cooling Plant to provide sufficient N+1 capacity to campus at peak cooling load. See the following table for a summary of campus cooling load and capacity based on 2011 data.

Table 4-1 Campus Chilled Water Summary

Total Campus Building Cooling Load (tons)	7,307
Diversity Factor	75%
Peak Campus Cooling Load (tons)	5,480
Installed Chiller Capacity (tons)	7,300
N+1 Chiller Capacity (tons)	6,050

Source: Stanley Consultants, Inc.

Expansion Considerations

It is estimated that peak campus cooling load will reach 11,696 tons by 2017 and 15,178 tons by 2025. Two options are proposed in Section 3 to satisfy future chilled water demand and are summarized below.

Scenario 1

In this scenario, it is anticipated that by 2020, Chillers #5 and #6 will reach the end of their service life and be taken out of service. By 2023, Chiller #5 will need to be replaced with a chiller of equal capacity. The following graph shows the design cooling load curve versus the chilled water production capacity for the central loop from 2011 to 2025.

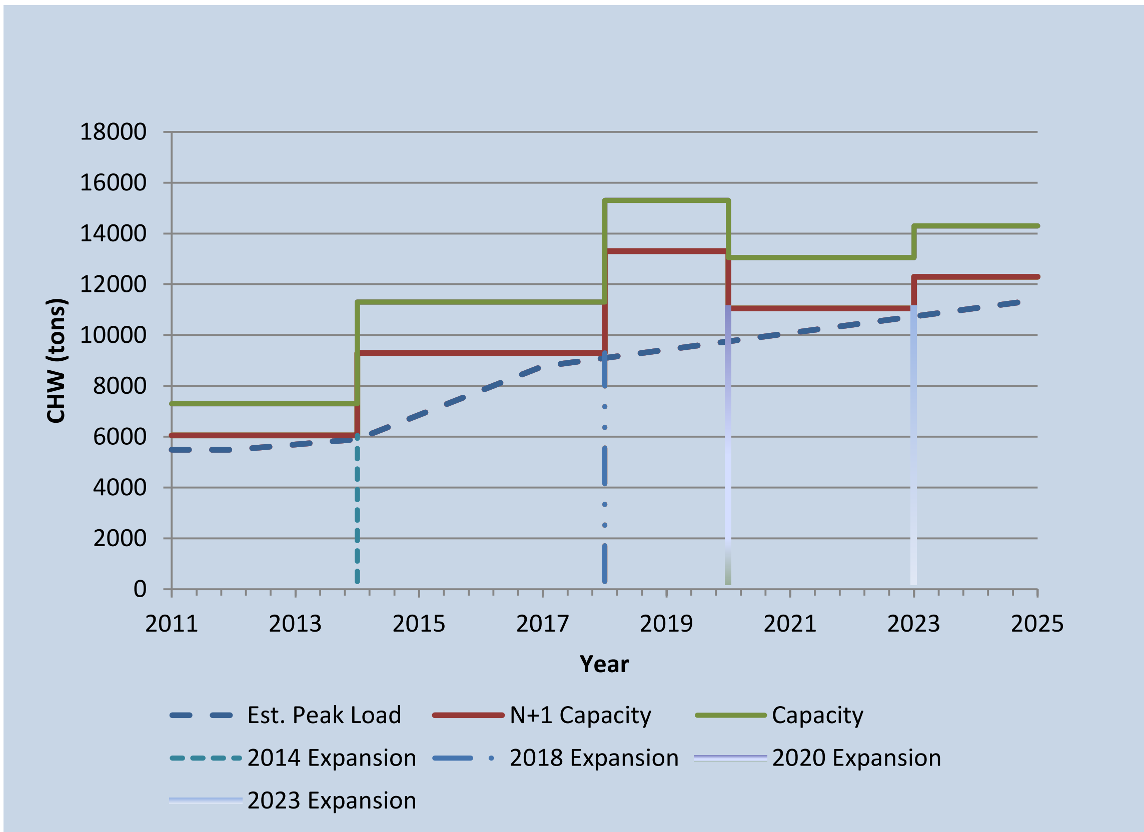


Figure 4-1: Cooling Load vs. Capacity (Scenario 1 - Chiller #5 Replacement)

As indicated in the graph above, it is assumed that 4,000 tons of chiller capacity is added in 2014 to support the proposed additions between 2012 and 2017. An additional 4,000 tons of chiller capacity is added in 2018. Chillers #5 and #6 reach the end of their service lives and are taken out of service in 2020. Chiller #5 is replaced with a chiller of equal capacity in 2023 to support the proposed additions by 2025. The graph above assumes total addition of 8,000 tons of new chiller capacity, as well as replacement of 1,250 tons of existing capacity.

Scenario 2

Alternatively, rather than replacing existing Chillers #5 and #6 in 2020, new capacity could be added at the new plant to displace the capacity lost. In this scenario Chiller #7 would also be removed from service.

The following graph shows the design cooling load curve versus the chilled water production capacity for the central loop from 2011 to 2025, assuming this scenario.

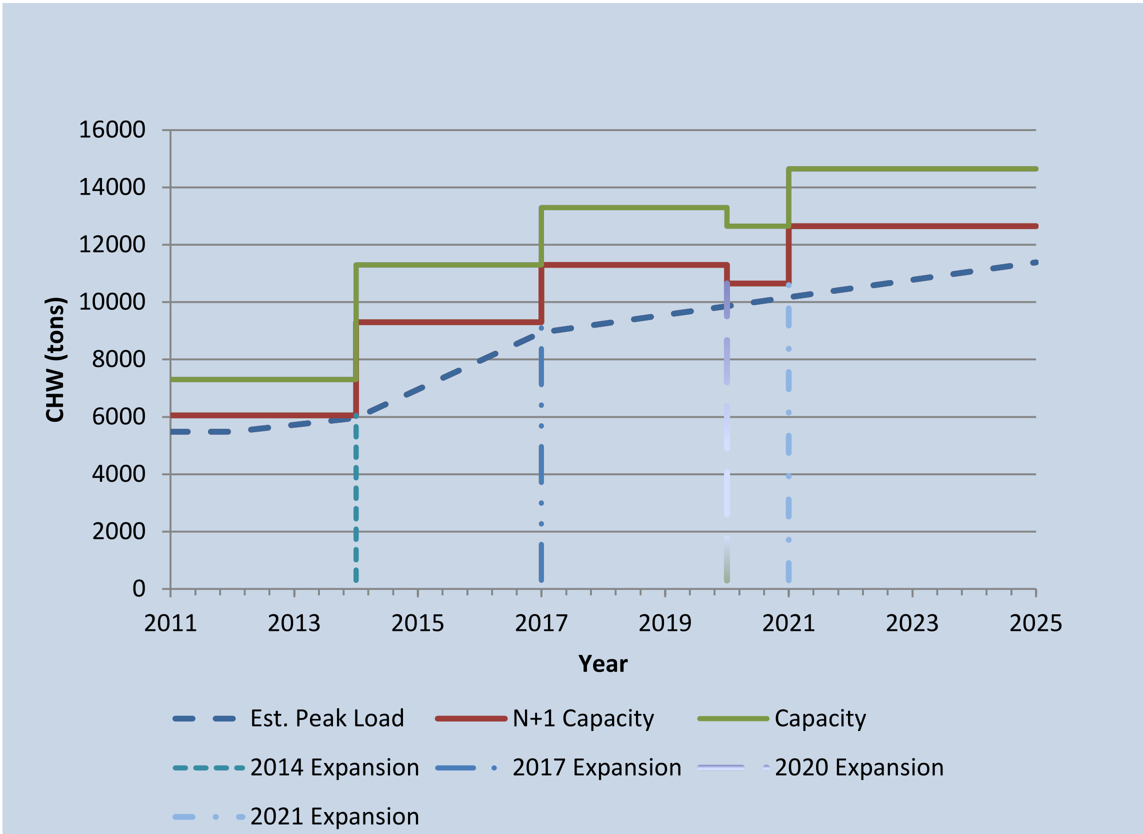


Figure 4-2: Cooling Load vs. Capacity (Scenario 2 - No Chiller Replacement)

As indicated in the graph above, it is assumed that 4,000 tons of chiller capacity is added in 2014 to support the proposed additions between 2012 and 2017. An additional 2,000 tons of chiller capacity is added in 2017. In 2020, Chillers #5, #6, and #7 are removed from service and 2,000 tons of capacity is added. In 2021, an additional 2,000 tons of capacity is added to support the proposed additions by 2025. The graph above assumes total addition of 10,000 tons of new chiller capacity, and 2,650 tons of capacity removed from service.

Scenario Comparison

The table below summarizes the two scenarios.

Table 4-2 Future Campus Chilled Water Summary

	Scenario 1	Scenario 2
Peak Campus Cooling Load - 2017 (tons)	8,946	8,946
Peak Campus Cooling Load - 2025 (tons)	11,384	11,384
Installed Capacity – 2025 (tons)	14,300	14,650
N+1 Capacity – 2025 (tons)	12,300	12,650

Source: Stanley Consultants, Inc.

Scenario 1 may require less space assuming the replacement chillers could occupy the same space as Chillers #5 and #6. Scenario 2 would more closely match the expected demand in 2025 and would most likely be less expensive to install on a cost per ton basis. Either of these scenarios could be tailored to select the chiller capacity and quantity to best fit the University's space, budgetary, and operational constraints.

New Chiller Plant and Distribution

Due to space constraints at the existing Cooling Plant, it is recommended that a second location be considered to locate some or all of the additional cooling capacity. It is also recommended that two cross connections be added between the different loops in the chilled water system. Both of these items will add needed redundancy to the system, help to ensure a reliable chilled water supply, and improve operational flexibility.

The English Counseling Services Building is a candidate for demolition. Demolition of this building would provide adequate space for a new chiller plant in a central location near the existing Cooling Plant. However, the University wishes to preserve this area as green space. Alternatively, a satellite plant could be added elsewhere on campus. One possible location is near the Wind Erosion Laboratory as shown on the drawings provided in Appendix B. The plant size shown on the drawings represents a six chiller plant with total capacity of approximately 12,000 tons. The plant should be designed to allow chillers to be installed in phases as the campus demand grows.

It is also recommended that cross-connections be added between the North Loop and the Chem-Biochem Loop, and between the Chem-Biochem Loop and the South Loop. This will provide redundancy and improved reliability of the chilled water system. It also provides the University with the operational flexibility to isolate sections of the system without compromising delivery to the rest of the loop. Suggested routings and sizes for these proposed cross-connections are shown on the drawings provided in Appendix B.

Pump head capacity should also be explored during detailed design. Incorporating all of the above changes would significantly expand the distance from the Cooling Plant to the furthest chilled water users and frictional losses through the distribution pipe may grow to exceed the design head of the chilled water pumps. Several options are available to remedy this such as increasing the pump head, increasing distribution line sizing, and relocating some cooling capacity closer to building loads.

"Break Points"

Several "break points" where significant capital investment is required to meet future demand loads exist in the master plan. The cost estimates are consistent with a study level of detail. They are not based on a quantity takeoff from a detailed design. Actual costs may vary with the actual scope determined by the design process. Cost estimates are given in 2013 dollars representing present value and do not incorporate inflation. Cost estimates given below include margin for undeveloped design details (25%), overhead (15%), profit (10%), and construction contingencies (10%).

2014 - Install Additional Chilled Water Capacity

In order to maintain N+1 capacity, additional chilled water production must be installed before additional buildings can be added to the central loop. In both expansion scenarios, an additional 4,000 tons of cooling is anticipated to provide for additional loads through the year 2017. A new chiller plant with two 2,000 ton chillers is recommended.

All new chillers (except those replacing Chillers #5 and #6 in Scenario 1) were assumed to be 2,000 ton capacity. If the University desired to use smaller chillers (e.g. standardizing on 1,250 tons) it would require less installed capacity to maintain the same N+1 capacity. However, the number of chillers would increase. Additionally, space requirements, maintenance, and capital costs per ton would most likely increase as well.

One proposed location for the chiller plant is on the site adjacent to the Power Plant. There are advantages to using this site for a new chiller plant. Being near the existing chilled water and steam plants, it provides convenience for operation and maintenance personnel. It is in a central location for campus distribution, and it can be more readily connected to the existing distribution system. Disadvantages include the added cost to demolish building #108, extensive costs to bring adequate electrical power to that location, and the University would prefer to utilize the area as a green space for the quad.

New Chiller Plant adjacent to the Power Plant - Estimated Costs

Demolish Building #108: The English/Counseling Services Building is a 28,049 square-foot building built in 1960. Demolition of this building to provide space for a new chilled water plant is estimated to cost $350,000.

Demolish Building #097: The Facility Grounds Building is a 4,221 square-foot building. Demolition of this building to provide space for a new chilled water plant is estimated to cost $53,000.

New Chiller Plant (4,000 tons): A new 9,000 square-foot chilled water plant housing two 2,000 ton chillers is estimated to cost $12.8 million. This building would need to be expanded for future chillers. To include space for two future chillers, an additional $960,000 is estimated. It is assumed that all new chillers will be electrical centrifugal type unless noted otherwise.

Connect to Loop: Based on installing 300 feet of 30" diameter, direct buried HDPE pipe (CHWS and CHWR); the cost to tie the new plant into the existing loop is estimated to be $250,000.

Cost to route extra electrical to this location is not included. Refer to the Electrical Utility Master Plan.

New Chiller Plant adjacent to the Power Plant: $13.4 million to $14.4 million.

Another proposed location is near the Wind Erosion Laboratory. This location eliminates the need to demolish any buildings and is located near the proposed substation.

New Chiller Plant near Wind Erosion Site - Estimated Costs

New Chiller Plant (4,000 tons): A new 9,000 square-foot chilled water plant housing two 2,000 ton chillers is estimated to cost $12.8 million. This building would need to be expanded for future chillers. To include space for two future chillers, an additional $960,000 is estimated.

Connect to Loop: Based on installing 3,000 feet of 24" direct buried HDPE pipe (CHWS and CHWR); the cost to tie the new plant into the existing loop is estimated to be $1.6 million.

New Chiller Plant near Wind Erosion Laboratory: $14.3 million to $15.3 million.

Cross-connect Chem-Biochem with North Loop

This cross-connect is proposed to run from the corner of Claflin Road and Mid-Campus Drive to the chem-biochem loop near Shellenberger Hall. Parts of the existing chem-biochem loop piping are undersized (less than 18" diameter) for the proposed cross-connection, and will need to be replaced.

Estimated Costs:

Biochem Loop Upsizing: Based on replacing 600 feet of existing buried pipe with 18" direct buried HDPE pipe (CHWS and CHWR); the cost is estimated to be $240,000.

Cross-connect: Based on installing 900 feet of 18" direct buried HDPE pipe (CHWS and CHWR); the cost to tie the south loop to the chem-biochem loop is estimated to be $330,000.

Cross-connect Chem-Biochem with North Loop: $570,000.

Cross-connect Chem-Biochem with South Loop

Certain south campus buildings can only be converted to central cooling once the 18" CHW cross-connect of the south loop to the Chem-Biochem loop is in place. The cross-connect is proposed to run from the Beach Art Museum north, up Butterfly Drive and Mid-campus Drive to the Chem-Biochem loop. Parts of the existing Chem-Biochem loop piping are undersized (less than 18” diameter) for the proposed cross-connection, and will need to be replaced.

Estimated Costs:

Increase CHW Pipe Size in Tunnel: Existing 10” CHW lines in the tunnel below 17th Street would need to be replaced with 18” CHW lines, as space will allow. Replacement cost for approximately 1,400 feet of CHWS and CHWR piping is estimated to cost $740,000.

Cross-connect: Based on installing 5,400 feet of 18” direct buried HDPE pipe (CHWS and CHWR); the cost to tie the south loop to the chem-biochem loop is estimated to be $2.0 million.

Biochem Loop Upsizing: Based on replacing 600 feet of existing buried pipe with 18” direct buried HDPE pipe (CHWS and CHWR); the cost is estimated to be $240,000.

Cross-connect Chem-Biochem with South Loop: $3.0 million.

Install Additional Chilled Water Capacity

In order to maintain N+1 capacity to future loads beyond the year 2018, additional chilled water production must be installed.

In expansion Scenario 1, an additional 4,000 tons of cooling is anticipated to provide for additional loads through the year 2023. This will provide adequate N+1 capacity during the time (by 2020) that chillers #5 and #6 would be taken out of service. By the year 2023 it is anticipated that Chiller #5 would need to be replaced to meet the demands through 2025.

2018 – Chiller Plant Expansion (+4,000 tons)

If the new chilled water plant is to be expanded for two new 2,000 ton chillers, the cost is estimated to be $10.4 million. If the plant was installed with space available for the new chillers, the cost is estimated to be $9.4 million.

2023 – Chillers No. 5 Replacement

Chillers #5 and #6 are absorption chillers. Chiller #5 is located in the existing Cooling Plant, and Chiller #6 is located in the existing Power Plant. Replacing the chillers with new absorption chillers of the same capacity, including demolition and removal of the existing chillers is estimated as follows. Chiller #6 would not need to be replaced prior to year 2025.

- Chiller #5 (1,250 tons): $1.4 million
- Chiller #6 (1,000 tons): $1.2 million

In expansion Scenario 2, an additional 2,000 tons of cooling is anticipated to provide for additional loads through the year 2020. This will provide adequate N+1 capacity as long as chillers #5 and #6 remain operational. Assuming chillers #5, #6, and #7 need to be retired in

2020, it is anticipated that two additional 2,000 ton chillers would be required to meet the demands through 2025.

2017/2020/2021 – Chiller Plant Expansions (+2,000 tons each)

If the new chilled water plant is to be expanded for one new 2,000 ton chiller, the cost is estimated to be $5.3 million. If the plant was installed with space available for the new chiller, the cost is estimated to be $4.8 million. These costs would be similar for expansions in 2020 and 2021.

North Campus Buildings

Bushnell Annex: Bushnell Annex is a 1,993 square foot laboratory. Currently, the building is cooled using electric air conditioners and would need to be converted to CHW. A short run of new 2” CHW piping would need to be installed. The estimated cost is $190,000

Bushnell Hall: Bushnell Hall is a 19,362 square foot laboratory. The building would need to be converted to CHW. A short run of new 4” CHW piping would need to be installed. The estimated cost is $1.8 million.

Call Hall: Call Hall is a 55,190 square foot science building. Currently, the building is cooled using fan coil units and a local chiller. It is anticipated that interior modifications will be minimal. A short run of new 6” CHW piping would need to be installed. The estimated cost is $10,000.

Cardwell Expansion: An expansion of 16,200 square feet is planned for Cardwell Hall. This building is currently cooled by the north CHW loop. The 8” supply and return lines are of sufficient size for the expansion. No additional cost (above that of the expansion) is anticipated.

Dole Hall: Dole Hall is a 28,011 square foot administration/classroom building. Currently, the building is cooled using electric units and would need to be converted to CHW. Approximately 400 feet of new 4” CHW piping would need to be installed. The estimated cost is $1.0 million. Conversion of this building should coincide with the expansion project planned for some time beyond the year 2025.

Dykstra Hall: Dykstra Hall is a 35,396 square foot shop and office building. Currently, the building is cooled using window units and would need to be converted. A short run of new 6” CHW piping would need to be installed. The estimated cost is $1.2 million.

General Richard B. Meyers Hall: Meyers Hall is a 32,288 square foot administration/classroom building. Currently, the building is cooled using window units and would need to be converted. A short run of new 4” CHW piping would need to be installed. The estimated cost is $1.1 million.

International Student Center: The International Student Center is a 5,057 square foot administration/classroom building. Currently, the building is cooled using fan coil units. Work should be coordinated with the planned 13,000 square foot expansion.

Approximately 400 feet of new 3” CHW piping would need to be installed. The estimated cost to convert the existing portion of the building to CHW and connect to the loop is $270,000.

Leadership Studies: The Leadership Studies building is a new 31,005 square foot administration/classroom building. Currently, the building is cooled using roof top units and would need to be converted, and a short run of new 4” CHW piping would need to be installed. The estimated cost is $1.0 million.

Planned Classroom Building: A 66,000 square foot classroom building north of Waters Hall is planned. It is assumed that the building project will include provisions for CHW cooling and the CHW supply and return mains. No additional cost is anticipated.

Umberger Hall: Umberger Hall is a 40,888 square foot administration/classroom building. Currently, the building is cooled using window units and central air conditioning and would need to be converted to CHW. A short run of new 6” CHW piping would need to be installed. The estimated cost is $1.4 million.

Waters Hall: Waters Hall is a 155,397 square foot science building. Currently about 2% of the building is on the CHW loop, and other spaces are cooled by window units. Approximately 152,289 square feet would need to be converted and approximately 500 feet of new 8” CHW piping would need to be installed. The estimated cost is $14 million.

Waters Hall Annex: Waters Hall Annex is a 14,427 square foot science building. Currently, the building is cooled using window units and central air conditioning and would need to be converted to CHW. A short run of new 4” CHW piping would need to be installed. The estimated cost is $1.3 million.

Weber Hall: Weber Hall is a 139,120 square foot dirt arena and science building. Currently, the building is cooled using roof top units and would need to be converted to CHW. Approximately 200 feet of new 10” CHW piping and 300 feet of new 8” CHW piping would need to be installed. The estimated cost is $12.8 million.

South Campus Buildings

Anderson Hall: Anderson Hall is a 49,795 square foot administration and classroom building. Currently the south half of the building is on the CHW loop, and the other half is cooled with a local chiller. Approximately 300 feet of existing CHW piping would need to be increase from 3” to 6” to accommodate the added load. It is anticipated that interior modifications will be minimal. The estimated cost is $89,000.

Beach Art Museum: The Beach Art Museum is a 33,839 square foot building. The space is currently cooled with chilled water. A short run of new 4” CHW piping would need to be installed. It is anticipated that interior modifications will be minimal. The estimated cost is $10,000.

Bluemont Hall: Bluemont Hall is a 106,167 square foot science building. Currently, the building is cooled using roof top units and would need to be converted. A short run of new 8” CHW piping would need to be installed. The estimated cost is $9.6 million.

Burt Hall: Burt Hall is a 29,297 square foot administration/classroom building. Currently, about 10% of the building is on the CHW loop. The existing CHW piping is of adequate size for the added load. Approximately 26,367 square feet of the building is cooled using window units and would need to be converted. The estimated cost is $870,000.

Calvin Hall: Calvin Hall is a 43,787 square foot administration/classroom building. The building would need to be converted, and a short run of new 6” CHW piping would need to be installed. The estimated cost is $1.5 million.

College of Business Administration: A 140,000 square foot classroom building to house the College of Business Administration is planned near the corner of Manhattan Ave. and Lover’s Lane. It is assumed that the building project will include provisions for CHW cooling and the CHW supply and return mains. No additional cost is anticipated.

Danforth and All Faiths Chapel: Danforth is a 7,883 square foot chapel. The space is currently cooled by the chiller located in McCain Auditorium. It is anticipated that no additional cost (beyond that of McCain Auditorium) will be required.

Dickens Hall: Dickens Hall is a 23,098 square foot administration/classroom building. Currently, the building is cooled using window units and would need to be converted, and a short run of new 4” CHW piping would need to be installed. The estimated cost is $770,000.

East Stadium: The East Stadium Welcome Center Project is now complete and adds a cooling load of approximately 116 tons to the south loop. No additional costs are anticipated.

Eisenhower Hall: Eisenhower Hall is a 42,149 square foot administration/classroom building. Currently about 10% of the building is on the CHW loop. The existing CHW piping is of adequate size for the added load. Approximately 37,394 square feet of the building is cooled using DX or window units and would need to be converted. The estimated cost is $1.2 million.

Engineering Complex Phase IV: An expansion of 80,000 square feet is planned for the Phase IV building of the Engineering Complex. This building is currently cooled by the central plant. The 3” supply and return lines for Fiedler Hall will need to be increased to 8” for the expansion. It is assumed that the expansion project includes the cost of replacing the CHW supply and return mains.

Fairchild Hall: Fairchild Hall is a 44,508 square foot administration/classroom building. Currently, the building is cooled using central air and window units and would need to be converted. Approximately 400 feet of new 6” CHW piping would need to be installed. The estimated cost is $1.6 million.

Holtz Hall: Holtz Hall is a 6,220 square foot administration/classroom building. Currently about 10% of the building is on the CHW loop. The existing CHW piping is of adequate size for the added load. Approximately 5,598 square feet of the building is cooled using window units and would need to be converted. The estimated cost is $180,000

Justin Hall: An expansion of 16,376 square feet is planned for Justin Hall. This building is currently cooled by the Chem-Biochem CHW loop. The 8” supply and return lines are of sufficient size for the expansion. No additional cost (above that of the expansion) is anticipated.

K-State Parking Structure: The K-State Parking Structure includes 12,287 square feet of office space. The space is currently cooled with a split system. Approximately 50 feet of new 3” CHW piping and 700 feet of 8” new CHW piping would need to be installed. It is anticipated that interior modifications will be minimal. The estimated cost is $200,000.

Leasure Hall: Leasure Hall is a 28,690 square foot administration/classroom building. Currently, the building is cooled using central air and window units and would need to be converted, and a short run of new 4” CHW piping would need to be installed. The estimated cost $950,000.

McCain Auditorium: McCain is a 94,176 square foot auditorium. The space is currently cooled with a local chiller which also serves Danforth Chapel. Approximately 200 feet of new 6” CHW piping would need to be installed. It is anticipated that interior modifications will be minimal. The estimated cost is $53,000.

Nichols Hall: Nichols Hall is a 55,523 square foot science building. The space is currently cooled with a local chiller which is undersized for the building load. Approximately 400feet of new 6” CHW piping would need to be installed. It is anticipated that interior modifications will be minimal. The estimated cost is $110,000.

President’s Residence: The President’s Residence is a 7,901 square foot residential building. Currently, the building is cooled by a local chiller. Approximately 300 feet of new 2.5” CHW piping would need to be installed. It is anticipated that interior modifications would be minimal. The estimated cost is $80,000.

Seaton Court: Seaton Court is a 40,145 square foot administration/classroom building. Currently about half of the building is on the CHW loop. Approximately 20,073 square feet would need to be converted, and approximately 100 feet of 2.5” CHW piping would need to be replaced with 4” CHW piping for the added load. The estimated cost is $690,000.

Seaton Hall & Seaton East: Seaton Hall and Seaton East include 218,018 square feet of administration and classroom space. Currently about half of the building is on the CHW loop. The College of Architecture addition should include up-sizing the existing CHW piping. Approximately 109,000 square feet of space would need to be converted for CHW loop cooling. This work should be included in the current project.

Thompson Hall: Thompson Hall is a 21,158 square foot science building. Currently, the building is cooled using central air and window units and would need to be converted. A short run of new 4" CHW piping would need to be installed. The estimated cost is $1.9 million.

West Stadium: The West Stadium Theatre Project is now complete and adds a cooling load of approximately 102 tons to the south loop. No additional costs are anticipated.

Willard Hall: Willard Hall is an 85,923 square foot administration/classroom building. Currently about 4% of the building is on the CHW loop. The existing CHW piping is of adequate size for the added load. Approximately 82,486 square feet of the building is cooled using window units and would need to be converted. The estimated cost is $2.7 million.

Individual Building Studies

Cost estimates for converting existing buildings to utilize the central CHW loop are based on the buildings' occupancy types, current cooling systems (if any), and square footage. These estimates are intended to provide a high level look at what buildings should be considered for the CHW loop. An in-depth study is recommended for each building to be considered. A building study should include a thorough investigation of the building's existing systems, detailed descriptions costs involved with converting it to CHW, and a cost-benefit analysis including possible energy savings.

Respectfully submitted,

Stanley Consultants, Inc.

Prepared by Matthew Wilkey, P.E.

Reviewed by Mark Wagner, P.E.

Approved by Ali A. Mahmood, P.E.

ALI A. MAHMOOD
LICENSED
21840
KANSAS
PROFESSIONAL ENGINEER

WM/MZ/AAM/mk/\\Chg-fs1\prj-private\kansas_state_university\2378201\Active\06-Studies\04-Studies\Printed-Final_030813

Feasibility Disclaimer

All recommendations and/or advice presented in this document are Stanley Consultants' opinions of probable project conditions. Project conditions are based on the information and data sources that are readily available to us, input by the client, and other reliable sources, all of which are believed to be accurate. Our recommendations and/or advice are made on the basis of our experience and represent our judgment and opinions. We have no control over new and/or non-public information, changed conditions, cost of land, cost of labor, materials, equipment, and/or other construction costs, or over competitive bidding or market conditions. Therefore, we do not guarantee that actual conditions or actual costs will not vary from those presented in this report, study, plan, etc.

"Cost Estimates" Disclaimer

All cost estimates presented in this report are Stanley Consultants' opinions of probable project, construction, and/or operation and maintenance costs. Costs estimates are made on the basis of our experience and represent our best judgment. We have no control over cost of labor, materials, equipment, contractor's methods, or over competitive bidding or market conditions. Therefore, we do not guarantee that proposals, bids, or actual construction costs will not vary from estimates of project costs, construction, and/or operation and maintenance costs presented. The estimates do not include inflation.

Appendix A

Building List

Kansas State University - Chilled Water Master Plan
Building List
Proposed Chilled Water Distribution

						2011 Data					Proposed for 2017					Proposed for 2025					
Property Code	Sheet No.	Property Name	Occupancy Type	Year Constructed	Existing A/C Type	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	Notes:
AK/AKC	2	Ackert/Chalmers Hall	LABS	1970/2002	CHW	North	180,728	685	1,370	8", 10"	North	180,728	685	1,370	8", 10"	North	256,728	1,252	2,505	8", 10"	Fume hoods are present. Desire to replace local chiller with RTUs for emergency A/C for animals. See Note 1 below. Ackert addition of 76,000 sf by 2025.
ER	1	Campus Creek Complex	ADMIN/CLASS	1949	CHW	Chem Biochem	19,401	70	140	4"	Chem Biochem	19,401	70	140	4"	Chem Biochem	19,401	70	140	4"	See Note 1 below.
CW	2	Cardwell Hall	SCIENCE	1963	CHW	North	129,183	440	880	8"	North	129,183	440	880	8"	North	145,383	646	1,292	8"	See Note 1 below. Planned expansion of 16,200 sq-ft assumed by 2025.
CB	1	Chemistry/Biochemistry	LABS	1988	CHW	Chem Biochem	85,535	430	860	10"	Chem Biochem	85,535	430	860	10"	Chem Biochem	85,535	430	860	10"	Fume hoods are present. See Note 1 below.
DU/DUR/DUF	1	Durland/Rathbone/Fiedler Hall	SCIENCE	1976/1982/2000	CHW	North/South	219,238	650	1,300	6", 10", 3"	North/South	299,238	1,330	2,660	6", 10", 8"	North/South	299,238	1,330	2,660	6", 10", 8"	See Note 1 below. Planned Engineering Complex Phase IV addition (80,000 sf) assumed by 2017.
ECS	1	English/Counseling Services	ADMIN/CLASS	1960	CHW	South	28,049	90	180	6"	South	28,049	90	180	6"	South	28,049	90	180	6"	See Note 1 below. Possible demolition.
FT	2	Feed Technology	SCIENCE	Unknown	CHW	North	17,059	76	152	N/A	North	17,059	76	152	3"	North	17,059	76	152	3"	Currently fed from Shellenberger.
GD	2	Goodnow Hall	DORM	1960	CHW	North	92,584	250	500	10"											See Note 1 below. Will have local chillers by 2017.
HL	1	Hale-Farrell Library	LIBRARY	1927/1970/1997	CHW	Chem Biochem	298,814	500	1,000	8"	Chem Biochem	298,814	500	1,000	8"	Chem Biochem	298,814	500	1,000	8"	Local chiller. See Note 1 below.
HH	1	Holton Hall	ADMIN/CLASS	1900/1989	CHW	South	21,894	70	140	4"	South	21,894	70	140	4"	South	21,894	70	140	4"	See Note 1 below.
JU	1	Justin Hall	ADMIN/CLASS	1960/2010	CHW	Chem Biochem	134,287	300	600	8"	Chem Biochem	150,663	529	1,057	8"	Chem Biochem	150,663	529	1,057	8"	See Note 1 below.Planned expansion of 16,376 sq-ft assumed by 2017.
K	1	Kedzie Hall	ADMIN/CLASS	1897	CHW	South	36,925	100	200	6"	South	36,925	100	200	6"	South	36,925	100	200	6"	See Note 1 below.
KG	1	King Hall	LABS	1966	CHW	Chem Biochem	37,062	250	500	6"	Chem Biochem	37,062	250	500	6"	Chem Biochem	37,062	250	500	6"	Fume hoods are present. See Note 1 below.
KF	1	Kramer Dining Center	RESTAURANT	1960	CHW	North	36,334	150	300	6"											See Note 1 below. Local HVAC by 2017.
UN	1	KSU Union	MULTI-USE	1956/1995	CHW	South	219,378	610	1,220	10"	South	219,378	610	1,220	10"	South	308,378	1,200	2,400	10"	See Note 1 below. Addition of 89,000 sf by 2025.
ML	2	Marlatt Hall	DORM	1964	CHW	North	101,488	250	500	10"											See Note 1 below. Will have local chillers by 2017.
SH	2	Shellenberger Hall	SCIENCE	1960	CHW	Chem Biochem	44,552	200	400	6"	Chem Biochem	44,552	200	400	6"	Chem Biochem	44,552	200	400	6"	See Note 1 below.
TH	2	Throckmorton Hall	SCIENCE	1981/1994	CHW	North	394,712	1,150	2,300	10"	North	394,712	1,150	2,300	10"	North	394,712	1,150	2,300	10"	CHW line is undersized. See Note 1 below.
WD	1	Ward Hall	ADMIN/CLASS	1961/1972	CHW	North	34,304	260	520	Various	North	34,304	260	520	Various	North	34,304	260	520	Various	Nuclear Reactor within. See Note 1 below.
A	1	Anderson Hall	ADMIN/CLASS	1879	CHW	South	24,898	87	175	3"	South	49,795	175	349	6"	South	49,795	175	349	6"	South half on CHW loop. Has local chiller. Add entire building by 2017.
BT	1	Burt Hall	ADMIN/CLASS	1923	CHW/WU/Split	North	2,930	65	130	6"	North	29,297	103	206	6"	North	29,297	103	206	6"	Only 10% currently on the CHW loop. Add entire building by 2017. See Note 1 below.
EH	1	Eisenhower Hall	ADMIN/CLASS	1951	CHW/DX/WU	South	4,215	80	160	6"	South	42,149	148	296	6"	South	42,149	148	296	6"	Only 10% currently on the CHW loop. Add entire building by 2017. See Note 1 below.
HZ	1	Holtz Hall	ADMIN/CLASS	1876	CHW/WU	South	622	20	40	2.5"	South	6,220	22	44	2.5"	South	6,220	22	44	2.5"	Only 10% currently on the CHW loop. Add entire building by 2017. See Note 1 below.
SC	1	Seaton Court	ADMIN/CLASS	1874/1977	CHW	South	20,073	50	100	2.5"	South	40,145	141	282	4"	South	40,145	141	282	4"	Only partially on the CHW loop. Assume 50%. Add entire building by 2017. See Note 1 below.
S	1	Seaton Hall + Seaton East	ADMIN/CLASS	1909/1922/1959	CHW	South	109,009	380	760	4", 8"	South	343,018	1,204	2,407	8", 8"	South	343,018	1,204	2,407	8", 8"	Only partially on the CHW loop. Assume 50%. Add entire building by 2017. See Note 1 below. College of Architecture addition of 125,000 sf by 2017.
WA	2	Waters Hall	SCIENCE	1923/1964	WU/Central	North	3,108	14	28	Unknown	North	3,108	14	28	Unknown	North	155,397	691	1,381	8"	Only 2% currently on the CHW loop. Add entire building by 2025.
W	1	Willard Hall	ADMIN/CLASS	1939	CHW/WU	Chem Biochem	3,437	80	160	8"	Chem Biochem	85,923	301	603	8"	Chem Biochem	85,923	301	603	8"	Only 4% currently on the CHW loop. Add entire building by 2017. See Note 1 below.
BH	1	Bluemont Hall	SCIENCE	1981	RTU						Chem Biochem	106,167	472	944	8"	Chem Biochem	106,167	472	944	8"	
D	1	Dickens Hall	ADMIN/CLASS	1908	WU						Chem Biochem	23,098	81	162	4"	Chem Biochem	23,098	81	162	4"	
ES	1	East Stadium	AUDITORIUM	1928	WU/Split						South	34,700	116	231	4"	South	34,700	116	231	4"	Welcome Center done end of 2012.
LS	1	Leasure Hall	ADMIN/CLASS	1908	WU/Central						Chem Biochem	28,690	101	201	4"	Chem Biochem	28,690	101	201	4"	
WS	1	West Stadium	AUDITORIUM	1938	WU/Split						South	30,500	102	203	6"	South	30,500	102	203	6"	Theater done end of 2012.
BUX	2	Bushnell Annex	LABS	Unknown	Electric						North	1,993	10	19	2"	North	1,993	10	19	2"	Possible demolition.
BU	2	Bushnell Hall	LABS	1949	Unknown						North	19,362	94	189	4"	North	19,362	94	189	4"	
CL	2	Call Hall	SCIENCE	1963	FCUs						North	55,190	245	491	6"	North	55,190	245	491	6"	Fairly new system w/ outside chiller.
	1	College of Business	ADMIN/CLASS	Planned							Chem Biochem	140,000	491	982	8"	Chem Biochem	140,000	491	982	8"	Planned 140,000 sq-ft building.
DY	2	Dykstra Hall	SHOP/OFFICE	1955	WU						North	35,396	106	211	6"	North	35,396	106	211	6"	
MS	2	General Richards B. Meyers Hall	ADMIN/CLASS	1943	WU						North	32,288	113	227	4"	North	32,288	113	227	4"	
ISC	2	International Student Center	ADMIN/CLASS	1977	Central/FCUs						North	5,057	18	35	3"	North	18,057	63	127	3"	Planned expansion of 13,000 sq-ft.
LSP	2	Leadership Studies Building	ADMIN/CLASS	2011	RTUs						Chem Biochem	31,005	109	218	4"	Chem Biochem	31,005	109	218	4"	New facility.
UM	2	Umberger Hall	ADMIN/CLASS	1956	WU/Central						North	40,888	143	287	4"	North	40,888	143	287	4"	
WAX	2	Waters Hall Annex	SCIENCE	Unknown	WU/Central						North	14,427	64	128	4"	North	14,427	64	128	4"	
WB	2	Weber Hall	AUD/SCIENCE	1988	RTU/DX						North	139,120	535	1,070	8"	North	139,120	535	1,070	8"	Dirt arena.
BA	1	Beach Art Museum	MUSEUM	1996	CHW											South	33,839	94	188	4"	Two buildings with local chillers.
C	1	Calvin Hall	ADMIN/CLASS	1908	Unknown											South	43,787	154	307	6"	
	2	Classroom Building	ADMIN/CLASS	Planned												North	66,000	232	463	6"	Planned 66,000 sq-ft building.
DC	1	Danforth and All Faiths Chapels	CHURCH	1949	CHW											South	7,883	23	46	3"	CHW provided from McCain.
F	1	Fairchild Hall	ADMIN/CLASS	1894	WU/Central											South	44,508	156	312	6"	Use FCUs.

Kansas State University - Chilled Water Master Plan
Building List
Proposed Chilled Water Distribution

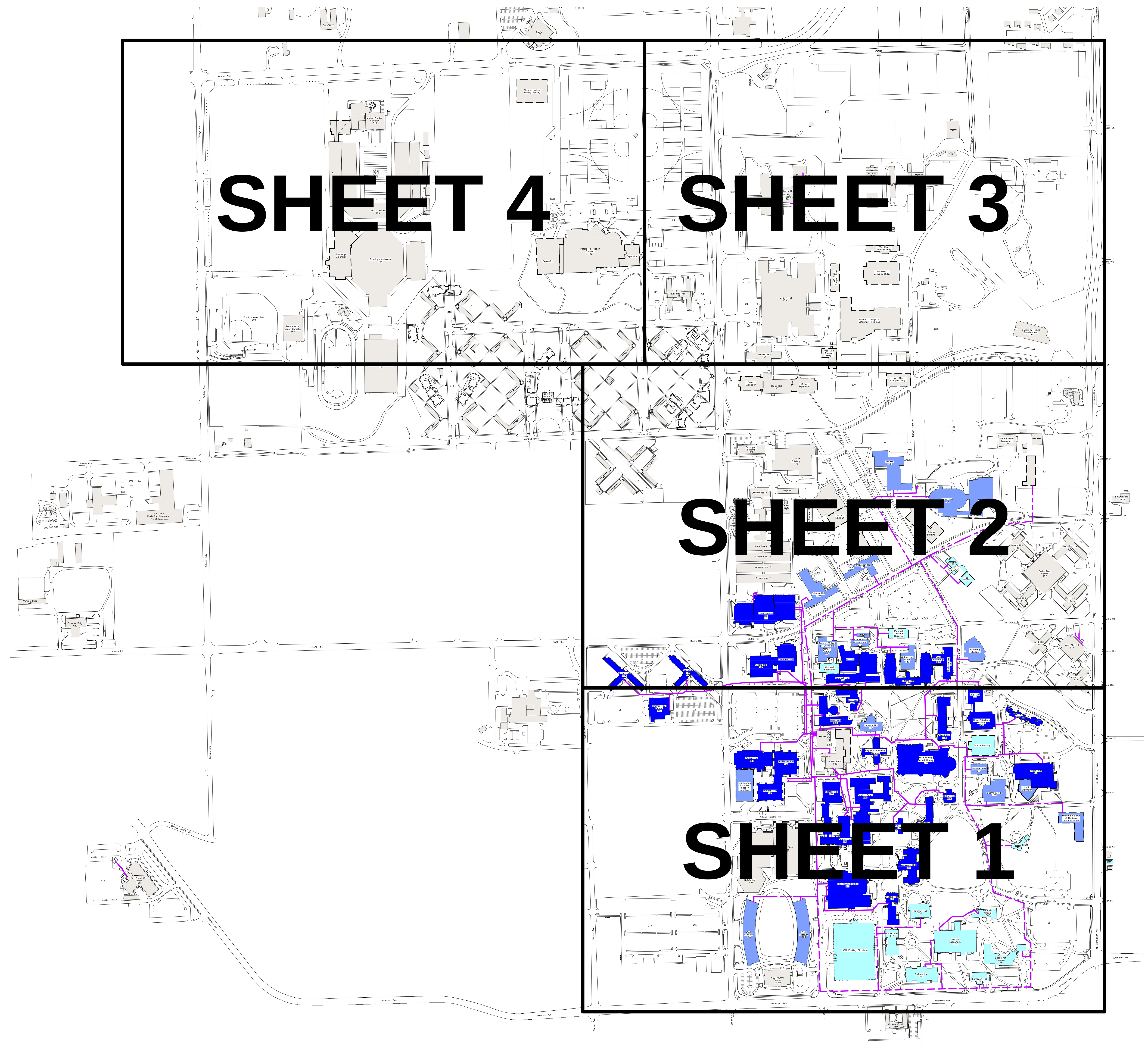
						2011 Data					Proposed for 2017					Proposed for 2025					
Property Code	Sheet No.	Property Name	Occupancy Type	Year Constructed	Existing A/C Type	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	CHW Loop	Net Area (sq-ft)	Load (tons)	Flow (gpm)	Line Size (inches)	Notes:
KPS	1	K-State Parking Structure	OFFICE	2010	Split											South	12,287	34	68	3"	New structure w/ A/C in one corner.
M	1	McCain Auditorium	AUDITORIUM	1970	CHW											South	94,176	314	628	6"	Local chillers. Serves Danforth Chapel.
N	1	Nichols Hall	SCIENCE	1985	CHW											South	55,523	247	494	6"	Local chiller is undersized.
	1	North of Dickens - New Building	ADMIN/CLASS	Planned												Chem Biochem	10,000	35	70	3"	Planned new building by 2025.
PR	1	President's Residence	RESIDENCE	1922	CHW											Chem Biochem	7,901	13	26	2.5"	Local chillers outside.
T	1	Thompson Hall	SCIENCE	1922	WU/Central											South	21,158	94	188	4"	
AC	1	Alumni Center	AUDITORIUM	2002	Unknown																
AFH	1	Ahearn Field House	GYM/FIELDHOUSE	1951	None																Not required.
KFS	4	Bill Snyder Family Stadium	GYM/FIELDHOUSE	1968	WU																A/C in skyboxes. Current project to add to Football Complex. Local chillers.
BC	4	Bramlage Coliseum	AUDITORIUM	1988	DX																R22 to be phased out.
BC	4	Bramlage Coliseum Addition	AUDITORIUM	New	Unknown																Current project. Local chillers.
BD	2	Boyd Hall	DORM	1951	Unknown																Housing - Not to be considered.
BR	4	Brandeberry Indoor Complex	GYM/FIELDHOUSE	1980	None																Distance.
CCD	3	Center for Child Development	CHILD CARE	2010	DX																Distance. May demolish for research building.
REC	4	Chester E. Peters Recreation Complex	GYM/FIELDHOUSE	1980/1995/2012	CHW																Local chillers. Renovation in progress, adding 88,400 sq-ft. Distance from Cooling Plant to be considered.
CC	N/A	College Court	ADMIN/CLASS	Unknown	Unknown																Distance.
DV	2	Davenport Building	SHOP/OFFICE	Unknown	Unknown																Housing - Not to be considered.
DF	2	Derby Dining Center	RESTAURANT	Unknown	Unknown																Housing - Not to be considered.
DO	2	Dole Hall	ADMIN/CLASS	1991	Electric																Addition of 60,000 sf planned beyond 2025.
ED	3	Edwards Hall	ADMIN/CLASS	1968	Zone																Known to have asbestos. Possible demolition.
EXF	N/A	Extension Forestry	SHOP/OFFICE	Unknown	Unknown																Distance
FG	1	Facilities Grounds	SHOP/OFFICE	Unknown	WU																To be demolished.
FS	2	Facilities Shops	SHOP/OFFICE	Unknown	Central Air																Small building.
FSB	2	Facilities Storage Building	WAREHOUSE	Unknown	None																No A/C required.
FD	2	Ford Hall	DORM	1967	Unknown																Housing - Not to be considered.
FMF	4	Frank Meyers Field	GYM/FIELDHOUSE	1955	None																No A/C required.
GHD	2	Greenhouse D Conservatory	SCIENCE	1907	None																No A/C required.
GY	1	Gymnasium	GYM/FIELDHOUSE	Unknown	None																Not on CHW loop per KSU review comments.
HB	3	Handball Building	GYM/FIELDHOUSE	Unknown	None																No A/C required.
HY	2	Haymaker Hall	DORM	1967	CHW																Housing - Not to be considered.
HST	2	Hoeflin Stone House	LABS	Unknown	Central																Nursery. Distance.
IPF	4	Indoor Practice Facility	GYM/FIELDHOUSE	1995	None																No A/C required.
	4	Indoor Rowing Facility	GYM/FIELDHOUSE	Planned																	Planned 10,000 sq-ft building with local HVAC.
JT	2/3/4	Jardine Apartments	APARTMENTS	Various	Unknown																Housing - Not to be considered.
GM	2	K-State Gardens Maintenance	SHOP	Unknown	None																Small building.
MO	2	Moore Hall	DORM	1967	CHW																Local chillers. Residence hall.
NA	1	Natatorium	GYM/FIELDHOUSE	1975	None																No A/C required.
BRI	3	Pat Roberts Hall	LABS	Unknown	CHW																High security. Must have it's own chillers.
PFS	2	Physical Facilities Storage	SHOP/OFFICE	Unknown	None																No A/C required.
PH	2	Pittman Building	WAREHOUSE	1967	CHW																Stand alone CHW system for refrigerated food storage.
PP	1	Power Plant	OFFICE	1928	WU																A/C for small office space only.
PU	2	Putnam Hall	DORM	1951	CHW																Local chillers. Residence hall.
SB	N/A	UFM Community Learning Center	ADMIN/CLASS	1960	Unknown																Distance.
VZ	2	Van Zile Hall	DORM	1926	CHW																Residence hall. Local chillers.
VFO	4	Vanier Football Complex	GYM/FIELDHOUSE	1972/2007	CHW																Local chillers.
	3	Vet-Med Complex																			
VMS	2	Coles Hall	LABS	1972	CHW																Local chiller. Planned expansion of 128,000 sq-ft.
VCS	3	Mosier Hall	LABS	Unknown	CHW																Local chillers.
VMT	3	Trotter Hall	ADMIN/CLASS	1973	CHW																Local chillers.
	3	Other	SCIENCE	Planned																	Local chillers. Planned addition of 168,500 sq-ft.
WH	2	West Hall	DORM	1967	CHW																Local chillers. Residence hall.
WEL	2	Wind Erosion Laboratory	LABS	Unknown	None																No A/C required.
		TOTALS					**2,299,817**	**7,307**	**14,614**			**3,335,033**	**11,696**	**23,392**			**4,078,584**	**15,178**	**30,355**		
	Note 1: Existing load estimated from 2010 JCI Facility Conservation Improvement Project.																				

Appendix B

Drawings

Stanley Consultants INC.

NORTH



LEGEND

- 2011 CHW LOOP
- 2017 CHW LOOP
- 2025 CHW LOOP
- PLANNED BUILDING
- 2011 CHW PIPING
- 2017 FUTURE CHW PIPING
- 2025 FUTURE CHW PIPING

KANSAS STATE UNIVERSITY – CHILLED WATER KEY PLAN

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SEE SHEET 2 FOR CONTINUATION

KANSAS STATE UNIVERSITY – CHILLED WATER MASTER PLAN SHEET 1

23782.01.00-\\CHG-FS1\PRJ-PRIVATE\KANSAS_STATE_UNIVERSITY\2378201\ACTIVE\11-CADD\KSU_CHW_PLAN_1.DWG

CADD 04-R3

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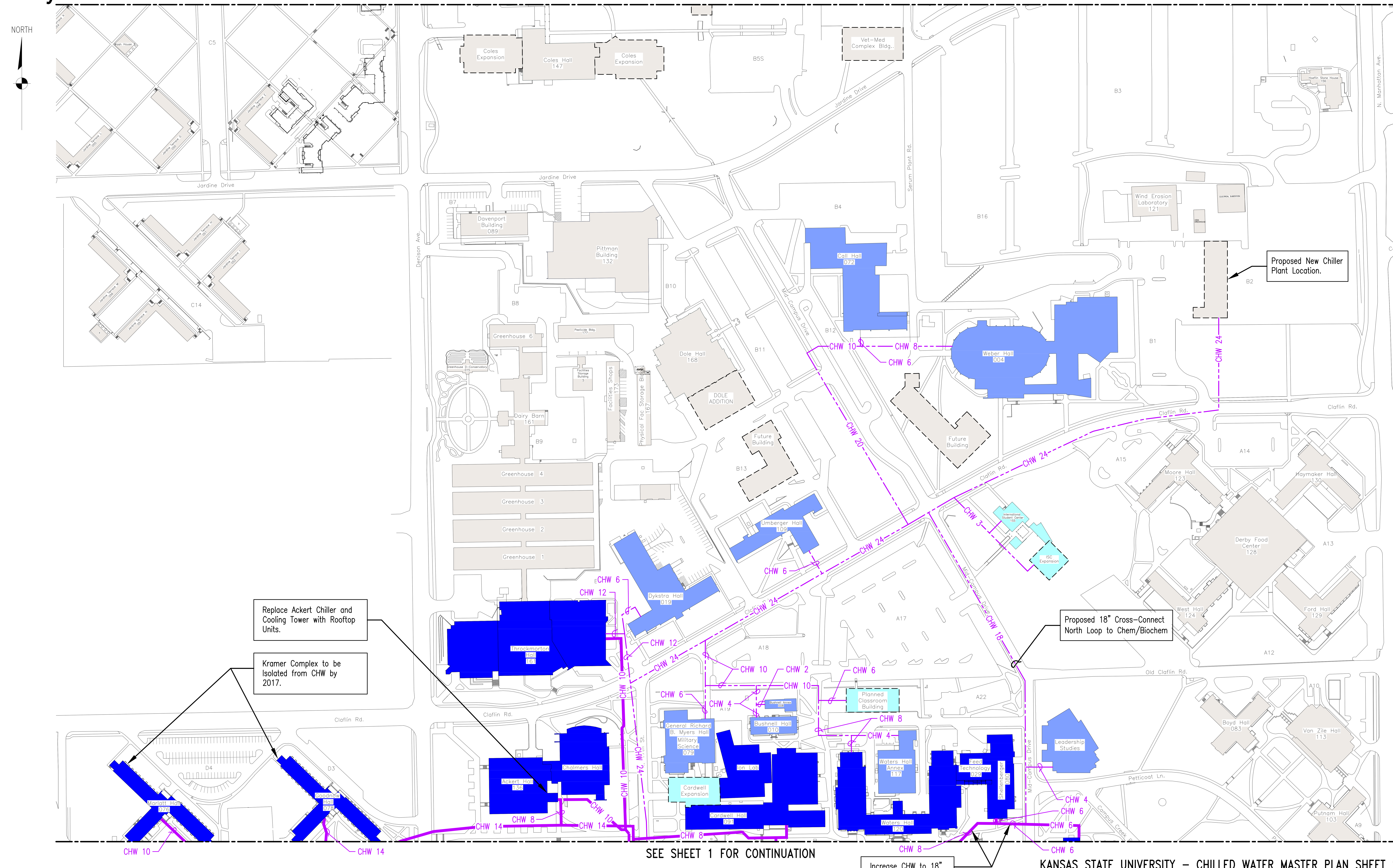
SEE SHEET 3 FOR CONTINUATION



SEE SHEET 1 FOR CONTINUATION

KANSAS STATE UNIVERSITY – CHILLED WATER MASTER PLAN SHEET 2

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SEE SHEET 4 FOR CONTINUATION

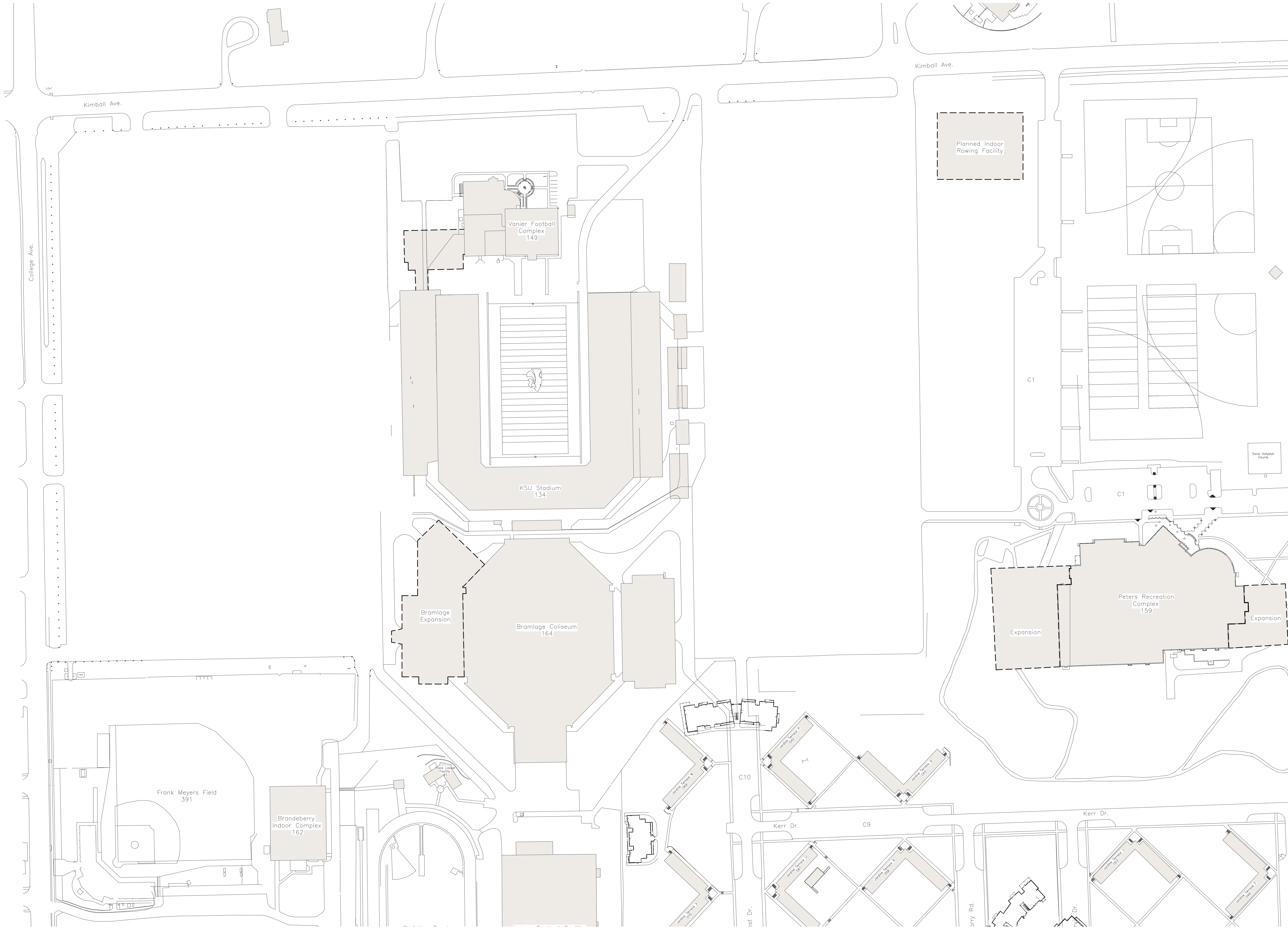
SEE SHEET 2 FOR CONTINUATION

KANSAS STATE UNIVERSITY – CHILLED WATER MASTER PLAN SHEET 3

23782.01.00-\\CHG-FS1\PRJ-PRIVATE\KANSAS_STATE_UNIVERSITY\2378201\ACTIVE\11-CADD\KSU_CHW_PLAN_3.DWG
CADD D4-R3

Stanley Consultants INC.

NORTH



SEE SHEET 3 FOR CONTINUATION

KANSAS STATE UNIVERSITY – CHILLED WATER MASTER PLAN SHEET 4

CADD 04-R3
23782.01.00-\\CHG-FS1\PRJ-PRIVATE\KANSAS_STATE_UNIVERSITY\2378201\ACTIVE\11-CADD\KSU_CHW_PLAN_4.DWG

Appendix C

Equipment Service Life

Equipment Service Life

Steam and Hot Water Systems	Service Life
Boilers (water tube)	40 years
Boilers (fire tube)	25 years
Heat Exchangers (shell and tube)	24 years
Pumps (condensate)	15 years
Pumps (pipe mounted)	20 years
Pumps (base mounted)	20 years
Condensers (air cooled)	20 years
Steam Turbines	30 years
Centrifugal Fans	25 years
Axial Fans	20 years
Pre-Insulated Underground piping	40 years
Pre-Insulated Underground piping (condensate)	30 years
Tunnels	75 years
Chilled Water Systems	
Packaged Chillers (centrifugal)	35 years
Absorption Chillers (steam)	23 years
Cooling Towers (galvanized metal - SS)	23 years
Replace Fill at 10-15 years.	
Cooling Towers (ceramic)	34 years
Condensers (evaporative)	20 years
Condensers (air cooled)	12-15 years
Pumps (base mounted)	20 years
Pumps (pipe mounted)	20 years
Fans (centrifugal)	25 years
Fans (axial)	20 years
Chilled Water Piping	50 years

Appendix D

Cooling Tower Information

/ **Marley MS** *Cooling Tower* /

SPX

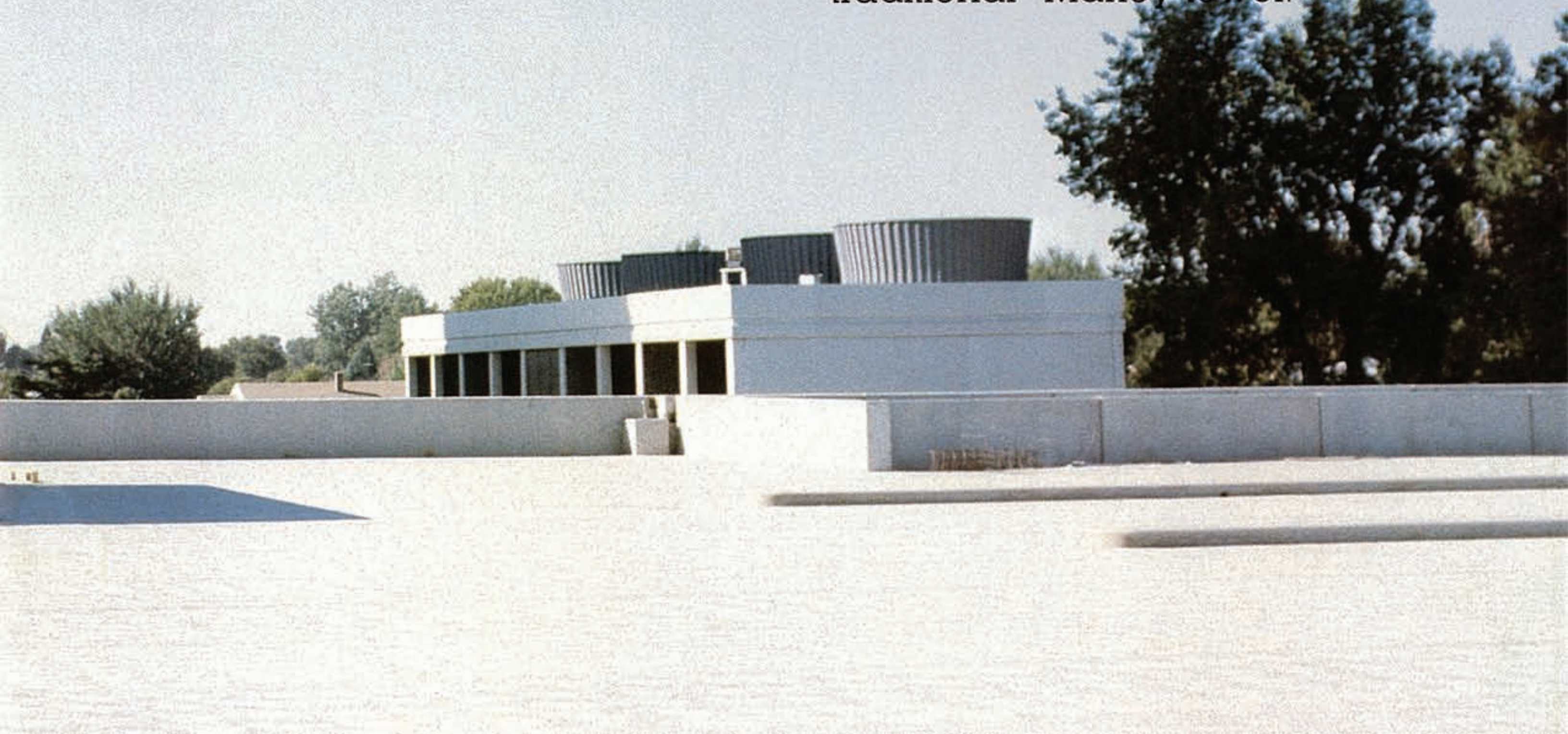
COOLING TECHNOLOGIES

SPX COOLING TECHNOLOGIES

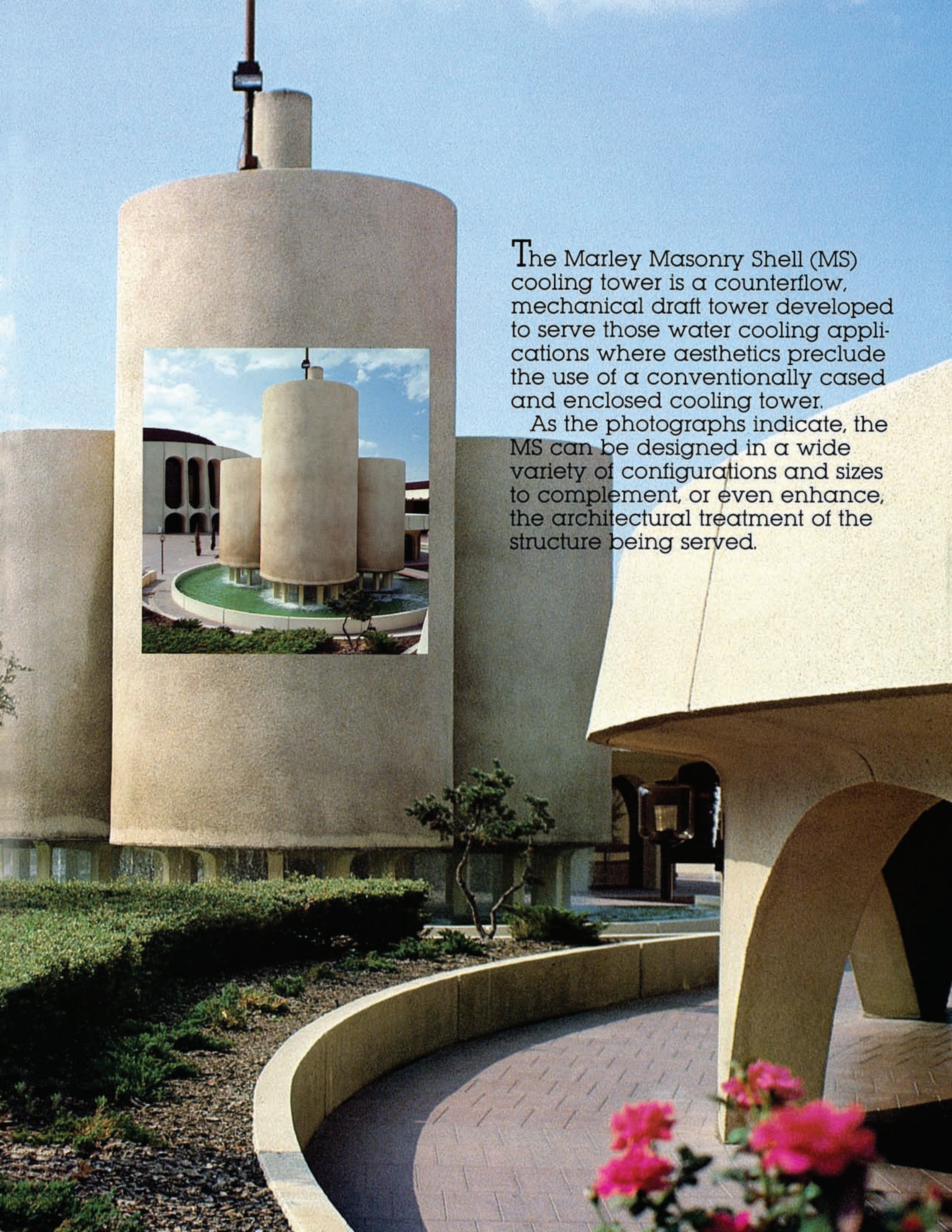
SPX Cooling Technologies has worldwide recognition as the pacesetter in the field of water cooling technology. Unique within its industry in the scope of products and services offered, we design and manufacture cooling towers of virtually any capacity and configuration. More than 400 Marley tower models are available to service the application requirements of air conditioning, industrial processing and electric generation. More simply stated, there's a Marley cooling tower for almost any conceivable water cooling need — from as little as 15 gallons per minute to more than 300,000 gallons per minute.

In the area of cooling tower design, Marley believes that form must yield to function — in most situations. After all, the exterior appearance of a cooling tower is not of primary importance in an industrial application. Such factors as first cost, operating and maintenance costs and overall practicality far outweigh aesthetic considerations.

Conversely, there are situations in which aesthetics become very important, in addition to the more practical elements of function and economy. In those instances Marley can design a cooling tower, in cooperation with the architect, that is a beautiful, integral part of an overall architectural plan — without sacrificing the high quality inherent in a "traditional" Marley tower.

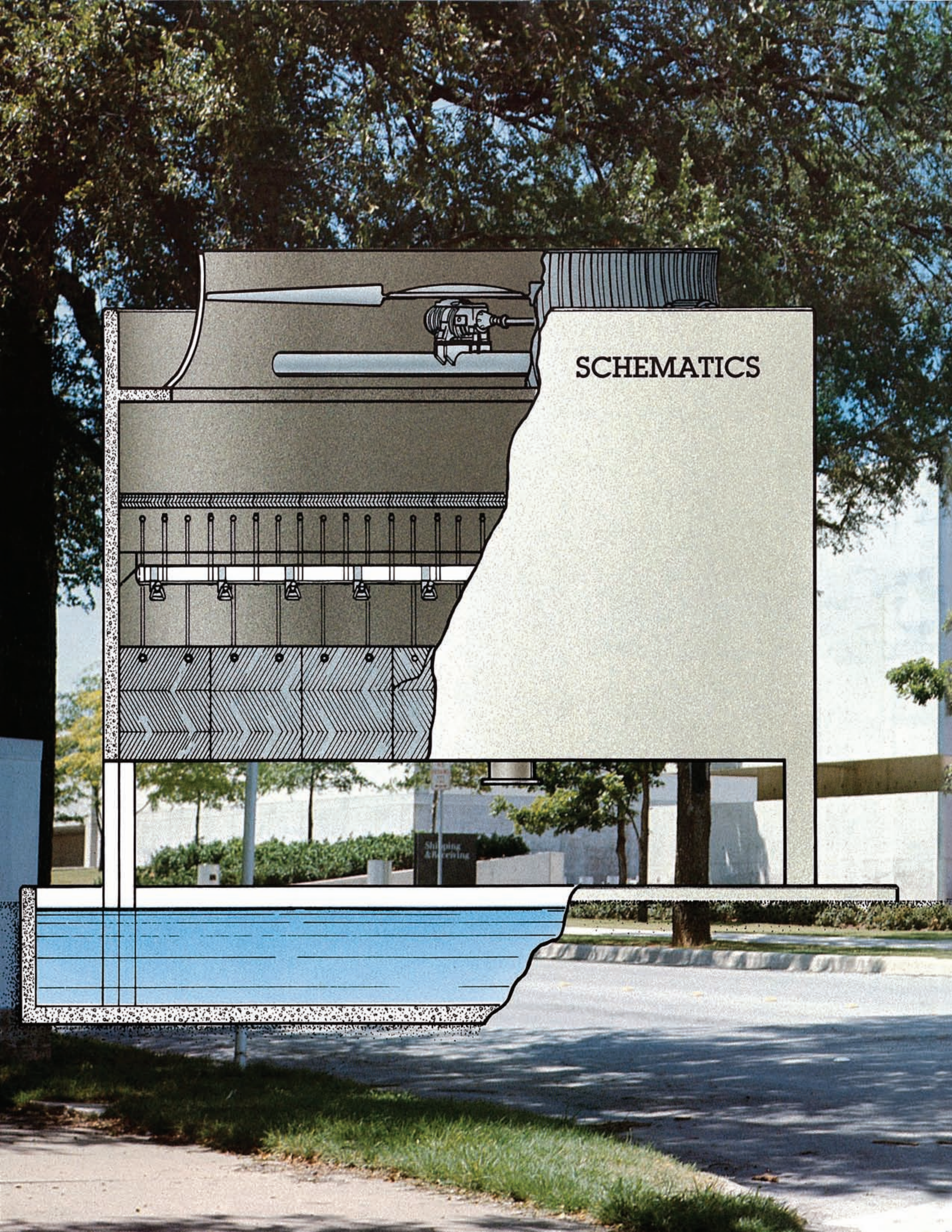


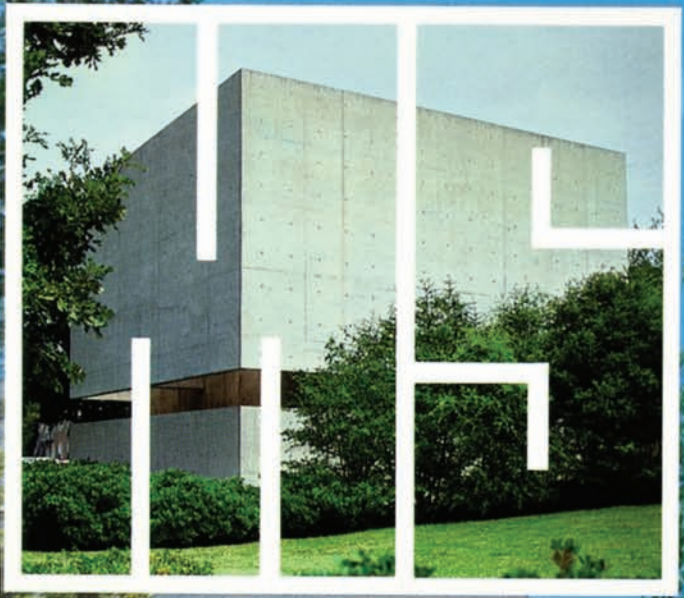
INSTALLATIONS



The Marley Masonry Shell (MS) cooling tower is a counterflow, mechanical draft tower developed to serve those water cooling applications where aesthetics preclude the use of a conventionally cased and enclosed cooling tower.

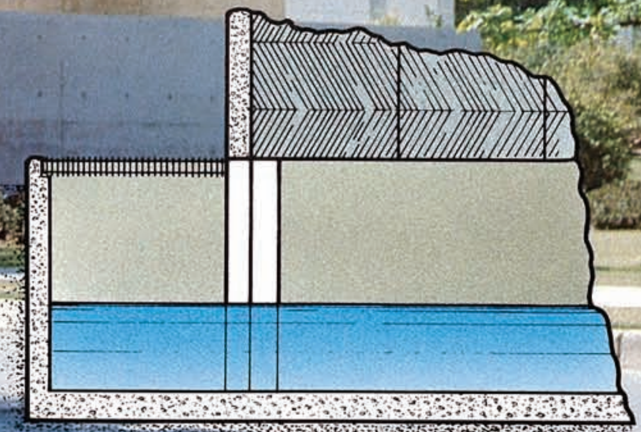
As the photographs indicate, the MS can be designed in a wide variety of configurations and sizes to complement, or even enhance, the architectural treatment of the structure being served.


SCHEMATICS



Like all Marley cooling towers, the MS is the end-product of a simple but highly successful three-part formula: 1) structural and mechanical integrity; 2) design and construction flexibility; and 3) on-line thermal capability.

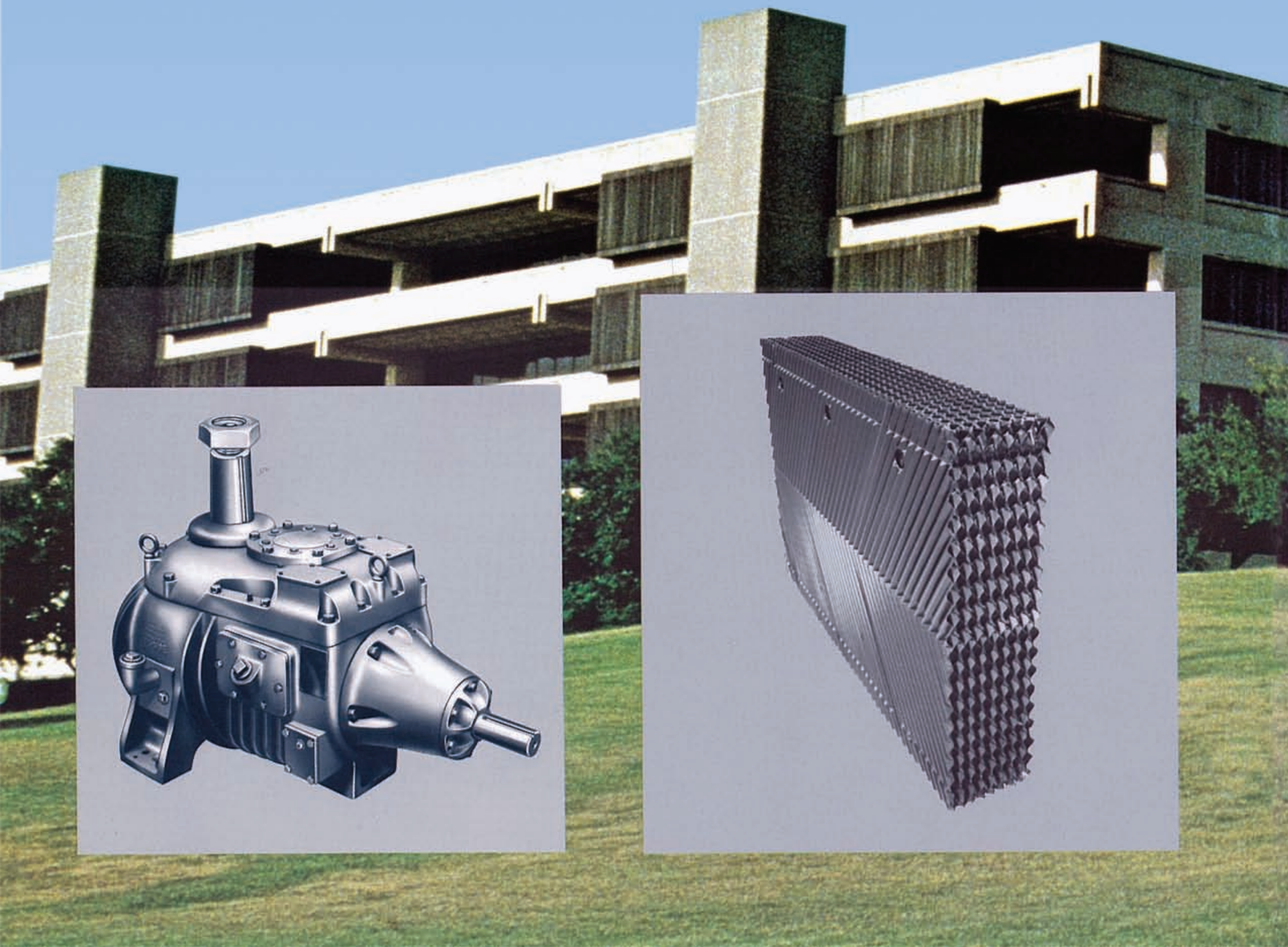
Mechanical equipment, fill, drift eliminators and other industrial rated components are the same as those used in Marley's larger Class 600 crossflow and Class 800 counterflow cooling towers. All major components, except the electric motor, are designed and manufactured by Marley, helping to assure meaningful performance projections and relieving the user of multiple warranty considerations.



COMPONENTS

FILL: Marley MC high performance PVC film fill sheets are thermoformed at the Marley factory to exacting quality and strength standards. Maximum performance and clog resistant designs are both available for a wide range of thermal and water quality requirements.

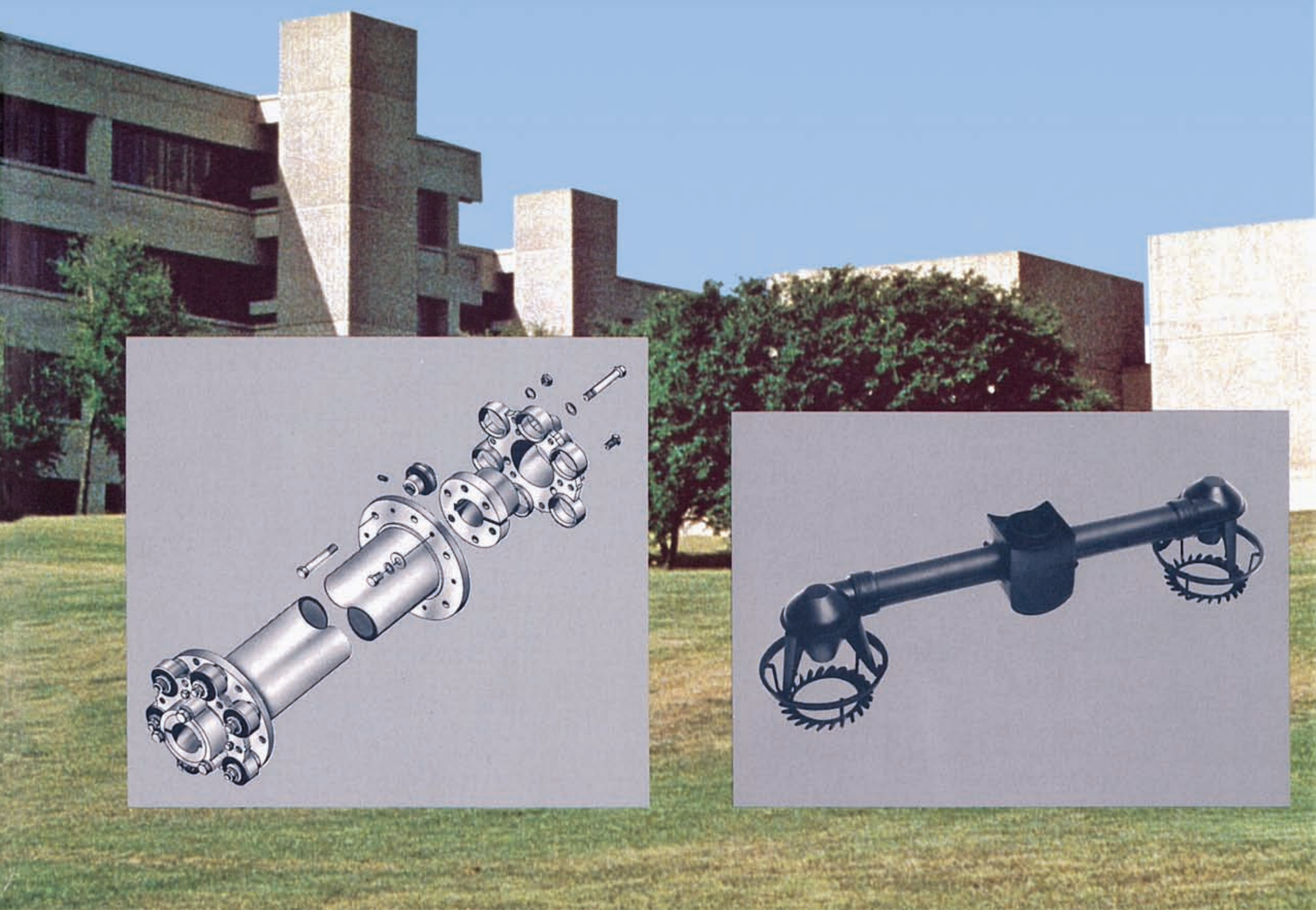
ELIMINATORS: Marley XCEL® drift eliminator panels—formed from PVC sheets into a cellular configuration—offer the lowest drift rates in the industry. They significantly lower air pressure losses, reducing fan horsepower requirements.



GEAREDUCERS: Marley Geareducer® drives are the industry quality standard. They are designed to meet or exceed the requirements of CTI STD-111 and AGMA Std, 420.4, and are run-in under load prior to shipment. Numerous reduction ratios are available so that horsepower is applied at optimum fan speed.

FANS: Designed, tested and manufactured by Marley, fan materials include cast aluminum alloy, glass reinforced polyester and glass reinforced epoxy. Fan sizes and materials are selected to be compatible with individual application requirements.

DRIVESHAFTS: Rugged Marley manufactured driveshafts are built from stainless steel or carbon fiber composite tubes with stainless steel flanges. All Marley driveshafts are dynamically balanced at the factory to minimize operating vibrations.

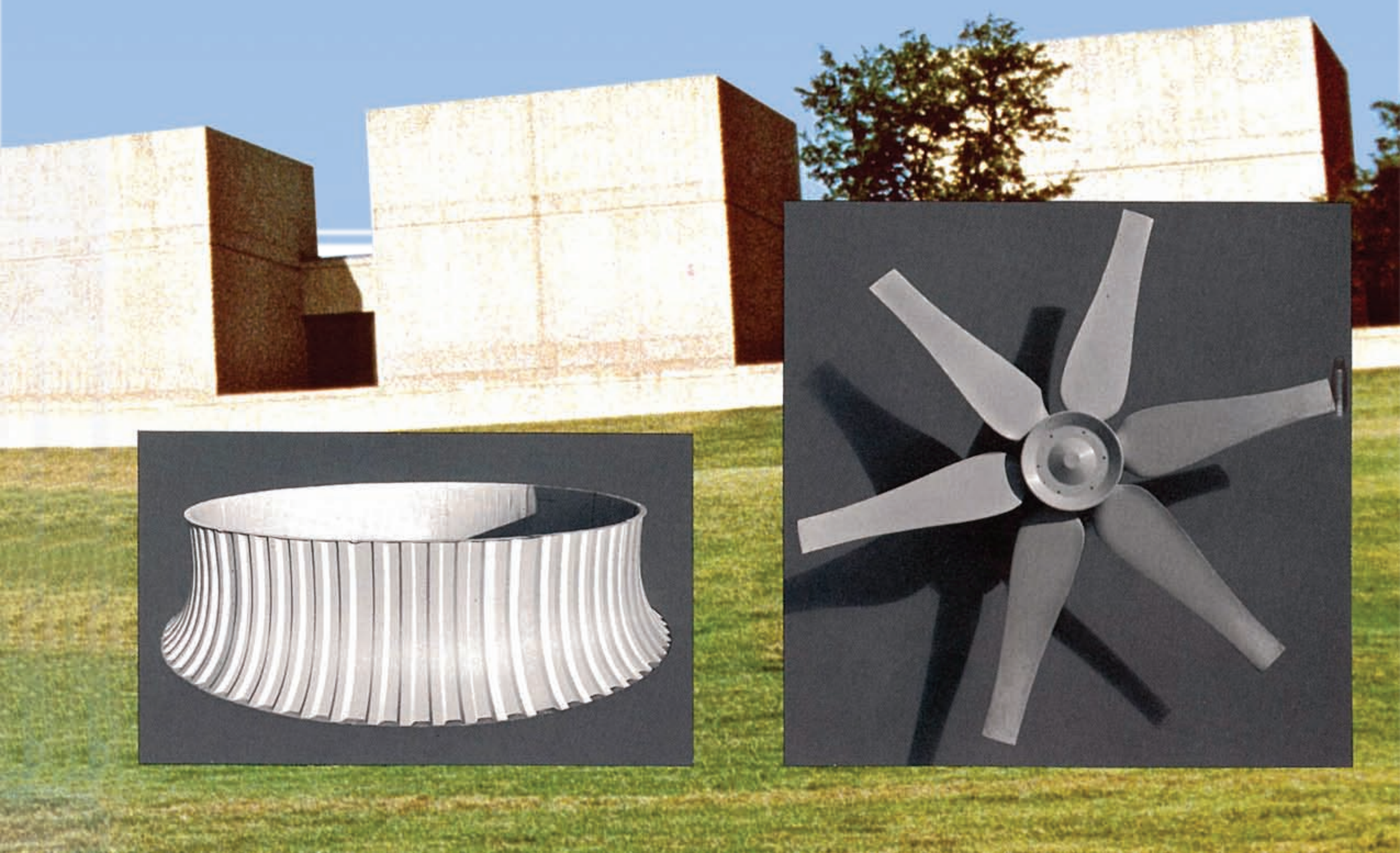


MECHANICAL EQUIPMENT SUPPORT: The Marley hot-dipped galvanized torque tube unitized support assures permanent alignment of the motor, driveshaft and Geareducer.

DISTRIBUTION SYSTEM: Marley-patented non-clogging, large diameter NS spray nozzles assure an unimpeded, uniform flow with min-imal operating pump head. Plus, they free you from the expense and nuisance of cleaning clogged nozzles.

FAN CYLINDERS: Marley FRP fan cylinders feature venturi shaped eased inlets and close fan tip clearance for maximum efficiency. If required, a concrete fan cylinder may be utilized.

STRUCTURE: Normal structure consists of 8" thick concrete exterior walls and interior cell partitions. Cast-in-place fan decks are normally 6" slabs. A furnished torque tube spans the full fan deck opening for mechanical equipment support, thereby avoiding concrete beam obstructions.



SPECIFICATIONS

COOLING TOWER: Furnish and install (1) Induced Draft Counterflow Cooling Tower. Cooling tower shall be_______ft. long x _______ft. wide x _______ ft. overall height with a maximum operating weight of_______lbs. Cooling tower shall consist of______fan cells with a maximum of______total fan horsepower and a maximum pump head of_______ft.

Other contractor(s) will furnish all external piping, valves, pumps, electrical equipment other than cooling tower fan motors, wiring, controls, etc. all in accordance with general overall dimensions to be supplied by cooling tower manufacturer. All internal components of cooling tower as described following will be furnished and installed by the cooling tower manufacturer.

CAPACITY: Cooling tower shall be selected and guaranteed to cool______GPM of water from _______°F to _______°F at _______°F entering wet bulb temperature.

MECHANICAL EQUIPMENT: Mechanical equipment shall be designed specifically for cooling tower usage and shall be mounted on a rigid unitized HDG steel support to assure permanent drivetrain alignment. Cooling tower manufacturer shall be responsible for equipment warranty.

FANS: Fans shall be of a multi-blade propeller type and blades shall be constructed of solid glass reinforced polyester, cast aluminum alloy or hollow glass reinforced epoxy. Hubs shall be HDG steel cast iron or aluminum plate. Blades shall be individually adjustable for required pitch angles.

DRIVESHAFTS: Driveshaft tubes and flanges shall be manufactured of type 304 stainless steel. Couplings shall be hot dip galvanized cast iron, joined to the driveshaft by flexible neoprene bushings and cadmium plated steel inserts. Connecting hardware shall be 300 stainless steel. Driveshaft assemblies shall be dynamically balanced at the factory at full motor speed.

SPEED REDUCERS: Speed reducers shall be provided for right angle fan drive and shall be designed to AGMA standards for continuous duty operation, capable of reverse operation. Oil fill and drain lines are to be extended outside the fan cylinder to an oil level sight glass.

ELECTRIC MOTORS: Electric motors shall be________ speed, single winding, variable torque, ______ hp maximum, TEFC, and specially insulated for cooling tower duty. Speed and electrical characteristics shall be ______ RPM, ______ phase, ______ hertz, ______ volts. If the load applied to the motor exceeds 90% of the nameplate rating, then the motor shall have a 1.15 service factor and the service factor beyond 1.0 shall not be considered available for load.

FILL: Heat transfer fill media shall be crosscorrugated 20 mil PVC sheets supported by stainless steel tubes which, in turn, are suspended by stainless steel tension hangers from concrete support beam members.

DRIFT ELIMINATORS: Drift eliminators shall be supplied in a 3 pass cellular arrangement of bonded 17 mil PVC sheets. Drift loss shall not exceed _______% of circulating water.

HOT WATER DISTRIBUTION SYSTEM: Hot water distribution system in each cell shall be supplied with a single interior inlet terminating 1'-0 below bottom of the tower filling. Materials will be of inert PVC and RTR and polypropylene piping supported by the support beams utilized to carry heat transfer fill media.

FAN CYLINDERS: Fan cylinders shall have eased inlet design and be of molded fiber reinforced polyester with a minimum height of 6' 0.

OPTIONS: Factory Mutual Approval. The tower shall include all design and material modifications necessary to meet the fire rating requirements of Factory Mutual. The product proposed shall be listed in the FM Approval Guide, latest edition.

Masonry structure options at owner's election:

1-Shell structure design shall be by cooling tower manufacturer.

2-Shell structure and cold water basin design shall be by cooling tower manufacturer.

3-Shell structure and cold water basin design shall be by cooling tower manufacturer. Shell structure construction including materials and labor shall be by cooling tower manufacturer.

4-Shell structure and cold water basin design shall be by cooling tower manufacturer. Shell structure and cold water basin construction including materials and labor shall be by cooling tower manufacturer.

WARRANTY: Warranty on all components against defective materials and workmanship will be extended for a period of one (1) year following initial operation but not exceeding eighteen (18) months from date of shipment. Components that may fail within warranty period shall be repaired and/or replaced including freight and installation labor.

Thermal testing of cooling tower will be done within one (1) year following structural completion in accordance with Cooling Technology Institute Acceptance Test Code CTI ATC 105. In the event test results indicate deficiency, manufacturer shall make alterations to overcome indicated deficiency and if such alterations are inadequate manufacturer shall refund a percentage of contract price proportional to tower deficiency.

SPX®

COOLING TECHNOLOGIES

7401 WEST 129 STREET
OVERLAND PARK, KANSAS 66213
UNITED STATES
913 664 7400
spxcooling@spx.com
spxcooling.com

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We're pulling the plug on the plume.
Plume Abatement and Water Conservation Solutions.

Marley

Let's Clear the Air…

For decades, cooling towers' cold-weather condensation plumes have been a major problem. At best, they're unsightly; at worst, they may impair visibility and waste water. Which make them a particular worry around airports and other environmentally sensitive areas.

At SPX Cooling Technologies, we've made it our mission to eradicate as much of the plume as possible – while conserving significant amounts of water along the way.

And we've succeeded.

Two Ways to Tame the Plume

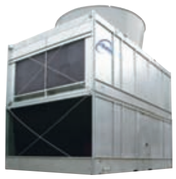
For years, SPX's coil-based, hybrid wet-dry cooling towers have been a highly popular choice. Now, our NCWD tower represents our most advanced application of this technology. SPX's hybrid technology adds a heated dry air stream to our coil system, keeping the plume undersaturated, even upon mixture with the ambient air. Therefore, visible plume is practically eliminated.

Another option is our new ClearSky™ technology, which comes at plume abatement from a slightly different, but similarly effective, angle. ClearSky uses heat exchanger packs to radically reduce condensation and keep the plume in check.

Both solutions can also conserve substantial amounts of water. And no matter which solution you choose, you'll be helping to make "plume history" – by helping to make the plume, well… history.

Our Hardest Working Technologies in Plume Abatement and Water Conservation

NCWD: Assembled on Our Site, Not Yours



The new Marley® NCWD package cooling towers are configured for applications of 914 tons or greater – yet, remarkably, are factory assembled. This significantly broadens the usability of wet/dry towers from "critical applications only" to more mainstream projects and installations.

By combining direct contact (evaporative) and indirect contact (dry) heat exchangers in a parallel arrangement, the NCWD's crossflow system can result in water savings as high as 20%* versus conventional cooling towers – while markedly limiting visible plume.

In addition, the NCWD line offers:

- Energy-efficient operation
- Lower maintenance requirements
- Cost-effective installation
- For those using chemical water treatment, less blowdown and thus less chemicals

*Dependent on system operating conditions and local weather conditions.

ClearSky: Creating Clearer Views

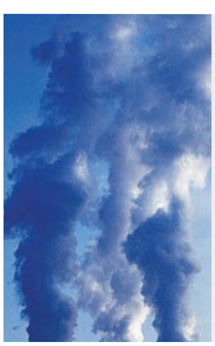
Our new, patented ClearSky system uses a series of PVC heat exchanger packs in the tower plenum to condense moisture before it escapes. The result: A substantial reduction in plume emission.

But there's more good news. ClearSky can reduce your cooling tower's water consumption by up to 20% annually*, making it the obvious choice anywhere that water conservation is a prime concern. And ClearSky can be used on either new or existing towers.

Because ClearSky is a fully integrated system, it's more reliable than exclusively coil-based systems, which means:

- Simpler hydraulics for simpler operation
- Fewer moving parts, requiring less maintenance
- No freezing worries

For a personalized economic payback analysis of the impact ClearSky can have on your planned or existing facility, and to sign up for updates on new ClearSky installations, visit spxcooling.com/clearsky.



If you're concerned with reducing visible plume or saving water, let SPX Cooling Technologies show you how to make our solution, *your solution.*

Visit spxcooling.com/clear for all the details.

SPX Cooling Technologies is a world-leading full-line cooling tower and air-cooled condenser manufacturer. The company provides exceptional-quality evaporative cooling towers, fluid coolers and evaporative condensers under the Marley, Balcke and Recold brand names.

SPX COOLING TECHNOLOGIES, INC
7401 WEST 129 STREET
OVERLAND PARK, KANSAS 66213
UNITED STATES
913 664 7400 | spxcooling@spx.com
spxcooling.com

In the interest of technological progress, all products are subject to design and/or material change without notice.

Clear-11