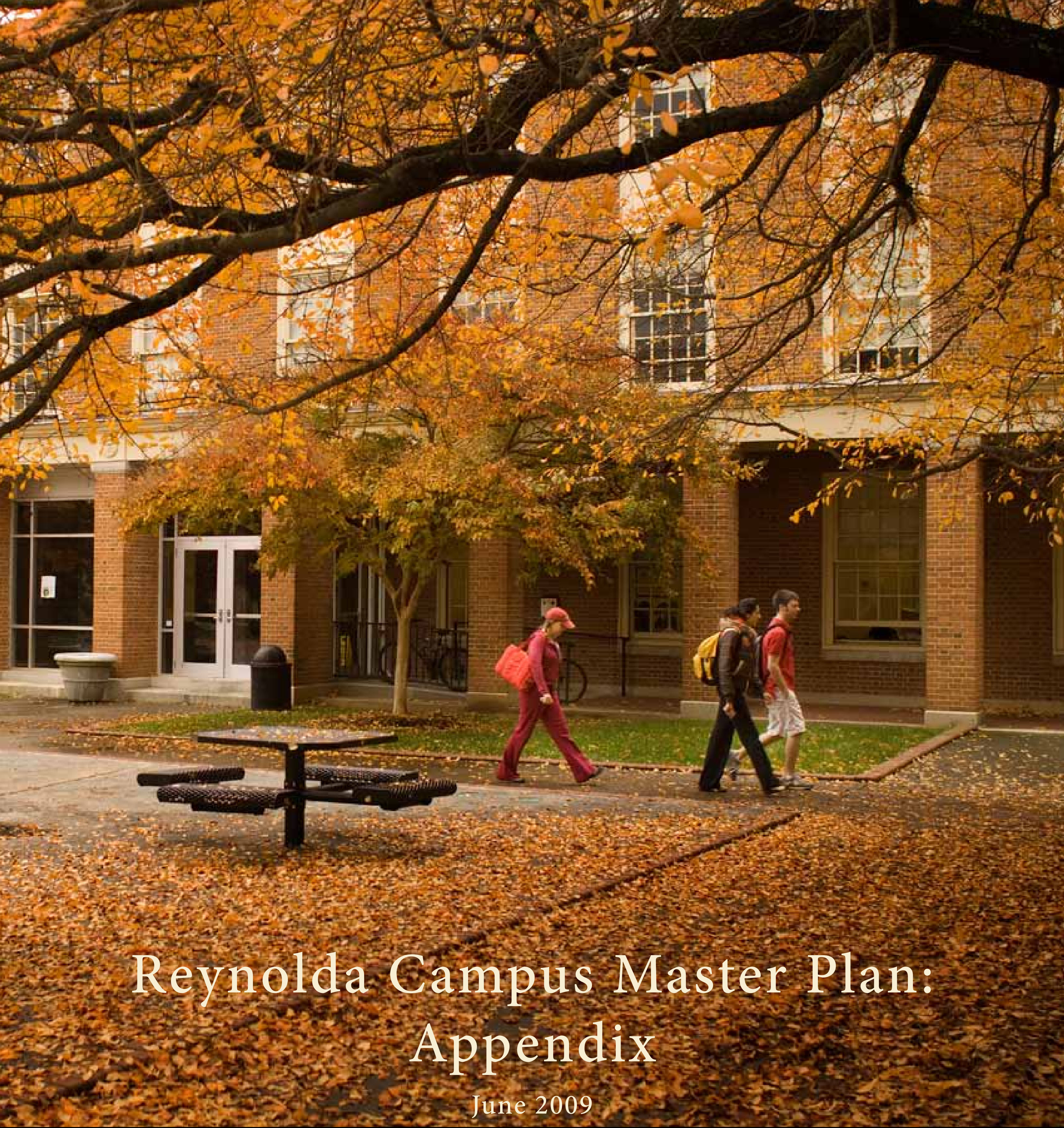


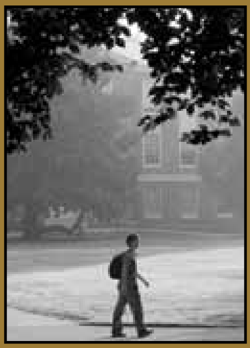
Reynolda Campus Master Plan: Appendix

June 2009

Wake Forest University

CONTENTS

The reports in this appendix were created as part of the planning process for the 2009 Reynolda Campus Master Plan. These detailed studies document important information about ecological and stormwater considerations; transportation and parking; and campus utilities and infrastructure. This information guided decision making during the planning process, and was instrumental in developing a successful master plan. As a result, the plan incorporates and reflects concepts and considerations related to each of these topics. These reports document valuable information about the campus, and are collected here for reference during the life of the master plan and its implementation.



Ecological & Stormwater Management Considerations

Biohabitats

Front to back: Benson University Center, Reynolda Hall, and Worrell Professional Center

1.0 INTRODUCTION

This report provides an overview of observations and assessment findings on ecological and stormwater management considerations at Wake Forest University (WFU). The summary reflects a combination of desktop and field analyses conducted by Biohabitats to better understand existing conditions and to develop strategies and recommendations on how to move forward with appropriate implementation strategies in conjunction with broader campus master planning activities.

Many of the observations, analyses, and recommendations presented in this report are related to preserving, restoring, or creating green infrastructure throughout the campus. Green infrastructure is a combination of natural and designed features that are linked and integrated across landscapes on campus. Green infrastructure provides a variety of ecological, engineering, and educational amenities such as habitat, plant diversity, heat island reduction, aesthetic enhancement, water conservation, and stormwater management.

Green infrastructure components addressed in this report generally fall into two categories: existing natural resources, which are discussed in the Ecological Characterization section; and engineered best management practices (BMPs), discussed in the last three sections of the report. Highlighted BMPs include features such as bioretention, porous pavement, rain gardens, cisterns, and constructed wetlands. These practices are designed to provide ecological diversity, aesthetic improvements, and stormwater management with an emphasis on water quality improvement and control of smaller, frequently-occurring storms.

This report is organized as follows:

1.0 Introduction
2.0 Ecological Characterization
3.0 Existing Stormwater Management Conditions
4.0 Local Stormwater Regulatory Framework
5.0 Recommended Green Infrastructure Approach
6.0 Treatment Opportunities
7.0 Implications of Master Plan Implementation
8.0 Summary of Key Considerations
9.0 References

2.0 ECOLOGICAL CHARACTERIZATION

Biohabitats performed a field investigation of ecological conditions on WFU property in September and October 2007, in conjunction with research and desktop analysis. Data from this effort was compiled, reviewed, and assessed, and was presented in the February 2008 *Wake Forest University Reynolda Campus Ecological Assessment Report* as part of this project effort. The intent of the report is to characterize the important ecological attributes of the site and to inform the Master Planning process regarding the nature of various ecological attributes. An overview of the findings and recommendations is provided below.

2.1 Forest Resources

As a general natural resource sustainability goal, the University is interested in conserving existing forest. Forest resources are integral to the campus green infrastructure network, providing habitat; open space and recreational areas; connections to the regional ecosystem;

teaching, research, and cultural opportunities; and stormwater management, among other benefits. A vigorous forest cover is also critical to maintaining healthy stream ecosystems and flood control. Practically all of the forested campus land is mature (50+ years old) and therefore valuable on both a local and regional basis. The time required to regain the current level of forest maturity and species structure makes these forest areas essentially irreplaceable.

The existing resource consists of forested habitat hubs and linkages. Hubs, or habitat patches, provide all three habitat requirements for survival – food, shelter and a suitable breeding location. Linkages, or corridors, provide organisms with a viable pathway between hubs. The hubs or patches provide habitat for birds and for terrestrial organisms, such as mammals (deer, raccoon, fox and opossum tracks seen onsite), reptiles and amphibians. Some avian species are more sensitive and require larger forest patches (generally contiguous areas greater than or equal to 10 acres, increasing to 40-50+ acres depending on the species) for breeding. Species of interest include neotropical migratory birds such as Purple Martin, Blue-headed Vireo, Blue-gray Gnatcatcher, Acadian Flycatcher, Eastern Kingbird, Blue-gray Gnatcatcher, and the Louisiana Waterthrush.

The migratory bird habitat brings to light that the hubs and linkages found on Wake Forest property also have an important regional ecological context. The regional forest structure has been impacted over time by clearing for agriculture and more recently for urban/suburban land uses. Nevertheless, there still exist hubs and linkages that provide refuge, food, and rearing areas for a range of species. These areas need to be maintained, and where feasible, enhanced to provide critical habitat and ecological sustainability. The most viable regional ecological connections tend to be to the northwest and west of the Reynolda campus.

Field assessment of forest patches and semi-quantitative rankings of their relative quality were developed and presented (Figure 1). Forest patches were assessed in terms of their function as hubs or corridors. Polygons were color coded based on rankings with darker shades being associated with patches of higher quality and lighter shaded patches being associated with areas exhibiting signs of disturbance and impact.

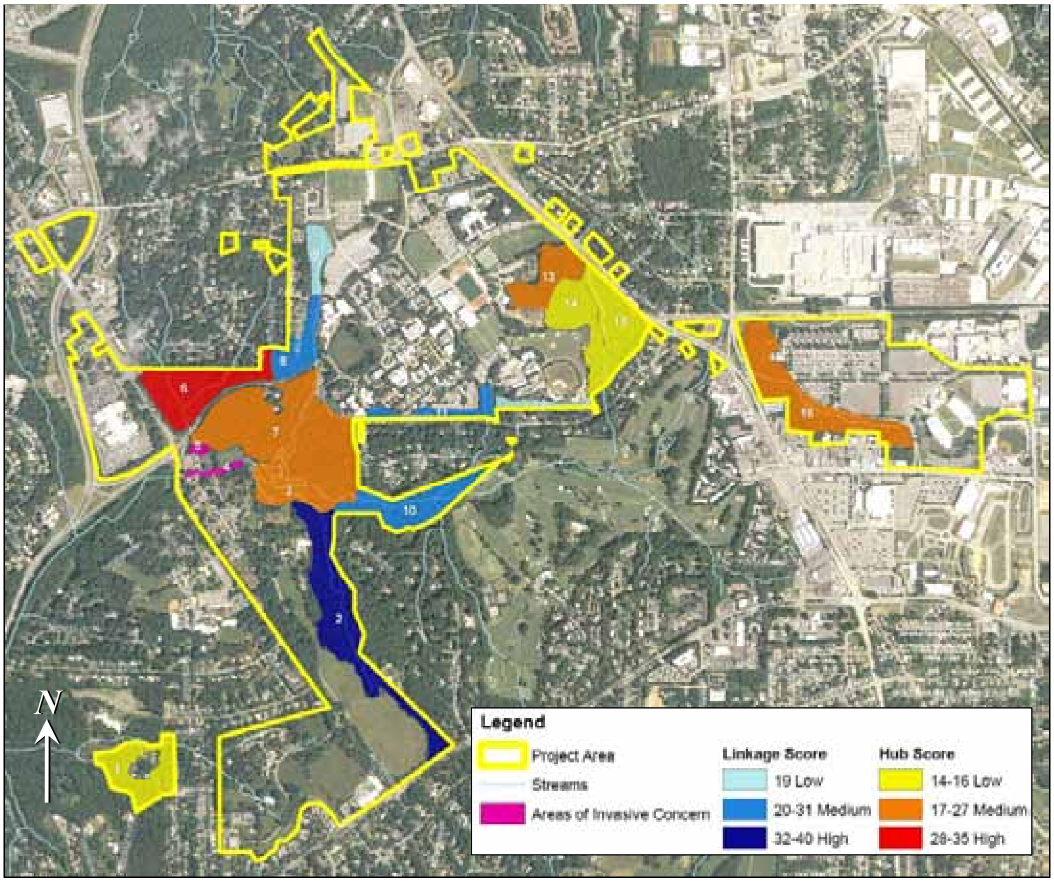


Figure 1. Habitat assessment of forest hubs and linkages.

Below is an overview of observations and recommendations for campus forest resources.

1. **Interior forest habitat** – Field investigation and subsequent research and analysis of forest hubs and linkages identified several areas of very high importance because of the interior forest habitat contained within. These interior forest areas are very important to the long-term ecological sustainability of the campus and the region. To the greatest extent possible, they should be protected from disturbance in order to maintain their ecological sustainability functions. Any development in the vicinity of these areas should be very carefully considered to minimize impacts.

    - West of University Parkway and east of various athletic facilities (throw field, golf facility and baseball field, etc)
    - Along Silas Creek west of the golf course and continuing west to Lake Katherine
    - Along smaller tributary to Lake Katherine south and east of Reynolda House
    - South of Wake Forest Road, from Reynolda Road entrance to rugby practice field, Lake Katherine and Faculty Drive

2. **Additional areas** – Other relatively intact hubs and linkages include the following areas:

   - The Lake Katherine wetland, which is potential habitat for bog turtles and should be surveyed to determine their presence.

   - The existing forested tract west of BB&T Field, along Silas Creek and University Parkway is a relatively mature (~60+ yrs), mixed hardwood/pine area. This area represents relatively good habitat (hub) for generalist avian and terrestrial species, in otherwise urbanized/impacted surroundings. The only "corridor" or land travel connection for terrestrial species between this area and other "patches" in the area is through the culvert under University Parkway.

   - The forest hub north of Wake Forest Road, from the Reynolda Road entrance to Allen Easley Drive has the highest quality of any hub on campus, with diverse and mature vegetation.

   - On both sides of stream east of Allen Easley Drive

   - Southwest of the President's residence

3. **Invasives** – Invasive vegetation species are present to varying extents in every forest patch. Ten invasive species were identified in this assessment, and there may be others. Invasive species control is recommended as a management strategy for all patches.

4. **Forest coverage** – It may be a challenge to enlarge the area of hubs and linkages on campus. However, incorporating minimum forest patch areas and widths of linkages into the campus master plan will help protect the future ecological sustainability of the campus.

2.2 Stream Resources

All but a small portion of Wake Forest University property holdings drain to Silas Creek, which is the major water feature of the Reynolda campus. Subwatershed delineations were developed to better understand watershed hydrology and the relative contributions to stream flows from non-University and University land holdings. The watershed context is also important in terms of understanding the conditions of the tributaries to Silas Creek and inferring the causes of the current stream conditions. As the University develops strategies for ecological restoration and conservation, watershed-based approaches are likely to be a part of the strategy.

A total of 11 watersheds were delineated to illustrate the relationship of all University land holdings with respect to regional hydrology and associated aquatic resources (Figure 2). Watershed area, watershed impervious cover, WFU-owned land area, and impervious area on WFU-owned lands were each calculated for the watersheds using GIS data coverage (Table 1). For this level of analysis, impervious cover was calculated based assumed impervious percentages within each land use, rather than direct measurement of impervious surfaces.

The Ecological Assessment Report contains a detailed discussion of the stream resources. Major highlights are provided below.

1. **Stability and habitat** – Stream stability and aquatic habitat vary dramatically between streams, and in some cases between different reaches of the same stream. Examples of the two extremes include the following:

- The stream with the best stability and aquatic habitat is the unnamed tributary flowing northward into Lake Katherine, on the east side of the Reynolda Estate. This stream could be used as an example or goal for the future condition of other tributaries on campus.

- At the other extreme, Silas Creek has been heavily impacted by stormwater runoff, leading to very unstable stream geometry and degraded aquatic habitat west of BB&T Field. Another example is the tributary east of Allen Easley Drive, which is steeply incised with steep, eroding banks along a portion of its length.

2. **Improvements** – Ways to improve stream stability and habitat should be explored and identified, in order to achieve sustainability of water quality and the aquatic habitat of the Silas Creek watershed. A detailed characterization of the channels is warranted in order to prioritize efforts. Improvements could include additional stormwater management, stream restoration, wetland restoration, and stream bank bioengineering.

3. **Wetlands** – Based on the mapping of hydric soils and the degree of incision of the stream channels that pass through some of those areas, jurisdictional wetland hydrology has been lost in some areas. Based on these conditions, wetland restoration opportunities exist. The extent of that potential is unknown. The advantages and disadvantages of restoration, from the University's perspective, should be explored.

Table 1. Watershed area, WFU ownership, and impervious cover.

Watershed	Total area (acres)	WFU-owned land (acres)	Existing conditions			
			Impervious cover (acres)	Impervious cover (%)	IC within WFU-owned land (acres)	IC within WFU-owned land (%)
1	140	28	33	23	4	14
2	117	111	42	36	39	35
3	145	129	58	40	54	42
4	86	33	26	30	4	13
5	332	95	234	70	57	60
6	74	49	5	7	4	8
7	207	74	44	21	16	22
8	81	41	21	25	8	18
9	431	11	238	55	3	30
10	640	73	207	32	9	12
11	170	22	35	21	3	13
Total	2424	667	942		202	

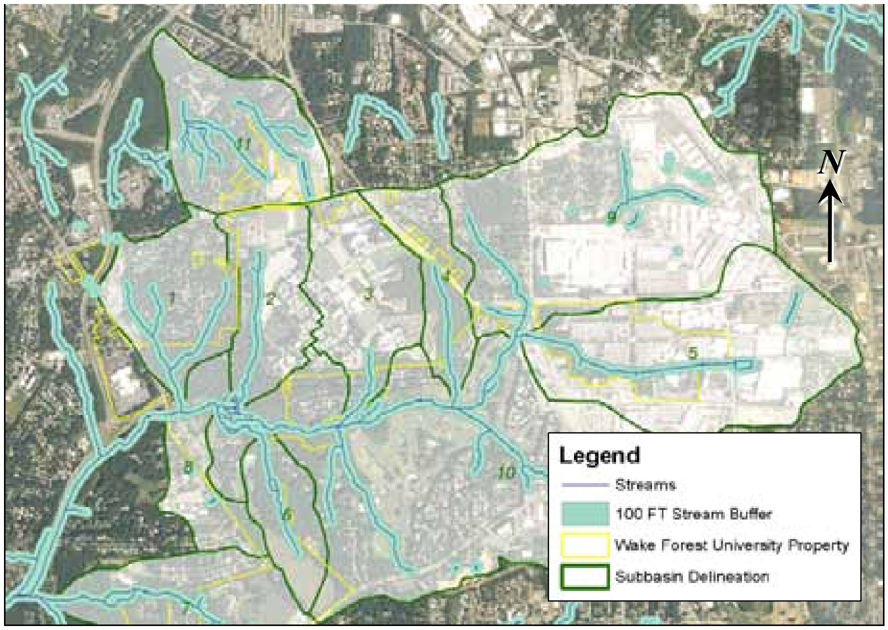


Figure 2. Watershed delineation.

2.3 Invasives

Invasive exotic species may be defined as non-native species that can adapt, grow and spread rapidly in an area, to the exclusion and displacement of native vegetation valuable to local fauna and ecological processes. During the field assessment process invasive species were commonly encountered. A comprehensive and exhaustive survey was beyond the scope of this project but a clear general account of the types and extent of invasive species present can be deduced. Observations and recommendations are as follows:

1. **Degree of infestation –** The presence of invasive, exotic grasses, shrubs and vines threatens both the ecological integrity and the aesthetic beauty of the majority of forested areas surveyed. These invasive species are either dominant or becoming the dominant plant species, especially along the streams. On a scale of 1 (very light infestation) to 10 (totally dominated by invasives), the current level of infestation is estimated at this time to be low (2-3) in approximately 50% of the forested areas and high (7-9) in the remaining 50%.

2. **Species documented** – Species documented include kudzu (*Pueraria lobata*), wisteria (*Wisteria sinensis*), Chinese privet (*Ligustrum sinense*), English ivy (*Hedera helix*), and Japanese stilt-grass (*Microstigeum vimenium*), all of which have been ranked as "severe threat" by the North Carolina Botanical Garden. A more complete inventory is contained in the Ecological Assessment Report.

3. **Horticultural shrubs** – In addition, assorted escaped horticultural shrub species have been observed in forested areas, especially those adjacent to residential neighborhoods.

Overall, the forested areas and streams on campus are very valuable assets, both aesthetically and ecologically. An invasive species control plan would further enhance the quality of habitat and the aesthetics of the campus. The invasive species already present will continue to spread and displace native vegetation unless the expansion of the infestation is arrested and the remaining invasive population is controlled and eradicated. Given the ability of the invasives on campus to spread aggressively, it will become more expensive to control them as time passes.

A combination of site assessment and prioritization, timing of treatments, and ongoing maintenance and monitoring can create a framework for an effective invasive management strategy. Elements of this approach are summarized below.

- **Inventory** – Conduct a botanical inventory in GIS format of each of the forest hubs and linkages previously identified. Inventories would account for both invasive and native/non-invasive vegetation, building on the ecological assessment conducted as part of this effort.

- **Prioritization** – Prioritize treatment areas based on ecological integrity. Treat least-affected areas first. Also, consider the feasibility of controlling invasives in each area.

- **Timing** – Phase in treatments over time to assess the response of the plant community and the potential direction of the successional trajectory. Coordinate treatments so that they occur at times of maximum vulnerability for each target species. Phasing also allows for a more consistent and reasonable level of budgeting.

- **Maintenance** – Ongoing maintenance is required to capture plants released from seed banks and those newly propagated by outside vectoring (i.e. “volunteers”).

- **Monitoring/adaptive management** – Monitor treated areas on an ongoing basis to assess efficacy and modify applications when needed. Adaptive management is key, as these systems are complex and can respond unpredictably. For instance, invasive species may emerge from seed banks after sunny patches are opened by initial treatment. Alternately, the frequency of disturbance and lack of native seed source at a specific location may lead to diminishing returns.

3.0 EXISTING STORMWATER MANAGEMENT CONDITIONS

Currently, no stormwater management facilities are present on campus, which is generally consistent with the accepted practices at the time of construction of most of the campus. The implications of the current state are:

- **Channel stability** – The volume and velocity of untreated stormwater from campus contributes to downstream erosion and threatens outfall stability at discharge points. For example:

  – The stream channel downstream of the stadium has been downcut and widened by flows from the twin 84-inch culverts and two 48-inch culverts which carry flows from the stadium, county fairgrounds, tennis pavilion and the upstream industrial areas, where the land cover is primarily impervious (buildings and parking lots).

  – Erosion in the stream parallel to Allen Easley Drive (i.e., the back side of the Fine Arts building) and an area at the northwest corner of Wingate Road and Faculty Drive (across from Facilities Management). This latter site has recently been modified to provide improved stormwater detention capabilities in an effort to ease downstream flooding along Faculty and Royall Drive.

- **Sediment transport** – Sediment from eroded streambanks is transported downstream where it impacts aquatic habitat and fills existing lakes. For example:
  - Lake Katherine is now filled with sediment and has converted to a large wetland complex due to the bank erosion of the upstream channel, especially at the sites mentioned above.
- **Water quality** – Poor water quality is a predictable outcome of uncontrolled stormwater runoff. For example:
  - Downstream of the campus, where Silas Creek flows into Muddy Creek, Muddy Creek is designated as an impaired water body under the Clean Water Act due to levels of turbidity and fecal coliform that exceed water quality standards.
- **Missed opportunities** – Lack of onsite stormwater management represents a missed opportunity to use rainfall for irrigation or other beneficial uses. For example:
  - A number of athletic fields and campus landscaping features are irrigated using potable water rather than stored rainwater or potentially graywater.
  - Many rooftop downspouts are directly connected to storm drain infrastructure which increases flow volumes and velocities. This water could be slowed and infiltrated with disconnection of downspouts across landscaped zones.
  - Parking lots across campus have limited or no landscape features. Increasing tree canopy and combining these areas with stormwater receiving zones to filter water and support plant life would provide multiple benefits.

4.0 LOCAL STORMWATER REGULATORY FRAMEWORK

Winston-Salem's stormwater discharges are regulated under Phase I of EPA's National Pollutant Discharge Elimination System (NPDES) program, and the City has had some form of post-construction stormwater control since 1995. When EPA rolled out the Phase II NPDES program, Winston-Salem's program shifted to include the six minimum measures that are the backbone of the Phase II requirements (Public Outreach and Education, Public Participation and Public Involvement, Illicit Discharge Detection and Elimination, Construction Site Runoff Control, Post-Construction Runoff Control, Pollution Prevention and Good Housekeeping). Winston-Salem funds stormwater projects and programs though a stormwater utility. Non-residential customers are billed based on their impervious surface area at a rate of $831/impervious acre per year.

Some highlights from the Winston-Salem 2008 Stormwater Code include:

- Water Quality – low-density projects
  - Use vegetated conveyances to transport stormwater to the maximum extent practicable.

- Water Quality – high-density projects
  - Control and treat runoff resulting from the first one inch of rain, with a drawdown time of between two and five days.
  - Discharge the water quality volume at a rate not exceeding the predevelopment peak discharge rate for the 1-year, 24-hour storm.
  - Use practices that annually remove at least 85% of Total Suspended Solids (TSS) (presumptive based on NCDENR 2007 Manual guidance)
- Water Quantity (Volume) – all projects
  - The stormwater runoff volume equal to the difference between the post- and pre-development volume from the 25-year, 6-hour event shall be detained on site so that the detention basin(s), or other appropriate stormwater facility, releases detained stormwater over a period of between two and five days.
- Water Quantity (Rate) – all projects
  - Post-development peak discharge rates for the 2-, 10-, and 25-year, 6-hour storm events cannot exceed the pre-development peak rates for the same events.
- Prevent Damage to Receiving System – all projects
  - Mitigation is required when the post-development volume from the 2-year, 1-hour event is 10 % greater than the corresponding pre-development volume.
  - Mitigation may include on-site detention and natural channel stabilization.
- Design standards – all projects
  - NC Stormwater Design Manual

5.0 RECOMMENDED GREEN INFRASTRUCTURE APPROACH

The overall philosophy and long-term approach recommended for the Reynolda campus is to develop a water budget for the site that mimics the natural, undisturbed infiltration capacity of the land to the maximum extent practicable using a distributed stormwater management approach. A priority will be placed on using BMPs that emphasizes vegetative filtering and uptake and/or infiltration, following design approaches and techniques that are generally consistent with state or local design guidance. Finally, concept plans and designs should proceed in a manner that provides treatment as close to the generating source as possible. Key aspects to the philosophy are highlighted below.

- **Treat close to the source** – Use BMPs to capture and treat runoff from small storms (< 1.5”) and promote shallow groundwater recharge.
- **Disconnection and reduction of impervious surface** – Applicable BMPs include green roofs, porous pavement, bioswales, and stormwater planters. Specific areas with the

potential for downspout disconnection were identified from the CAD basemap, including Martin Residence Hall, the student apartments at the north end of Allen Easley Drive, and the Indoor Tennis Center.

- **Limit new disturbance** – To the greatest extent possible, locate new impervious surfaces (buildings, parking lots) on existing disturbed areas. For example, consolidate surface parking and replace with structured or underground parking and redevelop the reclaimed area. This will minimize the growth of the impervious footprint of the campus, lower regulatory burdens, and minimize additional impacts on already-stressed waterways. Avoid encroaching on the edges of forested areas if at all possible. Bear in mind regulatory buffer requirements during the planning process.

- **Larger storm flood control, as needed** – Constructed wetlands can offer control of larger events as well as the opportunity for stormwater/graywater capture and reuse. Also, a distributed approach using BMPs provides volume reduction benefits and can significantly reduce the size of wetlands and ponds that provide peak flood control.

- **First costs** – First costs can be higher for distributed approach, but this approach has other benefits that are not captured by a first cost analysis, such as improved site aesthetics, reduced total maintenance, improved water quality, and opportunities to educate the University community on sustainability principles.

- **Multiple functions** – Create integrated landscapes that have multiple functions, including providing micro-habitats, ecological stepping stones, and educational and stewardship opportunities.

This proposed stormwater management approach has several benefits, including:

- **Hydrology** – Providing runoff treatment close to the source will reduce the volume and velocity of runoff, which will significantly curtail flooding for small events (< 1.5”) and partly alleviate flooding for larger events.

- **Water quality** – Water quality improvements efforts can help the City of Winston-Salem with meeting Stormwater NPDES permit requirements. The University can build on their relationship with the City and other neighbors with such efforts and look to explore additional ways to partner and cost share on efforts that benefit the City, the University, and the region as a whole.

- **Maintenance** – Capturing runoff close to the source will reduce the frequency and extent of maintenance for University infrastructure such as storm drains and stream channels. Native landscaping incorporated into BMPs will provide efficiencies in campus landscaping maintenance requirements by reducing demand for mowing, irrigation, fertilization, and pest control normally needed for turf areas or non-native plantings.

- **Aesthetic appeal** – Many BMPs can provide aesthetic improvements to sites through the use of native plants that flower and use of trees that provide canopy coverage and shading.

- **Utility costs** – Harvested and detained rainwater can be used as a resource to irrigate landscaping and reduce utility bills.

6.0 TREATMENT OPPORTUNITIES

The recommended approach to selecting BMPs is to define distinct zones on campus and identify the practices best suited to each zone based on common landscape positions. This approach creates a framework for identifying and implementing BMPs under the master plan as well as existing conditions. Specific opportunities for and implications of BMPs under existing campus conditions are also discussed.

6.1 Opportunities by Landscape Position

Five landscape positions are commonly found throughout campus, each of which present multiple opportunities for innovative stormwater management strategies (Figure 3). Together, they have the potential to form the backbone of an integrated green infrastructure network across campus.

- **Rooftops** – Rooftops can be treated using rain gardens, stormwater planters, infiltration trenches, cisterns, or small-scale detention devices. These practices are placed adjacent to buildings and should be designed to complement or enhance the existing landscaping.

- **Streets** – Road runoff can be captured in stormwater tree pits or rain gardens located in curb extensions. These features also promote traffic calming, improving safety for drivers, pedestrians, and bicyclists. Porous pavement could be considered for bike lanes, parking lanes, or infrequently-used roads.

- **Parking lots** – Runoff from parking lots can be treated by rain gardens placed around the perimeter or in linear islands within the parking lots. If space allows, grass filter strips placed between the parking lot and rain gardens will promote additional infiltration and reduce the pollutant load and velocity entering the rain gardens. Replacing all or part of a parking lot with porous pavement or paver blocks is another option. Pavers or colored porous concrete can be used to visually demarcate special parking areas.

- **Turf** – Converting turf to native plantings has multiple benefits including: increasing soil permeability through creating deeper macropores in soil structure, reducing overall mowing maintenance, reducing potable irrigation water demand, increasing canopy cover for rainfall interception and heat island mitigation, and reducing carbon footprints through sequestration and reducing maintenance.

- **Quads** – Quads represent existing landscape elements, usually in close proximity to hardscaped meeting places. The perimeter zones of quads represent an easy area to convert to depressional areas for stormwater collection that can be planted with native vegetation that provides vibrant colors and texture to edges of these spaces. Planting can be both formal and informal and provide aesthetic benefits through seasonal color.

An advantage of identifying and understanding the green infrastructure opportunities by landscape position is that it lends itself to the development of a series of basic design templates that can be applied throughout the campus and potentially on other WFU-owned properties as well. Descriptions and graphics of representative BMPs were provided to Wake Forest University Facilities staff.

Figure 3. Photo simulations of green infrastructure opportunities. Clockwise from top left: Cistern and turf conversion at Worrell Professional Center, rain garden in curb extension on Allen Easley Drive, turf conversion to native landscaping at Winston Hall, cistern and rain garden at Tennis Center, infiltration trench behind student apartments, rain garden parking lot island in Lot W1 southwest of Worrell Professional Center.

6.2 Opportunities by Campus Zone

Five main zones on campus were identified (Figure 4). Each contains a mix of the landscape positions identified above. Aesthetic and functional qualities of each zone influence the recommended stormwater management approach.

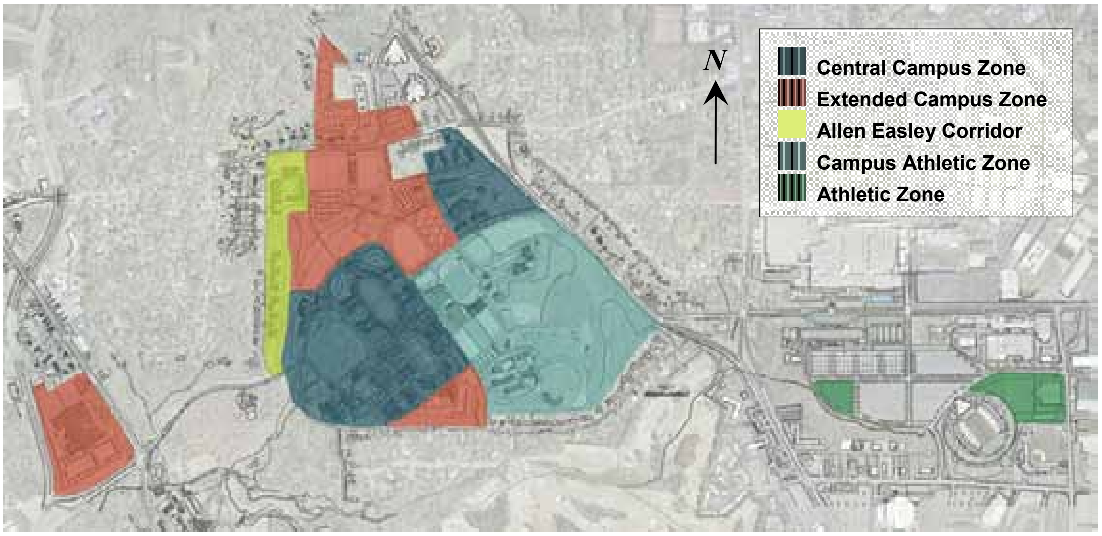


Figure 4. Map of campus zones.

Allen Easley Corridor

The Allen Easley Corridor is a predominantly student residential zone along the western edge of the campus. The corridor is defined by the north/south axis of Allen Easley Drive, as well as a dense tree canopy provided by the riparian corridor along the eastern edge. It is a less formal environment than the heart of the Reynolda campus; therefore, the aesthetics of the practices here could be less institutional and weave coherently into the residential landscape.

The recommended BMPs in this part of campus are intended to treat rooftop, parking lot, and road runoff. One opportunity for turf conversion was also identified at the north end of the corridor. These practices will reduce the volume, velocity, and pollutant load of stormwater entering the adjacent tributary and provide aesthetic enhancements in the corridor.

Central Campus Zone

The Central Campus Zone includes most of the academic buildings and core academic areas. A traditional campus aesthetic prevails, with cohesive architecture, clear sightlines and axes through the main gathering spaces including Manchester Plaza, and smaller pocket quads between various campus buildings. The treatment practices suggested for this zone will integrate with the existing look and feel while introducing new landscape elements.

BMPs in this part of campus should predominantly treat rooftop runoff and turf areas, as well as several smaller parking lots and interior campus streets. Rooftop treatment BMPs include rain gardens and cisterns that would be designed to enhance and complement the existing architecture and environment. The turf conversion aims to integrate attractive, naturalistic native plantings into public spaces while contributing to stormwater management and habitat enhancement. Street runoff may be treated by stormwater tree pits located strategically. Quad areas may in the future include permeable pavers or areas of native plantings integrated into the formal design of the quadrangle.

Campus Athletic Zone
A visual and functional extension of the Central Campus zone, the Campus Athletic zone contains a mixture of open and densely developed areas; this pattern will continue under the master plan. Tennis and golf facilities, gymnasiums, large fields, and Kentner and Hooks Stadiums are all located in the Campus Athletic Zone. The east side of the Campus Athletic Zone contains forest stands that are valuable as recreational, athletic, and natural resources. This area has high visibility because of its proximity to the Central Campus Zone and because of attendance at athletic events. By attracting the extended campus community and other visitors to athletic events, this zone provides an opportunity to showcase campus sustainability and green infrastructure initiatives.

Rooftops, roads and sidewalks, non-athletic turf areas, and athletic fields are the dominant features in this zone. Rain gardens, potentially accompanied by cisterns for irrigation of other landscaped areas, can be placed near buildings to treat roof runoff. Road and sidewalk runoff can be treated by curb extensions; or, if the right-of-way is narrow, by stormwater tree pits with structural soil or storage and exfiltration facilities under sidewalks. Open areas adjacent to tennis courts and parking lots can be used for rain gardens or other native landscapes. Finally, underground detention facilities can be considered in association with new athletic fields (located below the fields and integrated with field drainage systems) to provide system-wide storage that helps reduce downstream flooding.

Extended Campus Zone
The extended campus zone is characterized by parking areas of different scales, most of which exist around the vicinity of the central campus zone. These areas act as the outer boundary for the campus in many places, offering the opportunity for an aesthetic transition to surrounding natural areas and neighborhoods and the potential to strengthen campus gateways/entry points.

The suggested BMPs in this portion of campus are predominantly intended to treat parking lot and streets runoff through the use of rain gardens in parking lot islands and curb extensions. By introducing vegetation into paved areas and bringing water to the surface, these practices create a visual connection to the riparian corridor and accentuate the relationship between parking lots and the waterways into which they drain.

Athletic Zone
The Athletic Zone provides abundant green infrastructure opportunities. Major facilities in this area, located east of the Reynolda campus, include BB&T Field, Bridger Field House, the Indoor Tennis Center, and the Lawrence Joel Veterans Memorial Coliseum. Wide expanses of parking characterize this area, accommodating athletes and attendees for major events and regular practice. Sporting and other public events define the character of the area. High attendance during athletic events provides an opportunity to demonstrate campus green infrastructure and sustainability initiatives to the extended campus community and to out-of-town visitors. At the same time, stormwater treatment and suggested landscape changes should integrate in a way that does not impinge on circulation or public use.

The suggested BMPs are targeted at parking lot and rooftop runoff. There is also the potential for turf conversion in areas that are not used for sports-related activities. Rooftop runoff can be treated in innovative ways including cisterns, which could collect water to be used for irrigation; and rain gardens adjacent to the buildings and parking lots, which would soften the heavily paved and developed character of this area. Turf conversion would introduce native plantings in spaces where circulation would not be affected and reduce the maintenance burden by limiting mowing around buildings.

The Athletic Zone is also notable because its buildings and parking lots, and associated storm drains, form the headwaters of Silas Creek. Silas Creek is a resource that has been heavily impacted by stormwater runoff, as evident by eroded, unstable banks downstream of the Athletic Zone as well as the sedimentation in Lake Katherine. Comprehensive use of BMPs such as rain gardens throughout this area would help to curtail additional impacts to the creek by reducing the volume, velocity, and pollutant load of stormwater runoff. The most systematic approach would be the identify the catchment area associated with each storm drain inlet and construct an appropriate number of rain gardens or other BMPs to capture the one inch storm. Runoff from larger storms would be partially attenuated and the balance would be safely conveyed by the existing system.

6.3 Retrofit Benefits Under Existing Conditions

Under existing conditions, BMPs can be considered as a retrofit for existing buildings and rights of way. Even in areas that are slated for redevelopment, the benefits provided by such practices may be worth the capital investment, especially if redevelopment will not occur for several years. This approach will lessen the existing stormwater impacts on local streams and storm drain infrastructure. In addition, stormwater retrofits offer additional benefits to the campus, including the following:

- **Beneficial use of rainwater –** For example, collecting rainwater for landscape irrigation will reduce potable water demand on campus.

- **Education –** The central campus occupies an upland area between two drainages, including Silas Creek to the south. BMPs such as rain gardens and turf conversion provide an educational opportunity to discuss the significance of upland hydrology as well as native vegetation.

- **Sustainability –** BMPs are an important component of a shift from active to passive landscape management. After an initial establishment period, rain gardens require little maintenance except weeding, debris removal, and occasional plant replacement, as with any garden. Irrigation is not needed except in extended dry periods, and rain gardens thrive without fertilizer and chemical treatments. Distributed stormwater management also has the potential to lower maintenance requirements for the existing stormwater infrastructure, such as inlets and storm drains.

One approach to BMP implementation would be to prioritize areas that are currently irrigated with potable water. These areas could be partially replaced with native landscaping or rain gardens. Alternatively, cisterns could be installed to collect and store rainwater for irrigation of turf or planted areas. The approach will vary by site, but each approach has the potential to reduce potable water demand.

The basemap indicates areas that are currently irrigated. The locations are listed in Table 2 along with their potential suitability for cistern use, or for turf replacement with native landscaping or rain gardens.

Table 2. Existing irrigated areas with potential for cistern use or turf replacement

Location	Turf replacement	Cisterns
Wake Forest Road (west entrance)	X	
Starling Hall/Welcome Center	X	X
Polo Residence Hall	X	X
Worrell Professional Center courtyard	X	X
Quad between Benson Univ. Ctr and Tribble Hall	X	X
Area between Johnson and Bostwick Residence Halls	X	X
Parking lot west of Reynolda Hall	X	

Irrigation systems are also in place at Hearn Plaza and Manchester Plaza, but turf replacement might not be compatible with the use and/or aesthetic of these areas.

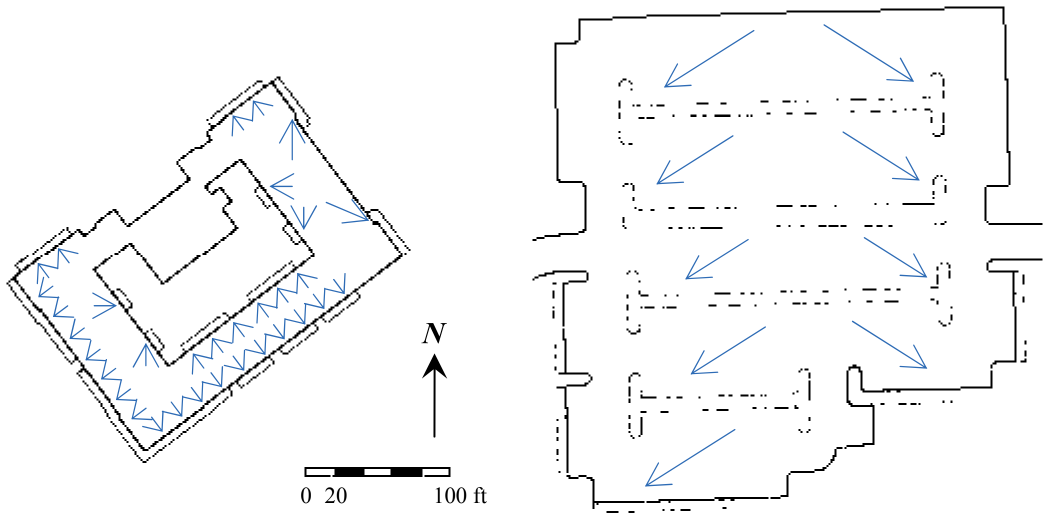
6.4 Sizing Guideline

Rain gardens, infiltration trenches, and vegetated swales are generally sized in proportion to the impervious drainage area. A somewhat conservative rule of thumb is for the footprint of these practices to be about 15% of the impervious drainage area in order to capture and treat the runoff from one inch of rain. The required footprint can be reduced through the use of other BMPs such as permeable pavement, green roofs, and cisterns. These practices reduce the amount of rainfall that is converted to runoff while providing multiple functions such as water reuse and energy conservation.

Watersheds 2 and 3 (refer to Figure 2), which cover the campus areas affected by the master plan, would require approximately 6 and 8 acres, respectively, of BMPs in order to capture the one inch storm. This estimate is calculated from impervious cover on WFU-owned land in each watershed (Table 1) and the 15% sizing guideline. The treatment targets would be met by distributing BMPs among the buildings, streets, and parking lots on campus.

Site-specific examples are useful for illustrating the implications of this sizing guideline. Davis Residence Hall has a footprint of 0.55 acres (24,000 square feet). To capture roof runoff from the one inch storm, 0.08 acres (3,600 square feet) of BMPs would be required. This is equivalent to a series of 6-foot-wide rain gardens placed around the outside and inside perimeters of the building, as shown in Figure 5. The rain gardens would be designed as a series of planting beds or boxes. This concept design accounts for sidewalks and steep slopes in rain garden placement; additional topographic or building features may need to be considered. The 15% sizing ratio should ideally be applied to each rain garden, rather than the site as a whole. In this example, the sizing ratio is smaller than 15% for the courtyard rain gardens because of limited space, and larger than 15% for the rain gardens on the outside perimeter.

Parking lots R2 and R3, east of Polo Hall, can be used as another example. They cover a total of 1.9 acres (83,000 square feet), excluding parking lot islands. The total footprint of BMPs needed to treat this area is 0.3 acres (12,500 square feet). Parking islands alone comprise 10,300 square feet. Additional treatment areas can be located along the perimeter of the parking lot. Aesthetic, logistical, and grading considerations will influence the placement of rain gardens in the parking lots. The hypothetical design shown in Figure 5 reflects the existing grading, with lower elevations at the bottom of the drawing. In detailed design, BMPs must be positioned in locations where existing or re-graded slopes will direct runoff to the treatment areas.



Davis Residence Hall
Target area: 3600 sq. ft.
Provided area: 3700 sq. ft.

Lots R2 and R3
Target area: 12,500 sq. ft.
Provided area: 13,200 sq. ft.

Figure 5. Example of rain gardens (shown as hatched areas) sized for the one inch storm event at two existing sites. Treatment footprints are shown in proportion to site footprint. Target area is the total rain garden footprint based on a 15% sizing factor. Provided area is the total rain garden footprint shown in the drawings. Arrows indicate approximate flow direction based on roof configuration or topographic layer in basemap.

7.0 IMPLICATIONS OF MASTER PLAN IMPLEMENTATION

From a stormwater perspective, the master plan has both water quality and hydrologic implications that can be quantified. Stormwater management requirements potentially triggered by new development and redevelopment as well as voluntary retrofit initiatives pursued by the University provide valuable opportunities to improve upon existing conditions in a way that enhances water quality, reduces erosion in receiving streams, and represents an important element of a campus-wide sustainability program.

To address local stormwater regulations, the stormwater management implications of the master plan can be examined in a watershed context. Of the 11 watersheds delineated (see "Stream Resources" section of this report), Watersheds 2 and 3 are of primary interest. These watersheds cover the campus areas affected by the master plan, including the vast majority of the Central Campus Zone and Allen Easley Corridor as well as portions of the Extended Campus Zone.

The following sections provide projected stormwater management scenarios based on proposed campus development as well as hypothetical growth. The analysis helps to illustrate the benefits of targeting growth on existing impervious and disturbed lands versus developing existing natural areas or pervious surfaces. A watershed based approach is used for the analysis.

7.1 Proposed Campus Development

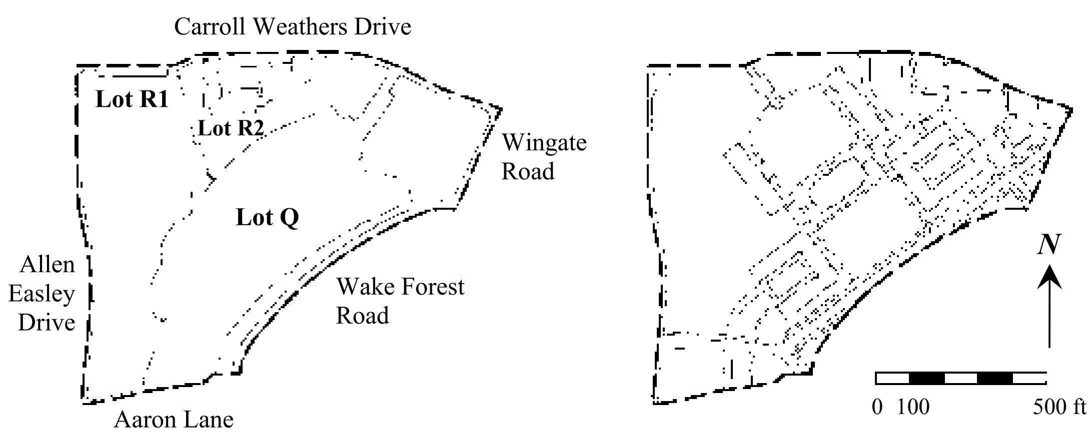
The master plan calls for new buildings, roads, sidewalks, fields, and parking. To a large degree, the master plan locates these new features within the footprint of existing impervious surfaces. Where this is not the case, new impervious cover is counter-balanced with new pervious features. Minimizing or eliminating a net increase in impervious area has two important benefits:

- **Avoid regulatory requirements –** Winston-Salem stormwater regulations apply only to those projects resulting in a net increase in impervious cover. Costly and maintenance-intensive facilities such as centralized detention could be mandated by an increase in impervious cover. These facilities would also consume land that could otherwise be preserved or used for other purposes.

- **Prevent additional stormwater impacts** – Achieving no net increase in impervious cover will preserve open space and minimize additional stormwater impacts to receiving waters. Given the importance of existing forest stands and streams discussed in this report, it is all the more appropriate for Wake Forest to pursue this Master Plan strategy.

Preliminary computations indicate that the master plan results in a 10 to 30 percent net <u>decrease</u> in impervious cover. To illustrate this net reduction, an analysis of the Lot Q area was conducted comparing existing conditions to proposed conditions. This area is an example of redeveloping land with existing disturbance or impervious areas. Figure 6 summarizes the findings.

By achieving a net reduction in impervious cover, it is anticipated that the University will not have to provide stormwater quantity control management. Ongoing detailed analysis will be required on a project specific basis to demonstrate that the quantity control criteria is being met. Temporary net increases in impervious cover may occur as the master plan is phased in, potentially requiring coordination with local regulatory authorities. BMPs such as rain gardens should still be a component of all new and redevelopment projects (see "Treatment Opportunities" section.)



Existing: 9.1 acres impervious coverage *Master Plan: 6.5 acres impervious coverage*

Figure 6. Impervious cover in Lot Q area under existing condition and master plan. Study area (dashed line) defined by the centerlines of existing roads.

7.2 Road Improvements

Under the master plan, portions of Wingate Road and Wake Forest Road will be realigned to accommodate new development and to meet campus transportation planning objectives. These roads have been identified as good opportunities to integrate stormwater management into phased streetscaping improvements. These improvements will control road runoff near the source and enhance the appearance and ecological competence of these roads. Potential opportunities associated with the proposed road improvements are expanded upon below.

1. Wingate Road, south end – Opportunities are limited south of the existing football practice field because of large, mature trees, a narrow right of way, and the lack of a parking lane. Several new residence halls and academic buildings are slated for construction near the intersections with Memory Lane and Gulley Drive.

- Shared rain gardens may be feasible between new or existing buildings and the roadway. Shallow trench drains can be used to convey runoff under the sidewalks to these facilities. Trench drain construction could coincide with sidewalk repairs and reconstruction.

2. Wingate Road, north end – Significant road reconstruction will likely need to occur from the Kentner Stadium area north to Wait Chapel. This stretch of road also contains fewer large trees along its length. These conditions create several stormwater opportunities:

- Storage/exfiltration of street runoff under sidewalks. Porous concrete could be explored as an option for sidewalk surfaces.
- The right of way may be too narrow for curb extensions into the roadway, but stormwater tree pits with structural soil could be created where trees do not already exist.
- Rain gardens in adjacent open areas, or shared with new or existing buildings, could be used in conjunction with trench drains under the sidewalks.

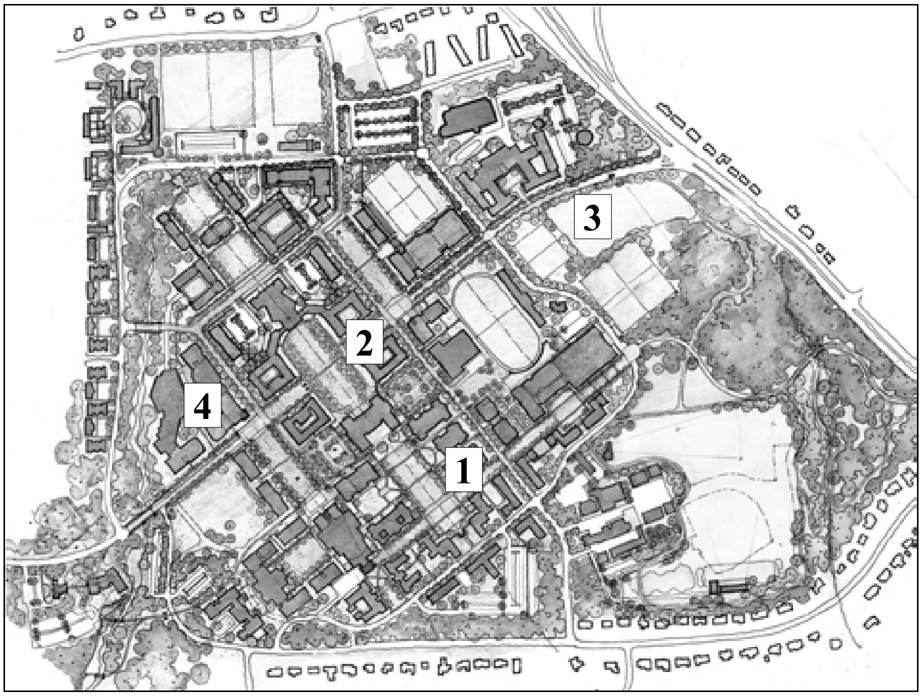


Figure 7. Locations of streetscaping and stormwater management opportunities along Wingate Road and Wake Forest Road under the master plan.

3. Wake Forest Road, east end – The roadway between University Parkway and the Worrell Professional Center contains angled parking which will be removed under the master plan.

- The existing angled parking area creates opportunities to construct curb extensions containing rain gardens.
- Stormwater tree pits with structural soil could also be used in this area.
- Storage under sidewalks could be used here, but may not be necessary if rain gardens are constructed.

4. Wake Forest Road, west end – The roadway from Wingate Road to Allen Easley Drive is being realigned to accommodate new construction around Wait Chapel and Davis Field. The master plan calls for a bike lane and no on-street parking.

- The bike lane provides an excellent opportunity to use porous asphalt or concrete to store and infiltrate runoff from the adjacent conventional asphalt surface. Paver blocks are another option but could create an uneven surface for bicycles. Porous concrete could be colored to visually demarcate the bike lane.
- Stormwater tree pits with structural soil would be applicable here.
- Shared rain gardens between the realigned road and new buildings are another opportunity.

– New sidewalk can be constructed with porous surfaces and subsurface storage/exfiltration capability for runoff from the adjacent roadway. This approach may be unnecessary if the other options are implemented.

7.3 Hypothetical Growth Scenario

Although preliminary analysis indicates that a net decrease in impervious cover will occur under the master plan, it is nevertheless instructive to quantify the implications of a net increase in impervious area. This exercise helps stakeholders to understand the infrastructure and land requirements of such a scenario. The stormwater management measures that are required in the event of a net increase in impervious cover are prescribed by the current Winston-Salem regulations.

For purposes of illustrating potential stormwater quantity control requirements, a hypothetical future development plan was evaluated in which significant quantities of pervious land are consumed, resulting in a 10% increase in impervious cover in Watersheds 2 and 3. (See “Local Stormwater Regulatory Framework” section for a summary of regulations.) The following assumptions were used for purposes of modeling:

- The most pervious areas in Watersheds 2 and 3 are converted to impervious to achieve the 10% increase.
- Runoff travel times (i.e. time of concentration) are based on the results of the 2007 campus utility study by Engineering Tectonics. These times are used to calculate peak discharge rates. The Western and Eastern drainage areas delineated in that study coincide closely with Watersheds 2 and 3, respectively. Times of concentration were assumed to be unchanged from existing to hypothetical conditions.
- The commonly accepted Natural Resources Conservation Service (NRCS) Technical Release 20 (TR-20) method was used to calculate required detention volumes for each watershed.

Hydrologic modeling indicates that a significant amount of land is required for the construction of centralized detention facilities in each watershed (see Appendix A). To maintain post-development peak discharge rates at their pre-development levels for the 2, 10-, and 25-year, 6-hour events, Watersheds 2 and 3 require 6 and 8 acre-feet of detention storage, respectively. These storage volumes correspond to detention pond footprints of approximately 0.8 and 1.0 acres, respectively, using a standard design approach. Each detention facility would have sufficient storage volume to satisfy the volume control requirement.

Winston-Salem stormwater regulations mandate mitigation measures to protect receiving channels and water bodies if the post-development runoff volume from the 2-year, 1-hour event exceeds the corresponding pre-development volume. Acceptable mitigation measures are case-specific and include detention and natural channel stabilization. If the detention ponds described above are deemed insufficient mitigation, BMPs sized to capture runoff from the 2-year, 1-hour storm (1.54-inches) could be constructed with the hypothetical development. Regardless of regulatory mandates, these practices are recommended for all new buildings, roads, and parking areas because of their ability to reduce the volume, velocity, and pollutant load from small (0 – 1.5-inch) storms and to partially reduce the runoff volume and peak discharge rate from larger storms.

Assuming that the development qualifies as a high-density project, stormwater facilities must also achieve an average annual Total Suspended Solids (TSS) removal of 85%. Dry detention facilities, such as those modeled for this scenario, are stipulated to have a TSS removal of 50% in the 2007 NCDENR manual. In this case, BMPs such as rain gardens would be needed in conjunction with detention basins to achieve the required removal. Wet detention facilities are stipulated to have a TSS removal of 85% in the 2007 NCDENR manual, satisfying the requirement. The footprints of wet ponds or constructed wetlands are slightly larger than those of dry detention basins, however.

8.0 SUMMARY OF KEY CONSIDERATIONS

Several key issues have been identified for Wake Forest University to consider with respect to ecological and stormwater master planning components of the overall campus master plan. These include:

- Forest patch/hub condition and invasive vegetation impacts
- Eroded and degraded stream corridors
- Inadequate stormwater management that has not taken advantage of opportunities to improve aesthetics, water quality, and sustainability objectives
- Practical considerations for incorporating source control BMPs under existing conditions and in the master plan
- Consequences of a net increase in impervious cover

Stormwater BMPs, streams, and forest patches should all be considered to be part of an interconnected network of green infrastructure. Streams and forested areas are significant natural assets to the campus, and connections to the regional ecosystem, that should be preserved and restored. The current lack of stormwater management represents a significant opportunity to improve the stormwater regime on campus and provide additional benefits.

BMPs will reduce runoff volume, velocity, and pollutant loading by controlling stormwater at or near its source. Doing so will alleviate ongoing stormwater impacts to receiving waters including Silas Creek, its tributaries, and Lake Katherine. Additional benefits include water conservation, educational opportunities, campus beautification, and meeting sustainability goals by simplifying landscape maintenance burdens.

Efforts should also be directed at retrofitting existing buildings, parking lots, turf areas, quads, and roadways. These facilities collectively exert a significant adverse impact on local streams because of uncontrolled stormwater runoff. Rain gardens, cisterns, permeable pavement, turf conversion, and other BMPs will effectively control runoff from small (0 – 1.5-inch) storms and provide hydrologic and water quality benefits for larger events. As demonstrated in this report, many sites have adequate physical space for BMP construction.

Integrated strategies that address these issues in a manner that is consistent with the overall campus vision will be pursued as the master planning effort is further developed. The planning process for new construction should set aside adequate physical space for BMPs and allocate portions of the capital budget for BMP construction and natural resource enhancements.

Operation and maintenance budgets should also account for maintenance activities associated with these practices as well. Finally, avoiding a net increase in impervious cover under any future development scenario will avoid regulatory mandates for costly and land-intensive stormwater management such as detention basins, as well as limit development impacts on campus natural resources.

9.0 REFERENCES

Biohabitats, Inc. 2008. *Wake Forest University Reynolda Campus Ecological Assessment Report.*

National Oceanic and Atmospheric Administration (NOAA). 2008. *Precipitation-Frequency Atlas of the United States, NOAA Atlas 14, Volume 2, Version 3*. Accessible at http://hdsc.nws.noaa.gov. Retrieved 3 Sep. 2008 (Winston-Salem data).

North Carolina Department of Environment and Natural Resources. 2007. *Stormwater Best Management Practices Manual*.

Winston-Salem, City of. 2008. *Ordinance Amending Chapter 75 of the City Code of Ordinances Related to Stormwater*.

APPENDIX A
HYDROLOGIC CALCULATIONS

Table A-1. Modeling results for hypothetical 10% increase in impervious area. Winston-Salem 6-hour rainfall depths for the 2, 10, and 25-year events are 2.38, 3.45, and 4.08 inches, respectively.

	Existing conditions		With 10% more impervious area + detention	
Watershed characteristics				
Watershed ID	2	3	2	3
Area (acres)	116	143	116	143
Composite curve number	76	80	81	84
Time of concentration (minutes)	24	17	24	17
Peak discharge control				
2-year, 6-hour peak discharge (cfs)	92	206	59 (139 w/o deten.)	132 (273 w/o deten.)
10-year, 6-hour peak discharge (cfs)	218	431	206 (284 w/o deten.)	375 (519 w/o deten.)
25-year, 6-hour peak discharge (cfs)	303	575	299 (378 w/o deten.)	522 (672 w/o deten.)
Detention basin characteristics				
Detention basin footprint (acres)			**0.8**	**1.0**
Detention basin depth (ft)			10	10
Detention basin storage volume (ac-ft)			5.9	8.1
Volume control				
2-year, 6-hour runoff volume (ac-ft)	6.0	9.6	8.3	12.2
Post-pre difference (ac-ft)			2.3	2.6
10-year, 6-hour runoff volume (ac-ft)	12.8	19.0	16.1	22.6
Post-pre difference (ac-ft)			3.3	3.6
25-year, 6-hour runoff volume (ac-ft)	17.4	25.1	21.1	29.1
Post-pre difference (ac-ft)			3.7	4.0

Table A-2. Watershed 2 detention stage-storage data.

Elevation (ft)	Surface (ac)	Storage (ac-ft)	Note
0	0.40	0	
2	0.48	0.9	
4	0.56	1.9	
6	0.6	3.1	
7.2		*3.9*	*2-year, 6-hr*
8	0.7	4.4	
8.9		*5.1*	*10-year, 6-hr*
9.9		*5.9*	*25-year, 6-hr*
10	0.8	5.9	*Top of basin*

Table A-3. Watershed 3 detention stage-storage data.

Elevation (ft)	Surface (ac)	Storage (ac-ft)	Note
0	0.6	0	
2	0.7	1.3	
4	0.8	2.7	
6	0.9	4.3	
6.9		*5.2*	*2-year, 6-hr*
8	0.9	6.1	
8.8		*7.0*	*10-year, 6-hr*
9.9		*8.0*	*25-year, 6-hr*
10	1.0	8.1	*Top of basin*

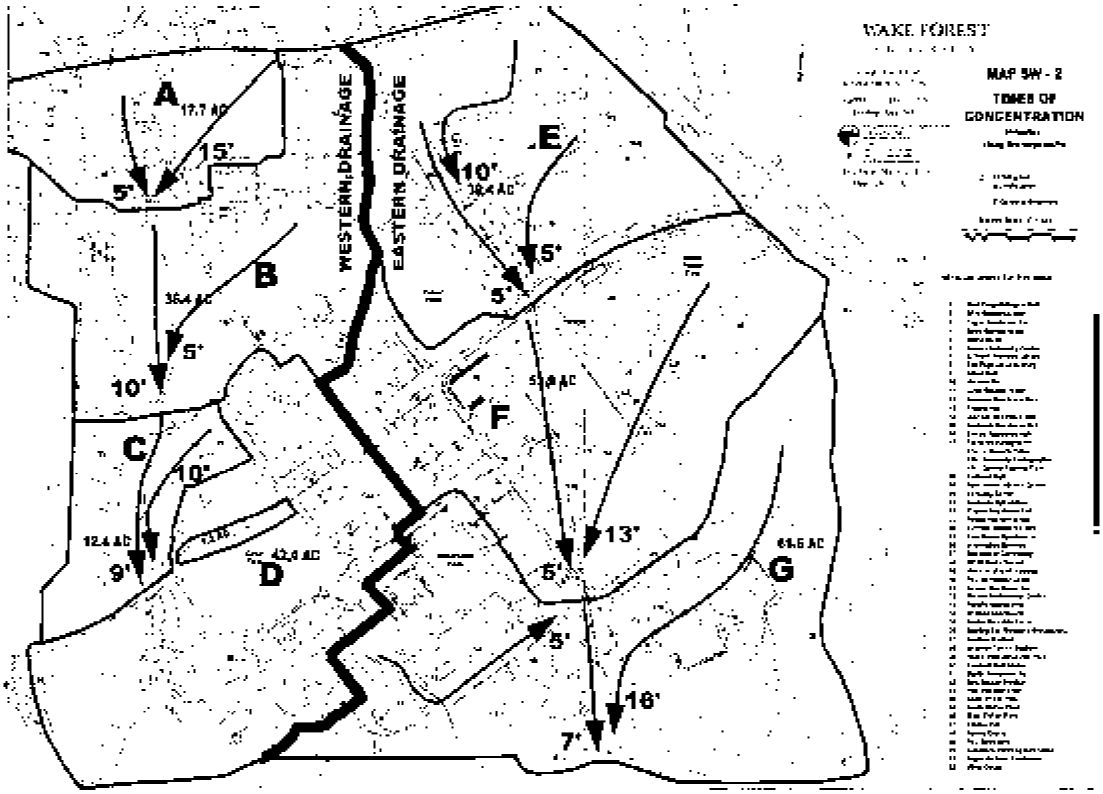
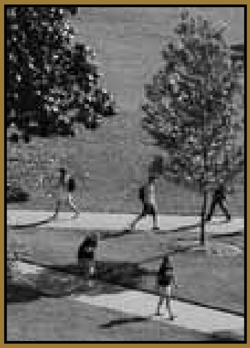


Figure A-1. Major flow paths and times of concentration (runoff travel times) from 2007 campus utility study by Engineering Tectonics. The Western and Eastern drainages coincide closely with Watersheds 2 and 3, respectively.



Transportation Elements

Martin/Alexiou/Bryson, PLLC.


Pilot Mountain, in background, aligned with Wait Chapel and Reynolda Hall

TRANSPORTATION ELEMENTS OF CAMPUS MASTER PLAN

Transportation issues for the Wake Forest University Campus (Reynolda Campus) extend well beyond the need to provide safe and convenient parking, access, and circulation for students, employees, and visitors. Transportation infrastructure – roads, parking lots, sidewalks, trails – comprises a significant portion of Reynolda Campus and can potentially influence how the campus changes in the future. Existing transportation facilities compete for limited space with potential academic, residential, recreational, athletic, green space, and other needs. Many of these needs could result in the elimination of parking areas, or could be constrained by access needs and the existing road network. At the same time, a projected student enrollment growth of 500 students may increase both traffic and parking needs, unless current travel behaviors change significantly.

Even without growth, the addition of new facilities to meet program needs, open spaces, and other associated improvements makes the desirability of the existing automobile-oriented campus and culture questionable. Substantial benefits can be realized by reducing the demand for travel by automobile, as opposed to increasing roadway and parking supply. Historically, this demand for automobile travel and parking has been treated as an unconstrained need to be met by the University. As a result, it should be possible to realize significant reductions in traffic and parking demand by taking some fairly simple, inexpensive steps. These strategies, collectively known as Travel Demand Management (TDM), consist of a set of coordinated incentives and disincentives – carrots and sticks – designed to provide attractive alternatives to driving a vehicle to or around campus. The key to a successful TDM program is the creation of an environment in which the true costs of various transportation choices are made obvious, so that rational decisions by individuals result in desirable outcomes. These outcomes can include reduced travel expenses by individuals; lower infrastructure costs for the University; preservation of limited campus land resources; benefits to the environment; and enhanced sustainability.

Existing Transportation Conditions

Access to Campus

Access: Campus Commuter Market

Most commuters to the Reynolda Campus live within the city of Winston-Salem. Faculty and staff are predominantly traveling from areas to the south and west of campus. Student commuters are mainly concentrated in neighborhoods just north of campus. There is potential to increase the number of people walking or bicycling to campus. A substantial proportion of both employees and students live within a reasonable walking or bicycling distance of campus (usually regarded as one mile for walking, and three miles for bicycling). The City of Winston-Salem has programmed bicycle facility enhancements along Reynolda Road.

Beyond those distances, the density, distribution, and size of the commuter market for Reynolda Campus present a challenge in attempting to provide attractive alternatives to the single-occupant vehicle. The relatively low numbers of commuters, and the fact that they are not concentrated in suitable corridors, combine to make fixed-route transit service inefficient and inconvenient. There are few isolated clusters of people, which traditionally offer the greatest potential for ridesharing.

Access: External Road Network

The external road network in the area around the campus has adequate capacity for today's traffic levels, and for anticipated near-term growth. No major highway improvements are currently planned in the area. Over time, significant traffic growth should be to the north, as land use and travel patterns shift in response to completion of the Northern Beltway.

However, these same roads present barriers to bicycle and pedestrian access to the campus from nearby neighborhoods. The difficult locations include Polo Road near the north entrance to campus, University Parkway near the east entrance, and Reynolda Road south of Reynolda Village.

Figure 1: Commuter Locations

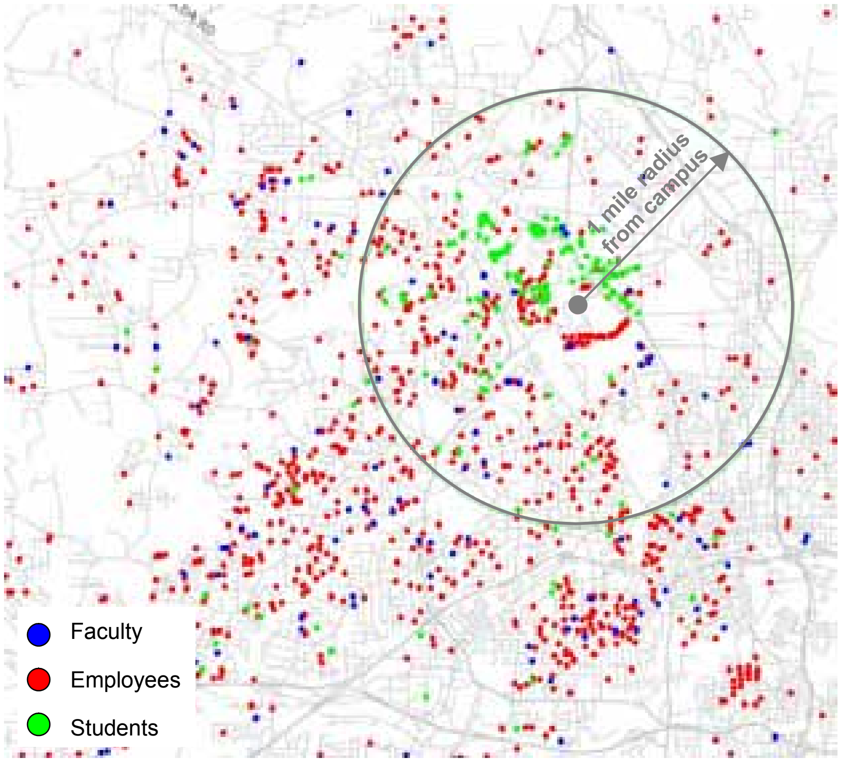
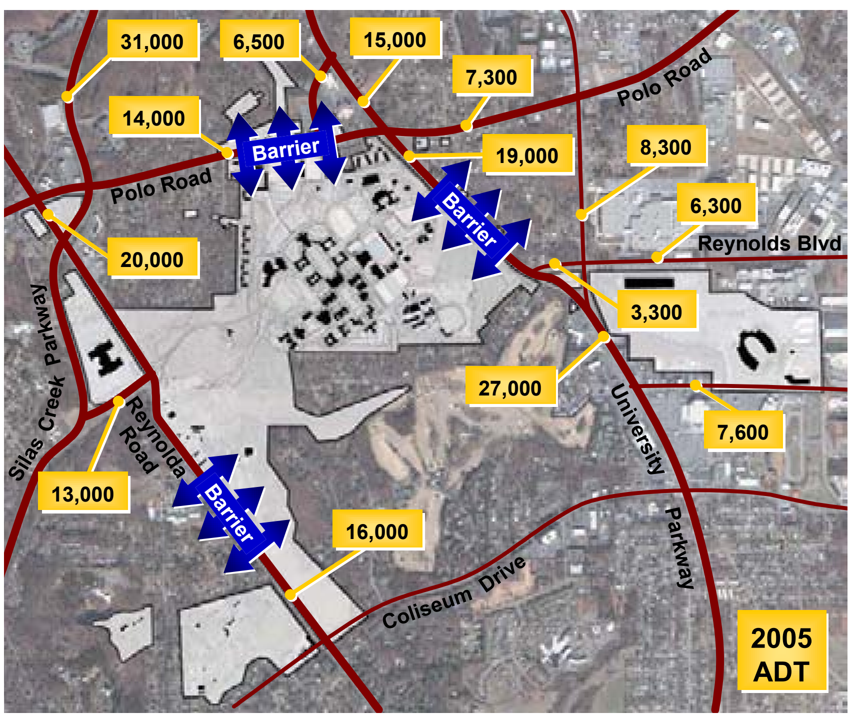


Figure 2: External Road Network and Average Daily Traffic (ADT) Volumes



Access: Campus Gateways

On a typical weekday, approximately 20,000 vehicles enter or leave the campus at one of three main gateways. This includes approximately 8,000 vehicles each at Polo Road and Reynolda Road, and approximately 4,000 at University Parkway. Each of these gateways has capacity for more than 10,000 vehicles.

Two locations have specific automobile crash problems: University Parkway at the east gateway, where exiting left-turns are the problem, and Reynolda Road at the west gateway, where high-speed turns are the problem.

Circulation on Campus

Circulation: Automobile

Unlike many campuses, automobile circulation on campus is entirely under University control. Other positive factors are a lack of significant through traffic, and minimal growth in future traffic volumes. However, the circulation system is not organized effectively, and can be confusing to those not well acquainted with the campus. A particular issue is the frequent need for drivers to travel **away** from a destination in order to get to that destination. The counter-intuitive and circuitous routing that results can confuse and frustrate drivers, as well as add to traffic volumes and conflicts. Traffic patterns on campus are complicated and unbalanced, with some roads carrying much heavier traffic in one direction than the other.

Also contributing to the confusion and inefficiency of the campus road network is the lack of an organizing hierarchy of streets and street types. There are no consistent design elements, visual cues, or other indications of the relative importance of a roadway in terms of parking access; traffic speed and volume; pedestrian/bicycle activity; truck routing; or other essential functions. An orderly, context-sensitive typology of roadway cross-sections, pavement treatments, and other design elements provides greater flexibility in campus layout, allowing for a wider range of travel options and creating more opportunities for preserving open space or building sites.

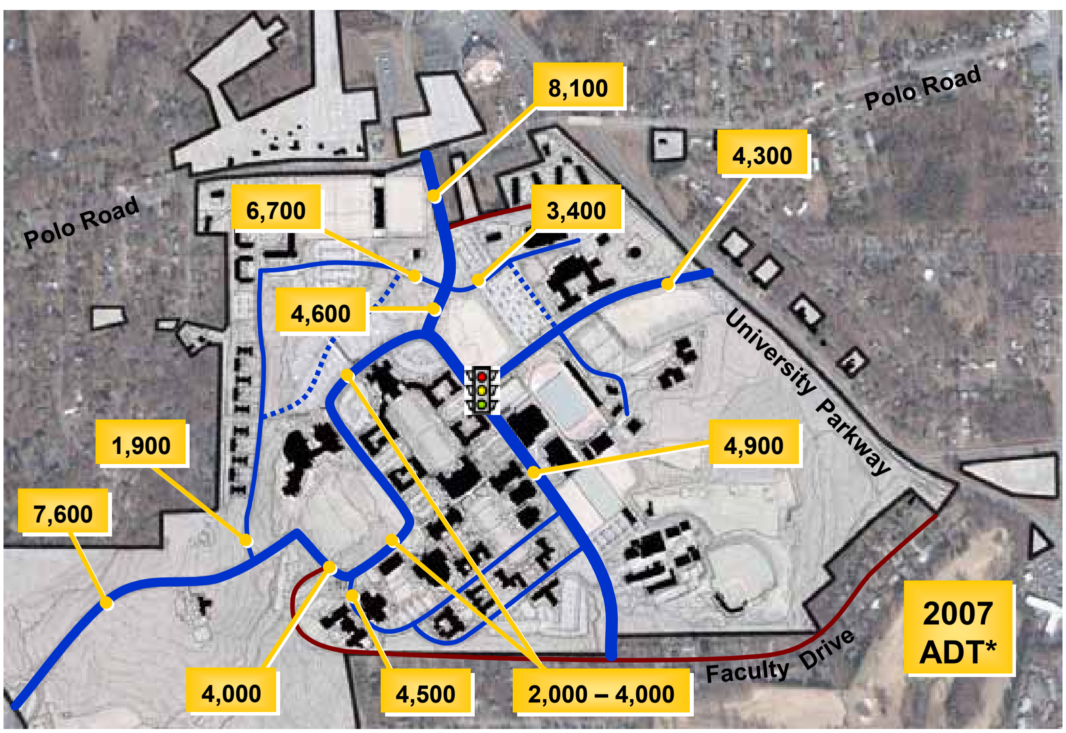
The distribution and volume of traffic throughout the day is not consistent with what would be expected from people driving onto campus, parking, and then walking, bicycling, or riding a bus to their destinations. Evidence strongly suggests that many Wake Forest University students and employees are driving from lot to lot in search of the best available spaces, as well as driving simply to get from one part of the campus to another.

Other issues include:

- Disproportionately large surface area (relative to campus population and size) devoted to roads and parking lots.
- On-street parking detracting from the streetscape.
- Cut-through traffic in parking lots.
- Significant pedestrian-vehicle conflicts.
- One-way streets.
- An unwarranted traffic signal.

Figure 3: Campus Gateways, Showing Percent of Traffic Using Each

Figure 4: Campus Road Network and Average Daily Traffic Volumes



* Counts and estimates

Circulation: Pedestrians

The Reynolda Campus benefits from a traffic-free core of attractive, formal quads linked by pedestrian connections. Elsewhere on the campus there are conflicts between pedestrians and vehicles, including along road corridors, at intersections and crossings, and in parking lots.

Circulation: Campus Shuttle

The University operates a shuttle service around the Reynolda Campus. With one van in service at any time, it connects the main academic areas with the freshman parking north of Polo Road and the small park-and-ride lot at Reynolda Village. However, the schedule and service frequency do not match class schedules and do not closely relate to students' needs. Serving the Reynolda Village lot is inefficient, as it takes up a large proportion of the van's time for very little ridership.

Nighttime service is characterized by long delays resulting from a variety of factors, such as:

- Limited bus capacity;
- Concentrated loadings (such as a large number of students needing transport at the conclusion of an event);
- Expectations of door-to-door service; and
- Lack of formal routes or stops.

Circulation: Inter-Campus Shuttle Service

The University also operates an additional shuttle that connects the main campus with the Bowman Gray Campus. There are opportunities to expand this service, with additional vehicles and extended hours, to provide additional connectivity to Groves Stadium and planned redevelopment in the Deacon Boulevard area (potentially including satellite parking) or downtown.

Parking

Parking: Supply

There are currently approximately 3,650 parking spaces on Reynolda Campus. There are also approximately 470 spaces in the freshman lot north of Polo Road, and the First Assembly of God makes approximately 440 spaces available for WFU commuters. This produces a total of approximately 4,560 spaces serving the campus population.

All students, faculty, and staff (resident or commuter) can park on campus, although freshmen students must park at the satellite lot north of Polo Road. This is relatively generous compared to many of the University's peers.

Figure 5: Campus Vehicular Circulation

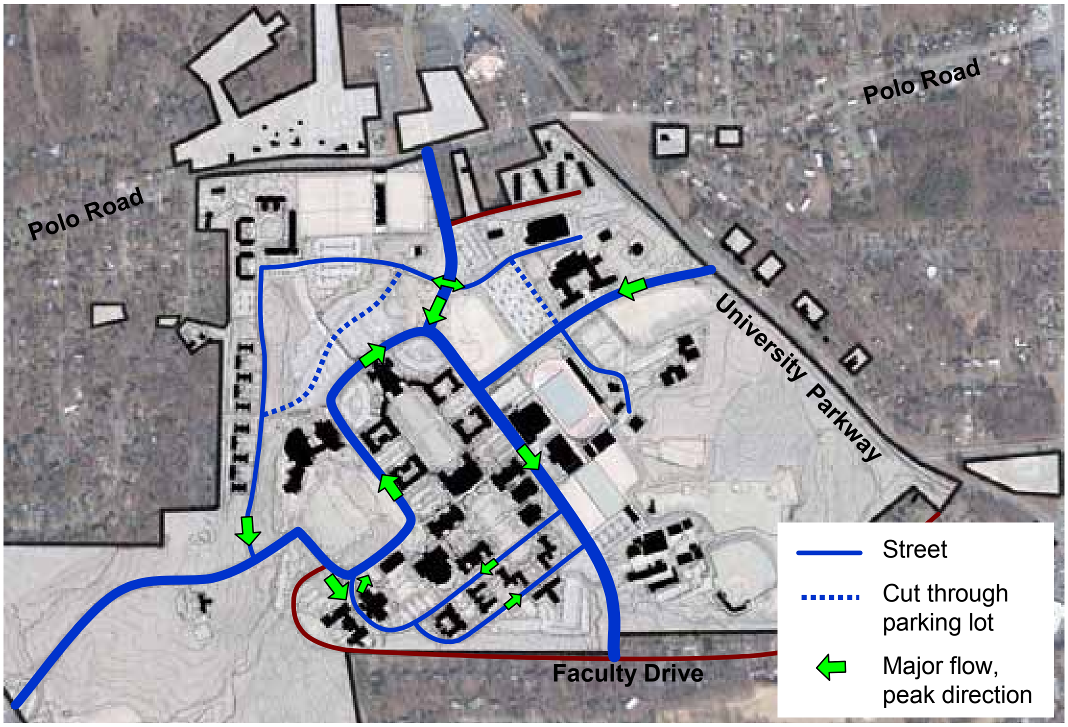


Figure 6: Conflicts Between Pedestrians and Vehicles

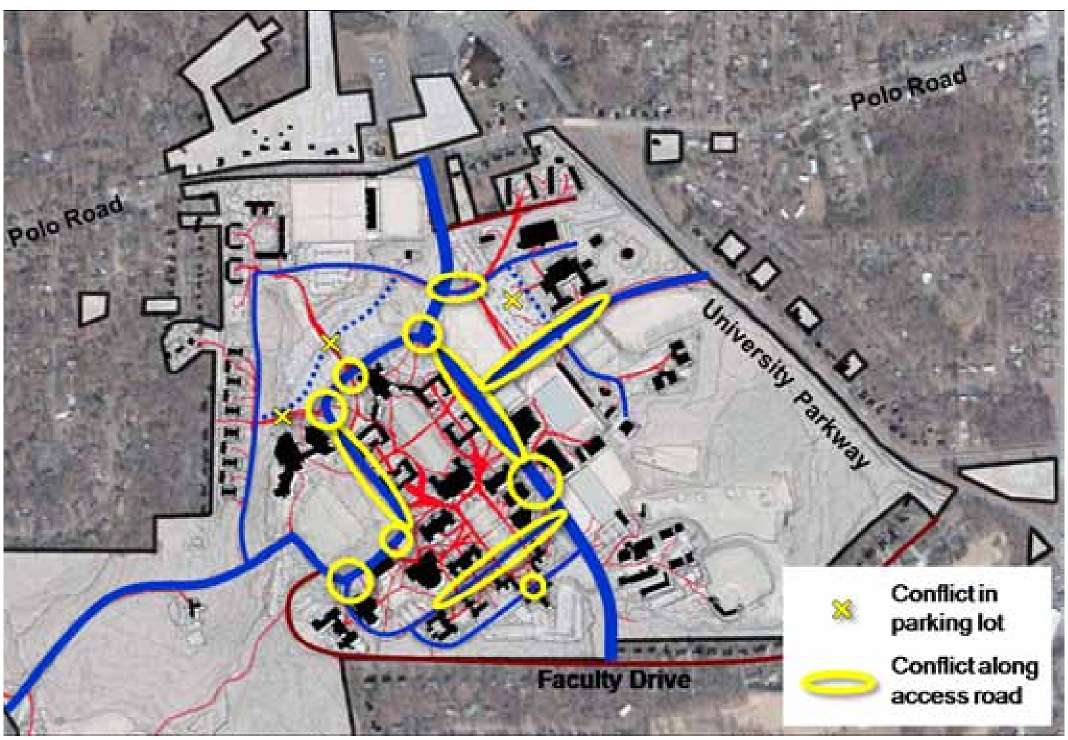


Figure 7: Campus Shuttle Route

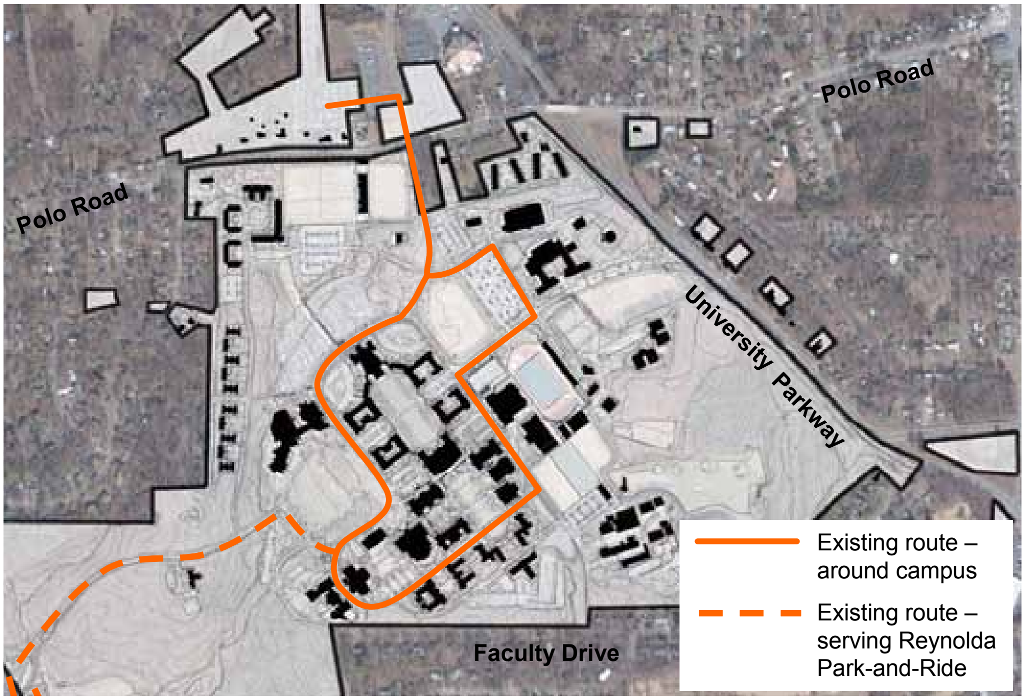
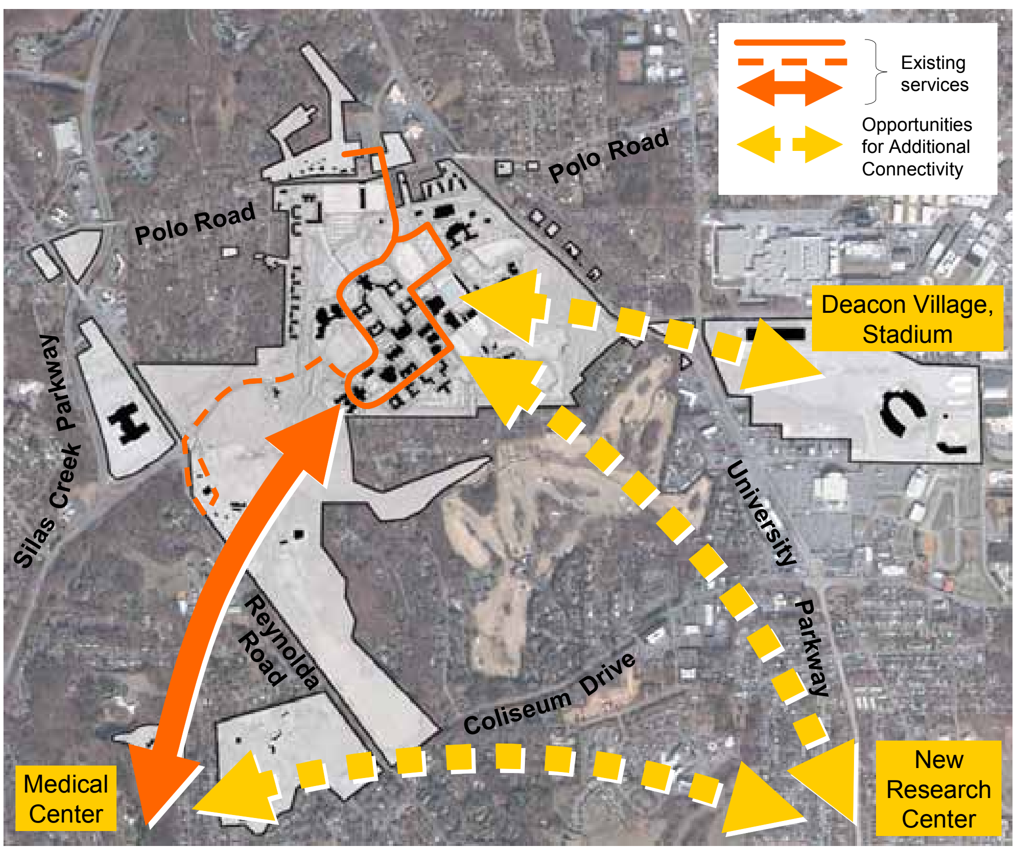


Figure 8: Inter-Campus Shuttle Service and Opportunities for Additional Connectivity



Parking: Occupancy

The target occupancy level for commuter parking on a university campus is typically 95%; this balances efficient use of space with the ability to find a vacant space easily. The busiest time for parking on-campus is mid-day Tuesday, and occupancy counts in Fall 2007 found the on-campus spaces to be approximately 97% occupied. However, the vacant spaces are generally in the outer areas of the campus, and most lots, including the largest lots Q and W, are full or nearly full for much of the day. This corroborates reports that some people drive to the convenient lots, find themselves unable to park, and then try less-convenient lots until they find a space.

Parking: Peer Comparisons

Figures 10 – 12 compare the quantity and pricing of parking among several peer institutions, highlighting observations about parking conditions and policies at Wake Forest University. From Figure 10, it is clear that Wake Forest does not lack parking supply, at least in comparison with its peers. In fact, Wake Forest University provides approximately 50% more parking per person than does the next-highest institution, Duke University, and more than twice the amount of parking as the institution with the lowest parking ratio, Brown University. Although these universities are located in settings with varying degrees of urbanization, these differences do not completely explain the situation at Wake Forest University.

Interestingly, the high occupancy rates described above appear inconsistent with an abundant parking supply, as does the relatively high price of student permits at Wake Forest University. Usually, the demand for parking goes down as the price goes up.[1] As indicated in Figure 11, however, the University's new permit fees for a "typical" student parking space are at the higher end of the range. It should also be noted that the general rate at Wake Forest University was just raised from $325 to $500. The previous rate falls near the middle of the range for peer institutions. Also, most of the schools with lower "typical" permit fees also offer options for premium parking that are significantly more expensive, while Wake Forest University charges freshmen a much lower fee of $225 to park at a satellite lot.

The most striking difference between Wake Forest University and its peers is immediately apparent in Figure 12. It is the only institution that completely subsidizes faculty and staff parking. None of the cost of providing parking is passed on to the consumers of this limited and valuable commodity. Without accurate cost feedback, there is no incentive for parking consumers to reduce demand, or to give alternatives serious consideration. The disconnect between actual parking costs and the prices paid (or not paid) by end users helps explain the seemingly counter-intuitive phenomenon of a very generous parking supply being filled beyond its effective capacity.

This approach to parking could be feasible when plenty of inexpensive, convenient land is available for parking, as was the case earlier in the history of Reynolda Campus. Under this scenario, there is minimal need for enforcement or active management of parking and permitting. This is no longer the case, particularly in the campus core, due to a combination of factors:

[1] Limited findings from other campuses suggest a typical price-elasticity of about -0.22 for students and -0.12 for employees, with commuting students having a slightly higher elasticity than residents.

- Increasing enrollment and staff;
- Desire to house more students on campus;
- Need to upgrade campus facilities (academic, residential, recreational, and athletic);
- Increased emphasis on open space;
- Loss of land suitable for parking lots; and
- Escalating costs of construction, financing, and environmental mitigation (especially related to water quality).

Increased competition for a limited supply of land means that the Wake Forest University community must now make some choices regarding the best use of valuable land resources. These decisions require transportation issues to be considered in terms of the degree to which they support or conflict with the mission of the institution. A key aspect of the Master Plan is its attempt to reconcile the arrangement of campus land uses and complementary parking policies with the mission of Wake Forest University.

Figure 9: Existing Parking Spaces

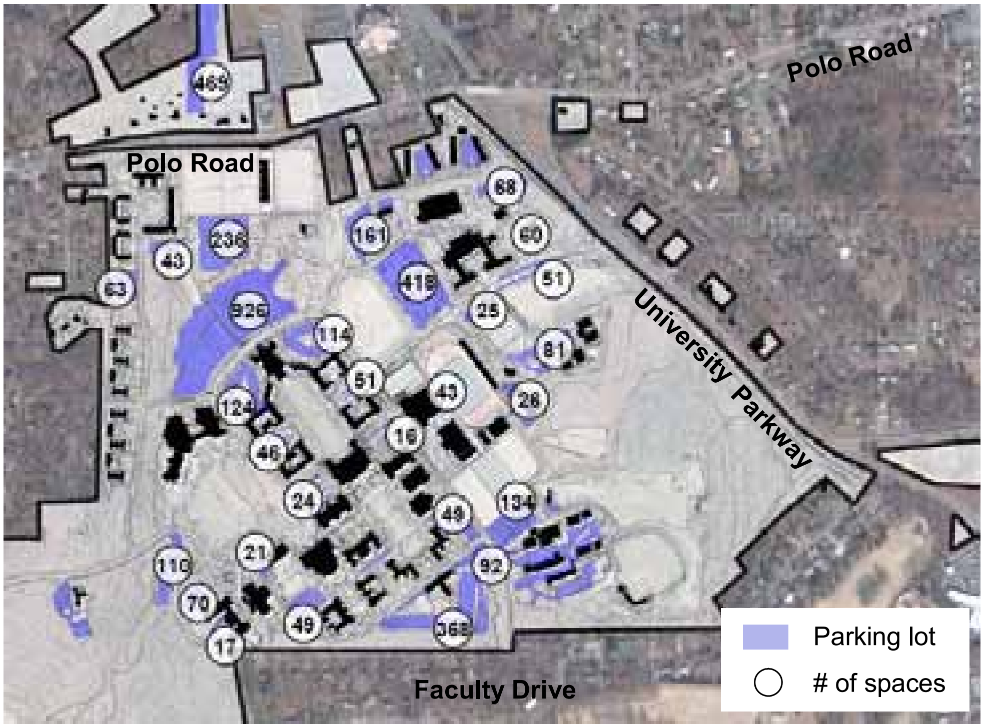


Figure 10: Peer Comparison: Per Capita Parking Supply

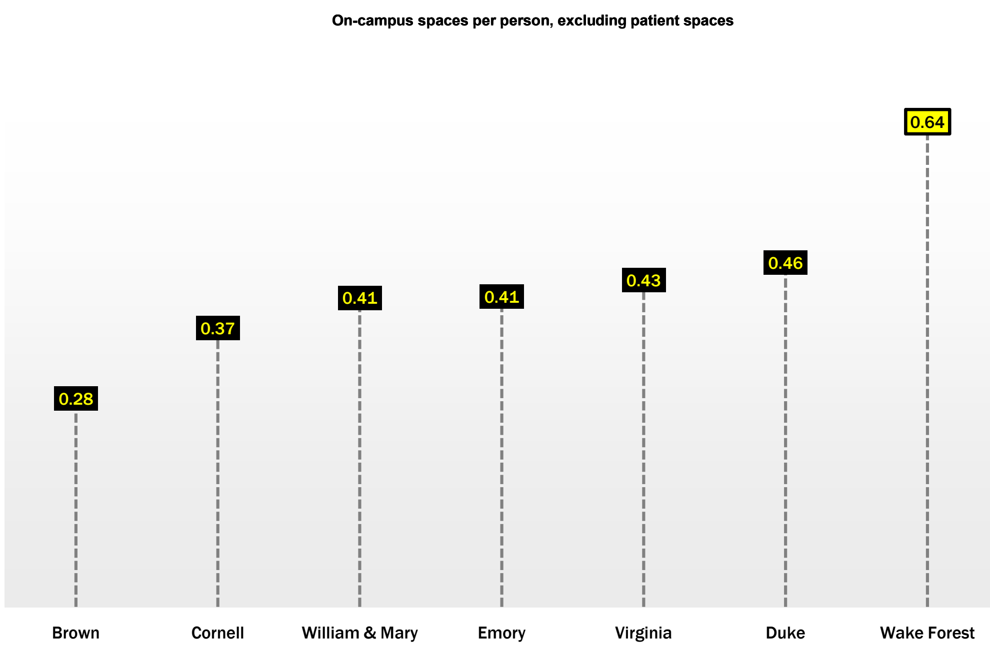


Figure 11: Peer Comparison: Annual Student Parking Fees

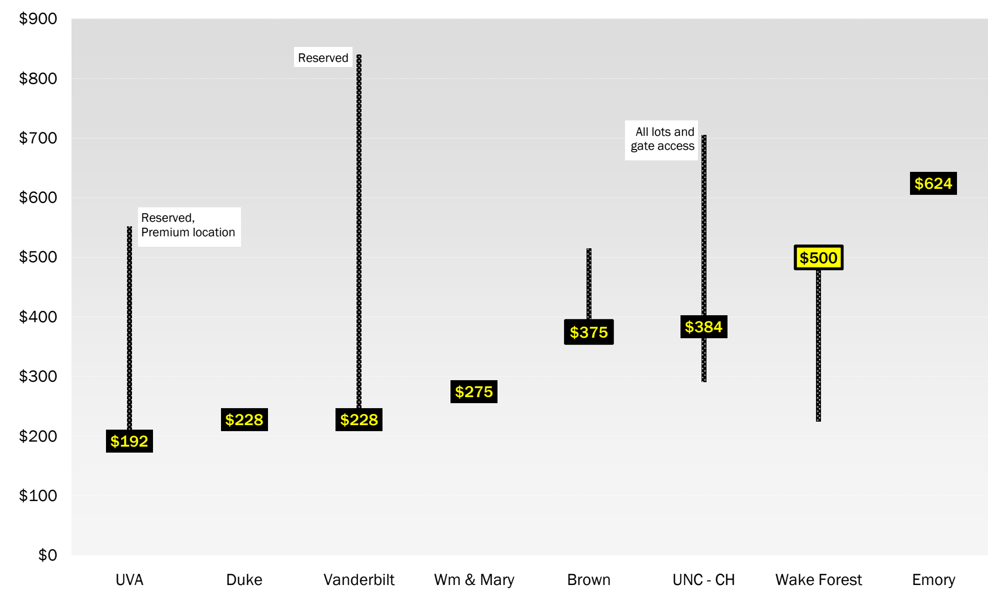
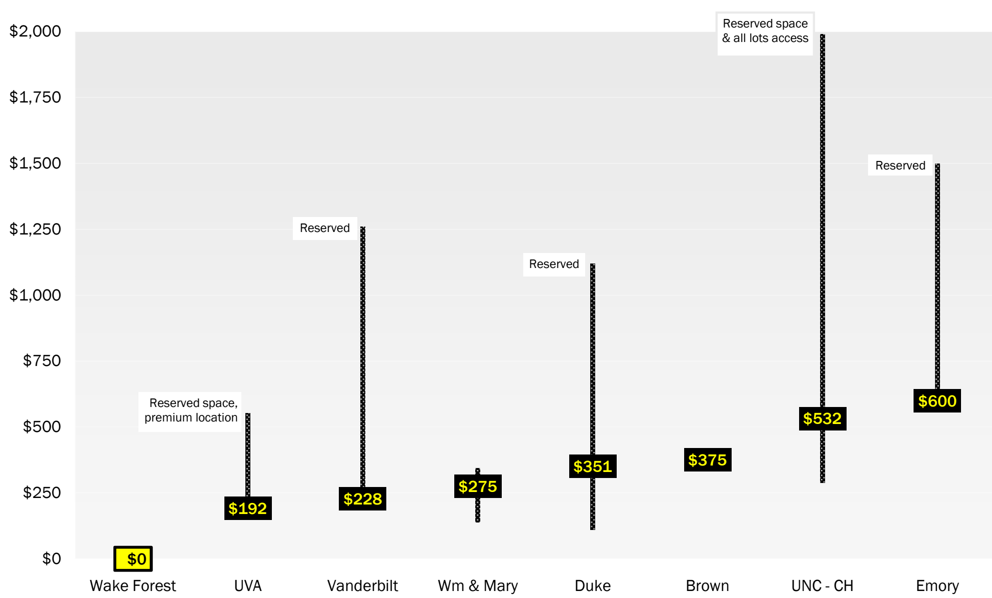


Figure 12: Peer Comparison: Annual Employee Parking Fees



Parking: Issues

The occupancy data confirm one existing problem: that most lots fill at peak time. For many people, their parking permit is therefore a 'hunting license' that merely allows them to search for a space. Some other parking issues are summarized below.

- It is acceptable and common for people to switch between lots during the day, since permits are valid in appropriate lots across the campus. This increases traffic volumes on campus beyond what is really necessary.
- Faculty and Staff are issued free, effectively permanent permits. This offers no incentives to switch to more sustainable modes.
- Although free of charge, visitor parking is essentially limited in supply and location to what is available in Lots B and C. Although technically for visitors, its remote location makes Lot S1 convenient only for trips to the Welcome Center. In addition, wayfinding to parking and common destinations is not as consistent or effective as it could be.
- Parking for special events on the campus can be problematic, especially when school is in session, due to conflicts with competing users and limited supply. In most cases, spaces in general parking lots are reserved for event patrons, although there are some complaints about a lack of coordination and adequate notification.

Enforcement is undertaken by the WFU Police department. As is usual on a campus, there are differing perceptions of the level of enforcement. Employees tend to feel that enforcement is too lax, meaning that students occupy employee spaces which in turn makes it difficult for employees to park. Students feel that enforcement is too strong and that they should not be penalized for parking in employee lots because of lack of space in student lots.

Overall, the parking fees and rules on Reynolda Campus reflect a suburban location where parking availability has not traditionally been difficult. The 'parking crunch' experienced a few years ago was solved with relative ease simply by constructing a satellite lot. This will not be the case in the future, as existing parking lots are lost to the construction of new or expanded facilities, and options for nearby satellite lots disappear.

Summary

<u>Access to Campus: How do people get to and from campus?</u>

- The campus and the community are automobile-oriented, due to plentiful parking and roadway capacity and limited alternatives.
- The roadways surrounding (and serving) campus are barriers to pedestrian and bicycle access.
- Transit access is limited.

<u>Circulation on Campus: How do people get around on campus?</u>

- Auto circulation has no capacity constraints, other than parking and pedestrian conflicts.
- The existing road configuration limits both transportation and development options.
- There is considerable potential for relatively low-cost improvements to the existing shuttle service.

Parking

- Current utilization is high, but so is available supply.
- Policy changes are needed to improve both user satisfaction and overall efficiency.
- A comprehensive travel demand management (TDM) program combined with satellite parking lots and shuttles could delay or eliminate any long-term need for building parking decks.
- Supportive parking policies, especially related to the management of price and supply, are critical to the sustained success of reduced reliance on single occupant vehicles.

Transportation Action Plan

In the foreseeable future, most of the transportation challenges faced by Wake Forest University involve parking, either directly or indirectly. Given the financial, ecological, aesthetic, and spatial constraints to building new surface or structured parking facilities on campus, other solutions are needed. Further complicating the solution to this problem is the long-standing tradition of not charging employees for parking. Fully subsidized parking increases demand, reduces the attractiveness of alternative modes, and provides less potential funding for effective management or for other options. At the same time, increasing fuel and automobile ownership costs and growing concerns about sustainability (not only environmental, but also social and fiscal) are encouraging many drivers to look for alternatives to driving. Although such options are currently limited for Wake Forest University's students, employees, and visitors, there are a number of short- and long-range steps that can be taken to improve this situation.

The next two sections describe the impacts of the Master Plan on campus roadways and parking, followed by a discussion of strategies to reduce the demand for parking on campus, including items recommended for immediate action.

Master Plan Changes to Roadways

As explained previously, the lack of an organized hierarchy that recognizes the differing functions of campus roads contributes to conflicts and confusion that, in turn, detract from the attractiveness and vitality of the campus. The modifications described below will help to address this deficiency, as well as being necessary for the realization of the Master Plan as currently envisioned. These modifications typically involve slowing traffic speeds; enhancing pedestrian and bicycle connectivity and safety; and allowing for the construction of new or expanded facilities, or for additional open spaces. Recognizing that the Master Plan is more concept than concrete, these specific roadway changes may not ultimately be implemented; they are, however, representative of the underlying principles involved.

The proposed Master Plan entails several types of potential changes to the existing campus road system, sometimes in combination with each other:

- **Modify road surface and/or cross-section** – Recommendations include narrowing travel lanes; adding textured or special paving treatments; raising pedestrian crossings or intersections; removing on-street parking; adding bicycle lanes; widening sidewalks; and enhancing streetscapes through planting, lighting, and other design elements. These modifications can be implemented separately or in combination, and may also be incorporated in the restriction of access on certain roads (see below). The following are examples of cross-section and surface treatment alterations that could be considered in implementing the Master Plan:

- A distinctive surface treatment and streetscape that encourages lower travel speeds and emphasizes the priority of pedestrians and bicyclists could be appropriate for Wake Forest Road as it approaches and wraps around the core campus (between Faculty Drive and the proposed extension of Memory Lane around the eastern side of Campus). The road could also be narrowed, and on-street parking removed.
- Wingate Road from relocated Carroll Weathers Drive to Memory Lane could receive a treatment similar to that described above for Wake Forest Road.
- The "greening" of Gulley Road would require Memory Lane to be converted from one-way to two-way traffic, and on-street parking removed.

- **Realign existing road** – Most realignments associated with the Master Plan as currently depicted entail shifting the location of an existing road to make room for another facility, or to improve the safety, capacity, or appearance of a particular segment of roadway. Some potential examples include:
  - 'Squaring the corners' of Wake Forest Road around the Campus core to slow down traffic and benefit pedestrians.
  - Straightening and shifting Carroll Weathers Drive northward to make room for the relocation of Poteat Field in Phase 1.
  - Rounding off the intersection of Allen Easley Drive and Carroll Weathers Drive to create a more continuous route around campus.
  - Connecting the western end of Faculty Drive to the existing Wake Forest Road just north of Allen Easley Drive, to allow for the expansion of Davis Field and to eliminate traffic through the Science Quad, as well as minimizing traffic on Faculty Drive.
  - Raising and straightening Aaron Lane in Phase 3.
- **Restrict access to road or segment of road** – In a number of locations, the proposed Master Plan would leave a road in its current location, but could benefit from limiting the type of traffic allowed on the road. Types of restrictions could include:
  - Managing access for daily users and service;
  - Allowing access for maintenance and public safety vehicles only; and
  - Allowing general access only for special events, moving in/out, etc.

  Specific examples of such restrictions potentially associated with the Master Plan include:
  - Converting Gulley Road to a pedestrian and bicycle way, with general access only during student move-in/move-out. Service and emergency vehicles would have access at all times.

- Managing access to Wingate Road south of Memory Lane to discourage unwanted traffic on Faculty Drive, while providing access to residents and their visitors.
- Using security staff to monitor vehicular access to the Library Quad.

- **Eliminate road completely** – There are only a few instances where the proposed Master Plan could require a segment of road to be entirely removed, without being replaced or realigned. In such cases, the intent would be to create or extend usable green space, or to reduce or eliminate traffic from a particular area. The best example of this would be the removal of portions of Wake Forest and Gulley Roads immediately northeast of Salem Hall in Phase 1. Another potential Phase 1 road abandonment could be the short link between Faculty Drive and the western end of Memory Lane.
- **Construct new road, or extend existing road** – Only a very limited amount of new roadway construction would be required to implement the Master Plan as currently proposed. Any such additions would be designed and built to be in harmony with their function and location. Two possibilities include:
    - A new segment of Wake Forest Road (a modified version of the original alignment that was removed years ago) constructed along the western edge of Davis Field. A key element of Phase 1, this segment would create a more defined and expressive entry to the core of Wake Forest University.
    - A key element of the proposed second phase of the Master Plan is the extension of Memory Lane from Wingate Road to Carroll Weathers Drive in a generally counter-clockwise direction, through Lot F and the existing football practice fields, around the expanded Miller Center and Kentner Stadium, and across Wake Forest Road between Worrell Professional Center and the new Recreation Center. This 2-lane facility, in combination with Faculty Drive, Allen Easley Drive, and Carroll Weathers Drive, would complete a loop around campus, and provide better access to the under-served southeastern quadrant. Key objectives of this project include reducing traffic in the core, preserving green space and promoting pedestrian activity. By providing more direct access to the closest available parking facility, this configuration should reduce total vehicle mileage on the campus, and result in fewer conflicts among motor vehicles, pedestrians, and bicycles.

Other Travelways

Each of the roadway projects identified in the Master Plan will include provisions for adequate and appropriate pedestrian and bicycle mobility as an integral part of their designs. The Master Plan also addresses two facilities not intended to carry automobile traffic. These projects are discussed below.

- **Upgrade the pedestrian/bicycle connection to Reynolda Village.** Expanding and enhancing the existing pathway to make it more convenient and secure will improve accessibility between the Village and the Campus, including the Visitor Center and associated parking.

- **Initiate a new connection with Groves Stadium and redevelopment in the Deacon Boulevard area.** To be an integral part of WFU's campus life, safe and convenient access to Groves Stadium and Deacon Boulevard is essential. If travel between the main campus and Deacon Village depends heavily on the private automobile, the result will be increased congestion and pollution, as well as the need to devote physical and financial resources to parking facilities at **both** locations for each car making the trip. A shuttle bus system serving a secure, low-cost (or free) satellite parking lot near Deacon Boulevard appears to be the most effective solution to this problem. This lot would also be part of the parking available for Deacon Village, football games, and other events, and would probably need to contain at least 500 spaces to provide a cost-effective park-&-ride service. The shuttle would serve three needs:

  1. WFU commuters parking at Deacon Village and riding to Campus;
  2. Students and others attending football games and other special events;
  3. People traveling between Deacon Village and the Main Campus, or even Reynolda Village.

  In addition to a shuttle system, the relatively short distance between Deacon Village and the WFU Campus would appear to be suitable for travel by bicycle, or even walking. Unfortunately, the existing pedestrian and bicycle routes are not continuous or direct, and require travel on or across wide, high-volume, high-speed roadways. There are also significant grade changes, safety issues, and personal security concerns, as well as the fact that these routes are simply not appealing to cyclists or pedestrians. To address these issues, the Master Plan proposes a series of new facilities and improvements to existing roads:

  - Extend a paved pathway from the eastern end of the "Gulley Green" (at its terminus with the extension of Memory Lane, near the expanded Miller Center) to University Parkway, just north of Reynolds Boulevard. This pathway would replace/supplement portions of the existing cross-country trail; curves, grades, and cross-section would be designed for shared pedestrian and bicycle use (as well as service vehicles), and would be ADA compliant.
  - The topography on either side of University Parkway immediately north of Reynolds Boulevard lends itself to a grade-separated crossing, with the proposed pathway passing over University Parkway and tying into Bethabara Road on the east side. Relatively minor improvements (possibly associated with development along this portion of Reynolds Boulevard) could provide a connection eastward along the north side of Reynolds Boulevard to North Cherry Street, where the existing traffic signal could be adapted to assure a safe crossing to the intersection's southeastern quadrant.
  - From the North Cherry Street/Reynolds Boulevard intersection, an off-road pathway or greenway would connect to Deacon Village and the stadium area. This facility could be constructed in conjunction with improvements to the existing stormwater and stream system.

Impacts of Parking Supply Changes and Enrollment Growth

Based on the analysis and assumptions described above, the cumulative **decrease** in parking supply at the end of each phase is approximately as follows:

- 900 spaces by the completion of Phase 1;
- 1,200 spaces by the completion of Phase 2; and
- 2,200 spaces by the completion of Phase 3.

This is out of a total supply of about 3,650 commuter or resident parking spaces on the main campus in 2007. Note that no attempt is made at this point in the analysis to allocate the remaining parking spaces by permit type; it is assumed that this reallocation will need to be performed as part of various policy scenario evaluations.

Finally, the parking deficits listed above do not consider changes in demand. Parking demand could increase as a result of enrollment and employment growth or an increase in on-campus housing. Reductions in parking demand could result from Travel Demand Management (TDM) measures or increased fuel costs.

Based on a projected enrollment increase of 500 students over the next 5 years, and a proportional increase in faculty/staff numbers, another 250 spaces would be needed by the end of Phase 1 in order to maintain the current ratio of parking spaces per person.

Potential sites for additional parking on campus all require structured/underground parking, or conversion of green space. Most deck options are located on existing parking lots, and because of the spaces eliminated in construction, there is an additional parking deficit during construction, and the net parking gain is reduced by the capacity of the original lot.

Given the long-term nature of capital investment in parking facilities and the significant influence it has on the character of the campus, prudence requires consideration of other options that could reduce the demand for parking spaces, now and in the future. Techniques for reducing reliance on the single-occupant vehicle – and, consequently, parking demand – are grouped under the rubric of **Travel Demand Management**, or **TDM**.

Travel Demand Management (TDM)

TDM Policies, measures, programs

Travel Demand Management (TDM) involves developing and promoting alternatives to reliance on the single-occupant vehicle – particularly alternative modes of travel:

- Transit (including buses and shuttles)
- Walking
- Bicycling
- Ridesharing
- Park and Ride
- Remote Parking

TDM is the best option for preserving and enhancing the campus environment and the resulting quality of life. As well as helping to reduce traffic volumes within and around the campus, it means that there is less pressure on land for parking, with potentially more green space or core academic buildings instead.

Institutional commitment is critical to success. The more support and encouragement the University provides, the greater the results (see text box below). TDM is most effective when 'carrots' – the positive inducements to use alternative modes of travel – are supported by 'sticks' – the factors that discourage people from driving alone. In particular, there will be minimal results as long as employees do not pay to park on campus.

Hallmarks of a Successful TDM Program

Flexible – offers people a range of choices; responds to opportunities and changes

Comprehensive – provides options that meet a diverse range of needs

Complementary – involves synergistic measures, not conflicting/competing

Dedicated Resources – a firm funding stream and dedicated staff position(s)

Stakeholder Input – before, during, and after developing the program

Marketing & Education – active outreach to the University community

Carrots & Sticks – changing individual behavior and University culture

Targeted – market-based; data driven

Evaluated – monitor, assess, and update

Integrated – with campus plans (long- and short-range), and with the surrounding community (governments, businesses, and non-profits)

Key Performance Indicators for Measuring TDM Effectiveness

Mode split	(from travel survey)
Carpool participants	(from parking permit records)
Parking occupancy	(from sample counts)
Shuttle riders	(from sample counts)
Vehicle trips generated	(estimated from data)
Commuter carbon emissions	(estimated from data)

Campus Shuttle

The current campus shuttle service does not match the class schedule and does not closely relate to students' needs. Serving the Reynolda Village lot is inefficient, as it takes up a large proportion of the van's time for very little ridership. In addition, the evening shuttle service is effectively acting as an on-campus taxi, which is an inefficient way to provide what could otherwise be a circulating evening escort service.

Service to Reynolda Village should therefore be eliminated, with the time savings used to reduce headways on the core route. The fixed route should continue through the evening, and a separate escort service should be available for people needing locations beyond the shuttle route.

In the future, campus shuttle service should be provided to Deacon Boulevard in association with proposed development in that area.

Car-sharing

Car-sharing involves cars placed on campus that are made available for rent to members of the campus community. The cars are owned and managed by an independent firm, and are made available to staff and students alike.

These programs provide people (or indeed departments) with access to a car when needed, without the costs of owning one. This not only reduces parking needs but also saves students and employees money.

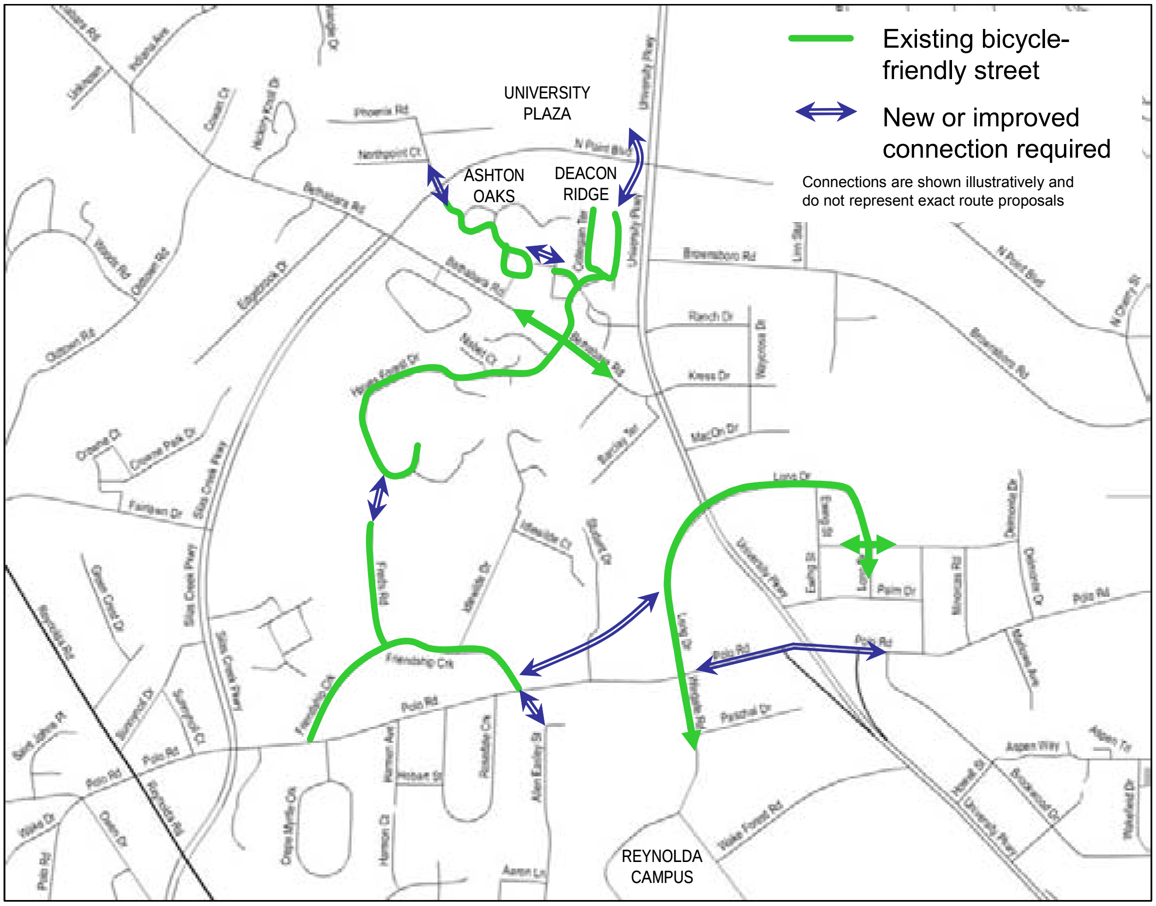
A typical cost for an individual to participate in a car-sharing program is a $30 membership fee and a $5-$8 per hour ($55-$85 per day) fee. The university will normally underwrite a certain level of use. Depending on the provider, the service may be available to drivers under the age of 21 through special insurance arrangements.

Off-Campus Bicycle Improvements

There are several opportunities for a partnership with the City of Winston-Salem, apartment complexes, shopping center management, and affected neighborhoods to develop bicycle/pedestrian links connecting the campus with student housing concentrations and retail businesses. The best example may be to the north of campus, along Bethabara Road and North Point Boulevard. With the elimination of just a few gaps (most of which are relatively short, and on land owned by WFU or residential complexes), a safe, convenient, continuous bicycle route on low-volume streets and off-street paths could be in place in a short time, with minimal investment (Figure 13).

For example, an off-street path could be constructed between Long Drive and Friendship Circle, all of which could be built on property owned by the University. Friendship Circle and Freds Road are well suited for on-street cycling. Only a short pathway is needed to connect Freds Road with Hayes Forest Drive, another bike-appropriate street that provides direct access to Bethabara Road at Deacon Ridge Road. This pathway appears to involve only one additional property owner, Baptist Homes of North Carolina. A very short link between the Ashton Oaks and Deacon Ridge complexes would allow access to all residential units via Deacon Ridge Drive. Access to University Plaza presents a greater challenge due to difficulty in safely crossing North Point Drive. However, there are several promising options, some of which require no property outside of Deacon Ridge.

Figure 13: Potential Off-Campus Bicycling Improvements



TDM Action Plan

A successful TDM Action Plan for Wake Forest University requires dedicated resources, and a commitment to effective involvement of the entire University community. A TDM Action Plan entails active management, continuing support, and two-way communication. Being "customer" driven, it requires a thorough understanding of the various travel "markets" associated with the University – their sizes, locations, and needs. As conditions change and the plan evolves, goals must be defined, priorities identified, performance monitored, and timely adjustments enacted. The following section identifies most of the elements likely to be considered in developing such a plan. While the details and timing may change, the first two bulleted items (hiring a Transportation Manager and creating a permanent Transportation and Parking Committee) are essential first steps. Most of these elements could be implemented with minimal expenditure.

- Hire a **Transportation Manager**. This position leads, promotes, coordinates, and manages TDM efforts. The Transportation Manager acts as a liaison/advocate to government (WSDOT, WSTA, PART, NCDOT), local neighborhoods, businesses, and non-profits to obtain support and/or funding for TDM programs. (Cost: $60,000-70,000 per year in salary and benefits.)

- Create a permanent **Transportation and Parking Committee** comprised of students, faculty, and staff who work with the Transportation Manager to develop policies, programs, and priorities, and to communicate with other stakeholders.
- Revise shuttle bus route and schedule. Omit the Reynolda Village stop, and reduce headways on the remaining route. Develop a new brand and improved marketing.
- Designate convenient **priority parking spaces** as an incentive to carpools and vanpools.
- Provide shared cars for short-term rental. (Cost: underwriting around $10,000 of rental fees per car per year.)
- Introduce **occasional use parking** vouchers. Such vouchers can be offered to students and employees who choose not to purchase a parking permit, providing these individuals with a limited number of single-use parking "passes" for occasions when a car is needed for a particular trip purpose. These passes can be similar to general or commuter permits, or can be designed as premium passes for short-term use at especially convenient locations.
- Strategic placement of **metered parking** can complement occasional use and visitor parking to provide alternatives for people without permits for on-campus parking. This could also lay the groundwork for a "pay-as-you-park" system, which provides an incentive for permit holders not to park, by charging (or debiting) them only when they use a parking space. This system can also be implemented so that rates vary by time of day, with peak periods and premium locations costing more than remote locations and off-peak hours. (Increased revenues.)
- Investigate partnering on shuttle services to/from student-oriented apartment complexes. (Cost: generally partially or fully funded by property owners as part of their market positioning.)
- Establish **bicycle/pedestrian group** and minor improvements budget. (Cost: negligible for group; budget could be $25,000 per year.)
- Begin '**Commuter Alternatives Program**' as framework for incentives below. (Cost: negligible.)
    - Offer **free transit passes** to transit commuters. (Cost: $360 per year per participant at current rates for monthly passes.)
    - Begin **Emergency Ride Home** service, which provides a limited number of free or discounted vouchers for taxi service in the event that a transit or rideshare commuter needs to return home due to illness or other family emergency. This eliminates one of the most frequently cited obstacles to use of these commuting alternatives. (Cost: less than $25,000 per year.)
    - Begin **Neighborhood Ride Home** service, which provides a ride home via shuttle to residents of designated neighborhoods who are willing to walk or bike to campus, but who may not want to return on foot or bicycle due to darkness or inclement weather. This helps address a frequently cited drawback to walking and bicycling. (Cost: $50,000 - 100,000 per year.)

- Implement **parking zones** to reduce on-campus traffic and to more efficiently manage oversell and occupancy rates. In addition, by providing greater convenience and reliability, zoned parking can justify charging higher parking rates for those who value and desire this benefit, while those who do not can pay far less for non-premium parking. This creates a revenue source that can be used as a cross-subsidy for other transportation needs.
    - Implement nominal **parking fees** in conjunction with the introduction of zoned parking:
        - Employee core permit costs $150 (campus core) or $50 (outside campus core).
        - Generates income.
- Work with City of Winston-Salem and others to **improve bicycle and pedestrian access** to the campus from nearby neighborhoods and retail/service centers.
- Apply for **'Best Workplaces for Commuters'** status through the Center for Urban Transportation Research.
- Eliminate freshmen parking; move some residents' cars off campus and make it free. (Cost: $450,000 or more in lost fees.)
- Offer $100 '**cash-out**' for returning parking permit. (Cost: $100 annually, per participant, plus any loss of permit revenue.)
- **Relocate resident parking** (free/discounted) to Deacon Boulevard, with new shuttle service. (Cost: absorbed within Deacon Village project.)
- **Negotiate U-pass scheme** in return for city transit improvements. (Variable cost.)
- **Give priority to commuters living further from campus.** Individuals living within a short distance of Wait Chapel (for example, two miles) would not normally be eligible for parking permits, with exceptions for special needs. This is because they have the most opportunities to walk or cycle. (Cost: some loss of permit revenue.)

Table 1 is an example of another way of looking at the implementation and tracking of TDM options and other supportive policies and services. It categorizes each element by sequential stage, and by the organizational/functional area most closely associated with it. Again, the entries in this matrix can be modified or shifted as appropriate to create an evolutionary plan for transitioning from an auto-oriented campus to a more sustainable, pedestrian-friendly campus with a wider range of choices for access and mobility.

Table 1: Prototype Three-Stage Transportation Transition Plan

		Stage I		Stage II		Stage III
		Implement TDM and Backup Programs		Implement Parking System Adjustments		Complete Parking System Transition
Organizational Changes	☐	Data Collection for TDM / Bus / Parking / Enforcement	☐	Data Collection for TDM / Bus / Parking / Enforcement	☐	Data Collection for TDM / Bus / Parking / Enforcement
	☐	Hire TDM Coordinator / Parking Manager	☐	Update Commuter Alternatives Program	☐	Update Commuter Alternatives Program
	☐	Begin Commuter Alternatives Program	☐	Apply for Best Workplace for Commuters		
	☐	Establish Transportation Committee				
	☐	Establish Process Evaluation Program				
	☐	Join ridesharing programs (PART, Share the Ride NC)				
Back-up Programs & TDM	☐	Research car-sharing	☐	Implement car-sharing	☐	Update Car-sharing
	☐	Establish WFU Ridesharing Program	☐	Monitor & update WFU Ridesharing Program	☐	Monitor & update WFU Ridesharing Program
	☐	Establish Bicycle/Pedestrian Program	☐	Monitor & update Bicycle/Pedestrian Program. Investigate bike-sharing program.	☐	Monitor & expand Bicycle/Pedestrian Program
	☐	Investigate Emergency Ride Home service	☐	Begin Emergency Ride Home service	☐	Monitor & expand Emergency Ride Home service
	☐	Investigate Neighborhood Ride Home service	☐	Begin Neighborhood Ride Home service	☐	Monitor & expand Neighborhood Ride Home service
	☐	Provide limted parking passes/vouchers to commuters not purchasing parking permits.	☐	Offer free transit passes, bicycles to commuters/residents not purchasing parking permits.	☐	Negotiate U-Pass scheme with PART & WSTA
			☐	Offer parking cash-out ($100?) for not purchasing permit.		
Parking Management System	☐	Begin discussions of freshman and resident parking changes	☐	Move some resident parking off campus	☐	Relocate resident parking to secure lot in Deacon Blvd area. Lot would be free/heavily discounted, with new shuttle service.
	☐	Designate preferential carpool/vanpool parking	☐	Eliminate/restrict freshman parking	☐	Eliminate permits for those living within __ miles of Wait Chapel
	☐	Update & improve special event / overflow parking plans	☐	Assess feasibility of secured storage lot near campus	☐	Monitor & update enforcement & appeals processes
	☐	Investigate metered parking options	☐	Implement metered/short-term parking	☐	Adjust visitor parking supply & location
	☐	Lay groundwork for increasing parking permit fees (including zoned parking and other options)	☐	Implement proximity-based parking zones (with corresponding fees)	☐	Consider premium, lot-specific (reserved) permits in core area
	☐	Review enforcement, appeals, & related processes	☐	Update enforcement and appeals processes		
	☐	Assess vendor & contractor parking	☐	Implement changes to visitor, vendor, contractor parking		
	☐	Evaluate visitor parking situation				
Transit Operations	☐	Establish a feedback / suggestion program	☐	Adjust routes according to feedback	☐	Adjust routes according to feedback
	☐	Revise campus shuttle route and schedule	☐	Evaluate contracting for transit service	☐	Reduce headways & increase capacity (as needed)
	☐	Establish perfromance measures & data collection needs	☐	Begin data collection, surveys, & performance monitoring	☐	Revise & continue data collection & performance monitoring
	☐	Evaluate medical & research center shuttle service	☐	Revise medical & research center shuttle services	☐	Initiate shuttle service to Deacon Blvd area & remote lot
	☐	Investigate shuttle partnerships with student apartments	☐	Implement apartment shuttle services		
	☐	Formalize route schedules / maps				
	☐	Enhance "brand image" and system marketing				
Budgeting	☐	Develop new 5-year financial plan & budget	☐	Adjust permit prices to balance with fewer permits sold	☐	Adjust permit prices to balance with fewer permits sold
	☐	Establish Transportation Capital Improvement Program	☐	Transit improvement plan	☐	Implement parking facility improvements
	☐	Identify bus stop improvements (lights, shelters, signs, phones)	☐	Develop Transit Improvement Plan	☐	Implement transit improvements
	☐	Develop Bus Maintenance Plan			☐	Implement other transportation capital improvements
	☑	Check box when milestone is completed				
		Stage I establishes back-up programs the University will offer to individuals as alternatives to driving alone, and begins improved parking management processes.		**Stage II** begins the reduction of parking supply & permit sales, and seeks to capture true costs of parking in the rates charged.		**Stage III** introduces a more sustainable, pedestrian & transit-oriented campus and culture.

Parking Management Plan

The following section steps through the analysis and assumptions used to estimate parking needs and proposed solutions for each of the two phases identified in the Campus Master Plan. Again, these are intended for planning purposes, and should be adjusted to reflect more current and detailed information as it becomes available, or as more definitive decisions are made. The Appendix to this document provides a more detailed accounting of specific parking losses and gains associated with individual components of the Master Plan.

<u>Phase 1 Parking Supply/Demand</u>

- Anticipated loss of just over 900 spaces is equivalent to approximately 25**%** of existing on-campus commuter/resident spaces.
  - Additional 250 spaces needed for growth.
  - Total deficit of ~1150 spaces at the end of Phase 1.
- Assume **5%** commuter demand reduction due to TDM (frees-up approximately 150 spaces), for a ~1,000-space deficit.
- Assume freshmen & sophomore residents shift to free satellite storage; juniors move to Polo Rd lot (or any similar combination that moves two-thirds of residential parking off-campus).
  - Frees-up around 700 spaces on campus, for a 300-space deficit.
  - Costs $450,000-$475,000 per year in lost permit fees.
  - Requires a shuttle service (either on-call or scheduled).
- Would also need to ban freshmen cars to achieve a parking surplus.
  - Frees-up approximately 400 more spaces.
  - Provides ~**100** space **surplus** for Phase 1.
- Loss of resident parking income could be offset by average faculty/staff fees of around $250.

<u>Phase 2 Parking Supply/Demand</u>

- Anticipated cumulative loss of 1,200 spaces (900 in Phase 1 and another 300 in Phase 2) is equivalent to approximately 35**%** of existing on-campus commuter/resident spaces.
  - Total deficit of ~1,450 spaces at the end of Phase 2 (1150 from Phase 1 + 300 in Phase 2).
- Assume **12%** commuter demand reduction due to TDM (frees-up approximately 300 spaces), for a ~1,150-space deficit.
- Assume <u>**all**</u> residents shift to free satellite storage.
  - Frees-up around 1,200 spaces on campus and at Polo Road.
  - Costs $790,000 in lost permit fees.

        - Provides ~**50** space **surplus** for Phase 2.
    - Loss of resident parking income could be offset by tiered faculty/staff fees averaging $440.

TDM and Parking Summary

In the long-term, a full TDM Action Plan could reduce employee parking demand by about 12% (about 150 spaces) and could reduce commuter student parking demand by about 15% (about 250 spaces).

However, it will take time to build programs up to this level. In the short-term, an overall commuter parking reduction of about 5% (about 150 spaces) can be expected if initial TDM efforts are successful.

Remote/satellite parking could provide 1,000 or more resident student spaces, but this depends on available "free" land and a potentially expensive shuttle service. Satellite parking is less feasible for commuting students or employees, because of the much more expensive shuttle service that would be required for a smaller potential market. Also, shifting this much parking off campus will significantly affect special events held on campus. Providing deck capacity can cost a similar amount to a satellite-and-shuttle system, but would generate revenue from parking fees that would not be viable for satellite parking.

Summary of TDM Program

Realistic program can save 150 - 400 spaces over time

- Eliminates or delays deck construction
- Requires improved shuttle service
- Depends on resource commitment & person-in-charge
- Partnering with outside entities required
- Program should start *before* it is really needed
- Must include reasonable parking fees

APPENDIX: TRANSPORTATION

Master Plan Impacts on Parking Supply

The following sections describe the impacts of individual projects on specific parking lots, in terms of spaces lost to new construction, spaces recovered through reconfiguration, and spaces gained in new parking lots or other facilities. The projects are grouped by Phases:

- Phase 1 – Years 0 through 5;
- Phase 2 – Years 6 through 10; and
- Phase 3 – Beyond Year 10.

Some temporary or interim parking lots have been identified. These would share the footprint of a proposed building until its construction, typically in the following Phase.

Phase 1

New Science Building on Lot E

> Of the 49 (mainly faculty/staff) spaces in Lot E, it should be possible to reclaim at least 12 (and as many as 20) by constructing a small lot east of Salem Hall that mirrors Lot D. At a minimum, this lot (identified as Lot 1-E, for Phase 1 modification or replacement of Lot E) would include necessary accessible (ADA) spaces.

New Admissions Building

> The new Admissions Building will eliminate the 28 faculty/staff spaces in Lot S2, but as many as 120 spaces could be provided in the associated new parking lot, Lot 1-S2. To be most effective, this lot will require a safe and convenient pedestrian connection eastward, to the main campus. This should be addressed as part of the proposed upgrading of pedestrian connections to Reynolda Village.

New Upper Class Residence Hall and Student Services Building

> Construction of these two buildings is the first step in the gradual elimination of Lot Q and the creation of two new quads. An estimated 165 residential/general parking spaces would be lost from Lot Q. Furthermore, Lots R1 and R2 may also be affected, depending on the earthwork involved, and improvements to the intersection of Allen Easley and Carroll Weathers Drives will likely be needed to handle increased traffic volumes (increased turn radius and some widening to provider smoother flow for heaviest traffic movements). It would be possible to expand Lot R3 at either end, and/or to construct an interim parking lot on the future site of the second upper class Residence Hall (proposed for Phase 2). These steps could provide at least 65 interim spaces and up to 20 permanent spaces to offset the loss of existing residential/general spaces. This would result in a net loss of 380 spaces for Lots Q, R1, R2, and R3.

New Freshman Residence Hall on Memory Lane

This Residence Hall is adjacent to the southwest side of Collins Residence Hall. Its construction will reduce the size of Lot J by an estimated 42 residential/general spaces.

New Campus Recreation Center and Relocated Poteat Field

These projects, in combination with necessary realignment of Carroll Weathers Drive, eliminate Lot W1 and, effectively, Lot W2. Assuming demolition of the adjacent Townhouse Apartments, a new parking lot could be constructed west of Information Systems, in the approximate location of Lot W2. This lot, 1-W2, has an estimated capacity of 160 spaces, resulting in a net loss of approximately 450 spaces of various types.

Realigned and Improved Wake Forest Road

Several parking lots are affected by plans to realign Wake Forest Road in order to expand and enhance the pedestrian-friendly campus core; allow for changes to Davis Field and a new Library Quad; improve wayfinding and the entry/arrival experience; and upgrade overall aesthetics. Lots B and N are to be converted into green courtyards, resulting in 97 fewer parking spaces. Approximately 65 commuter and faculty/staff spaces are lost in the reconfiguration of Lots S and T.

Library Quad

It is assumed that the design of the Library Quad will preserve limited access to Lots C and D, and that a handful of short-term, accessible (ADA), reserved, or other special-use spaces will be provided at either end of the quad, resulting in no significant parking losses.

Phase 2

Salem Hall Expansion

This project eliminates both Lot D and Lot 1-E (the latter built after the new Science Building was constructed on Lot E). Total impact is a 33-space reduction in faculty/staff parking.

Practice Football Field Relocation / Palmer-Piccolo Residence Hall Demolition

The resident parking lot serving Palmer-Piccolo (Lot U) and a small faculty/staff lot (Lot U2) will be eliminated when the football practice fields are relocated to the area immediately southeast of the Water Tower Field.

New Freshman Residence Hall on Lot G

This Residence Hall eliminates all 49 faculty/staff parking spaces in Lot G.

Upper Class Residence Hall north of east end of Lot Q

This Residence Hall eliminates all 65 residential/general parking spaces in temporary Lot 1-R1/R2.

Miller Center Expansion

The expansion of the Miller Center to the northeast eliminates all 26 faculty/staff spaces in Lot V.

Manchester Center Demolition

As many as 50 parking spaces could be located temporarily on the site of the Manchester Center, pending construction of a proposed academic building. Construction of these spaces has not been assumed for the purposes of this analysis.

Redevelopment of Gulley Drive

The proposed redevelopment of Gulley Drive entails its transformation and northeastward extension as a green space/pedestrian way. The most obvious parking impact of this project is the loss of 60 on-street parking spaces. It will also (in combination with the extension of Memory Lane around the Miller Center and over to Wake Forest Road, discussed below) require Memory Lane to be converted to a two-way street. This would require removal of all 87 on-street parking spaces on Memory Lane. This redevelopment project would allow construction of a new parking facility (Lot 2-E1) near the southwest end of existing Gulley Drive, in front of Luter Residence Hall. The 40 spaces in this lot would primarily provide visitor and faculty/staff parking for the library and the science quad.

New road on east side of Campus (Memory Lane Extension)

The proposed road extends from Wake Forest Road (between Worrell Professional Center and the new Recreation Center), around the expanded Miller Center, and through the existing practice football fields and Lot F before connecting with the northwest end of Memory Lane. Combined with earlier improvements to Wake Forest Road; the realignment of Carroll Weathers Road to accommodate the Poteat Field relocation; and an improved road running between Worrell Professional Center and the new Recreation Center, this is the last segment of a near-continuous route around the entire campus. This facility will reduce traffic on Wake Forest and Wingate Roads, improve access to the underutilized southeast area of Campus, and help create a more walkable campus, especially at its core. As part of the construction of this new roadway, Lot U3 can be expanded in front of the new wing of the Miller Center, creating 40 spaces in a new Lot 2-U3.

The new east campus road also affects Lot F. By reconfiguring the remainder of Lot F and expanding it into the equipment storage area behind the Central Heating Plant (assumed vacated as these functions are migrated off campus), losses can be reduced to as few as 40 spaces. In addition, there may be an opportunity for interim parking located northwest of Lot F, on a portion of the abandoned football practice field. This parking would need to be configured to avoid interfering with the conversion and extension of Gulley Drive, and would be available only until construction of buildings in this location. However, at least 85 parking spaces could be located here (new Lots 2-32 and 2-34/35).

Phase 3

New Academic Buildings and Quad on Lot 1-Q

Construction of this quad on the site of existing Lot Q will eliminate 625 parking spaces of various types. A very limited number of spaces will need to be provided for service, special needs, deliveries, etc., but no significant replacement can be provided on campus without the use of structured parking. Due to the grades involved and the amount of fill needed, it may be feasible to locate one or two levels of parking beneath at least the southwestern-most building and the plaza portion of this quad. Depending on site geology and design considerations, as many as 400 spaces could conceivably be located beneath the quad.

Upper Class Residence Halls on Lot Z

Construction of these residence halls will eliminate all 63 spaces in Lot Z.

Upper Class Residence Halls on Lots A and P

Although these residence halls will eliminate all 238 parking spaces in Lots A and P, 90 of these spaces can be regained in two smaller lots (3-A and 3-P) tucked between the new halls and Wait Chapel.

Freshman Residence Halls along the eastern extension of "Gulley Green"

The three halls proposed in this location (on the site of the present day practice football field, opposite Manchester Athletic Center and Miller Center) would require removal of any interim parking placed there during Phase 2 (Lot 2-32 and Lot 2-34/35).

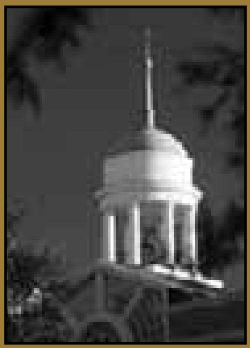
Other potential parking facilities

A number of other options for additional on-campus parking capacity were also considered, and are described below. These facilities are not required to satisfy the parking needs described in the preceding analysis; they could yield parking benefits, and warrant consideration on a case-by-case basis. More detailed design and analysis will be needed to establish the feasibility of these projects, particularly the structured parking beneath the Recreation Center and the Lot Q Quad, as well as the shelf over existing Lot J.

- Capacity: 125 spaces
- Phasing: Can be implemented at any time as permanent or interim lot
- Pros
  - Easy access from Polo Rd, minimizing traffic on campus roads
  - No loss of existing parking
  - Flexible implementation
- Cons
  - May not make for a desirable entrance experience
  - Loss of green space
  - Not centrally located

- Deck under all or part of new Recreation Center
    - Capacity: up to 150 spaces
    - Phasing: Implemented permanently in Phase 1
    - Pros
        - Convenient central location
        - Good access from two directions
        - No loss of existing parking or green space
        - Can be implemented in Phase 1
    - Cons
        - Expensive
        - Limited size and flexibility
- Shelf or deck on eastern portion of Lot J
    - Capacity: 140 spaces gained
    - Phasing: Implemented permanently at any time
    - Pros
        - No loss of green space
        - Less costly than deck
        - One of few options in under-served part of Campus
        - Flexibility in implementation timing
    - Cons
        - Loss of J Lot during construction
        - Limited capacity
        - More expensive than surface lot
        - Potential neighborhood issues
- Surface lot or deck on current Facilities Management site
    - Capacity: Up to 400 spaces, possibly more
    - Phasing: Permanent or interim implementation upon off-campus relocation of all or part of Facilities Management physical plant.
    - Pros
        - No loss of existing parking or green space
    - Cons
        - Depends on relocation of most of Facilities Management plant
        - Least convenient access for cars and pedestrians

        - Potential neighborhood issues
- Deck under all or part of new academic buildings and quad on current Lot Q site
    - Capacity: Up to 400 spaces, possibly more
    - Phasing: Implemented permanently in Phase 3
    - Pros
        - Convenient pedestrian and car access
        - No loss of existing parking or green space
    - Cons
        - Very expensive
        - Limited flexibility; cannot be implemented before Phase 3
- Expand Lots W2 & W3 near water tower
    - Capacity: Fewer than 40 spaces gained
    - Phasing: Permanent or interim implementation at any time
    - Pros
        - Short walk to Worrell Center
        - Flexibility in implementation
    - Cons
        - Limited capacity
        - Loss of trees and buffer
        - Drainage/stream impacts
        - Auto access is not convenient
        - Loss of existing parking during construction



Utilities Systems

Affiliated Engineers, Inc.

Reynold Hall with downtown Winston-Salem in the background

Executive Summary

Wake Forest University is planning for future campus renovations and building construction at the Reynolda Campus over the next five years (Phase 1), the following ten years (Phase 2), and beyond (Phase 3). As building square footage increases, the demands on utilities infrastructure will as well. Upgrades and modifications to the utilities systems should be coordinated with implementation of the master plan. Affiliated Engineers, Inc. (AEI) was retained to develop a long term utilities systems master plan that identifies necessary modifications and expansion to meet the projected load increases and to correct existing deficiencies. AEI evaluated the cooling system, the heating system, the electrical system, the telecommunication system and the water and sewer systems. Step-by-step analysis included the following major tasks:

- Existing Conditions and System Assessment
- Current and Future Load Projections
- Options for Expansion and Improvement
- Recommendations for Separate Projects

Chilled Water System: The existing chilled water infrastructure is in relatively good condition. Four chilled water plants are interconnected and can deliver chilled water to separate regions, or to the entire campus. Almost immediately, chilled water capacity must be increased in order to accommodate any planned expansion on campus.

To meet the anticipated growth, it is suggested that the South Chiller Plant go through a major upgrade to increase its capacity to 4,800 tons. The South Chiller Plant was originally built to accommodate an additional 1,200 ton chiller, which should be installed as the first step. This will allow sufficient capacity through Phase 1 and into Phase 2. In Phase 2, it is recommended that the North Chiller Plant be redesigned and expanded to provide a total of 6,000 tons worth of cooling capacity. With the capacity and efficiencies gained in the North and South Chiller Plants, the aging West and Worrell Chiller Plants could then be demolished, thereby freeing up those two locations on campus for potential development. Also, it is recommended that three major piping distribution lines be installed on campus to allow for efficient distribution of the increased capacity.

Steam System: One single heating plant currently provides all of the campus steam needs. With the anticipated campus growth, additional steam capacity will be required. Late in Phase 1, a boiler installation project is recommended for the existing boiler plant. The steam plant was originally constructed with two 60,000 lbs/hour boilers and expansion space for a third boiler. The installation of an additional 60,000 lbs/hr boiler will provide enough capacity and redundancy to the campus for the total proposed build out. The existing steam infrastructure has adequate capacity for the current load. It is recommended that new steam mains be constructed on campus, primarily on the north and west portions of campus, to allow for efficient distribution of the steam.

Electrical System: The existing infrastructure is in good condition and has sufficient capacity to accommodate Phase 1 of the master plan. Prior to the beginning of Phase 2, the utility transformer and the Cherry St. substation should be upsized to allow for enough spare capacity to serve the Reynolda Campus through Phase 3. The two Reynolda Campus distribution switchgear line-ups should be retrofitted to provide submetering at each feeder circuit breaker. The metering should be integrated into the existing campus SCADA system to increase

reliability and monitor usage. Additionally, the campus “Central Feeder” distribution loop has six separate cabling segments that are undersized. That cabling should be replaced with #500KCMIL cabling to provide full circuit capacity. This will expand overall system redundancy and flexibility.

Telecommunications/Information Technology: The existing telecommunications infrastructure is nearly at full capacity and requires immediate upgrades to accommodate Phase 1 of the master plan. It is recommended to install a robust central raceway infrastructure that can serve each new and/or existing building. The planning strategy is to use existing and refurbished steam tunnels to route new conduits around the campus and back into Reynolda Hall and Reynolds Library telecommunications core locations. When the steam tunnels cannot be utilized, new underground conduits in ductbank should be installed where new roads are being built outside of the campus core. They will connect the Information Systems building back to the campus core as well as provide pathways for buildings on the campus perimeter.

Domestic Water, Storm Water and Sanitary Sewer: The majority of the existing domestic water system is over 50 years old, but in relatively good condition. There are a few areas of campus that have low pressure. The sanitary system is of the same vintage. The existing system has capacity for campus growth, but also has some areas which require repair.

The overall capacity of these systems can support the campus expansion detailed in the master plan. It is recommended that the low pressure deficiencies of the domestic water system be corrected by upsizing of piping, coupled with connection onto another higher pressure city main. It is recommended that known damaged areas of the sanitary sewer system be repaired prior to adding additional buildings to the system.

I. Cooling Systems

Existing Conditions and System Assessment

The cooling needs for Wake Forest University are currently met by a chilled water loop connected to 4 chiller plants. The plants were constructed between the late 1980's and the mid-1990's to replace the aging cooling system that was installed at the campus's inception in the 1950's. These new centralized plants contain electric-drive, water-cooled centrifugal chilling units using a primary-secondary type pumping arrangement. As the cooling load has grown on campus, additional chillers have been added to satisfy the campus load. Figure I-1 below shows the locations of the four plants and the existing chilled water distribution system.

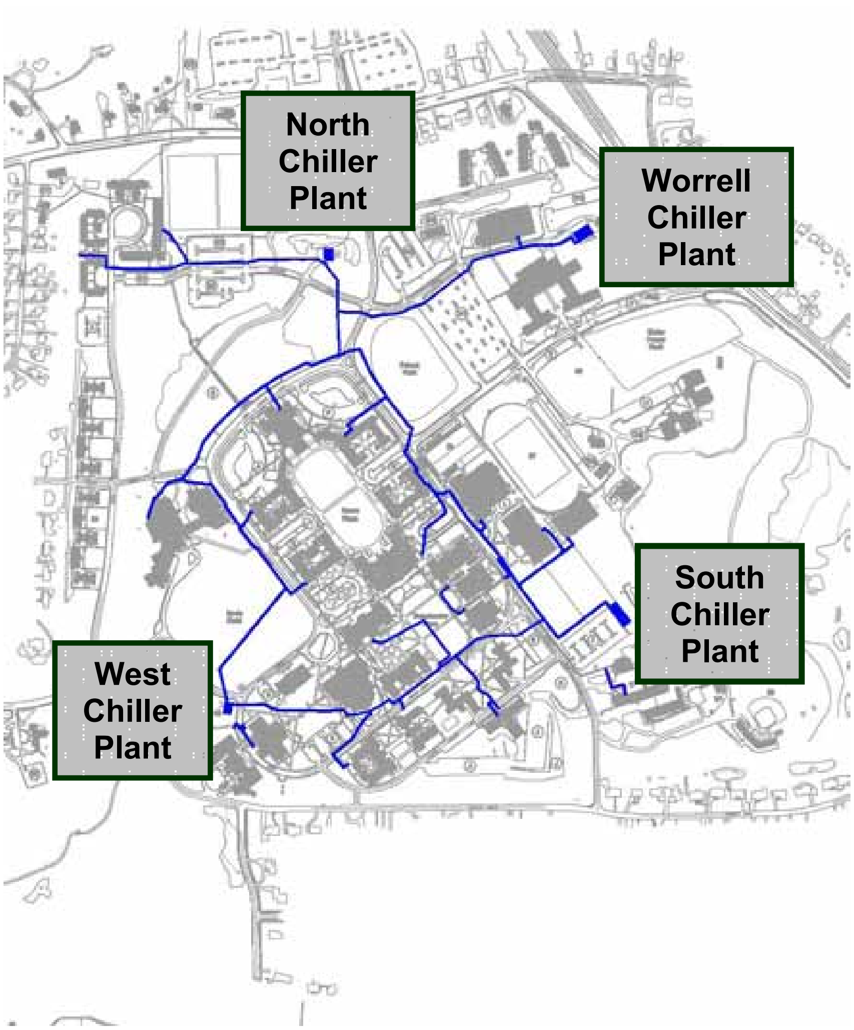


Figure I-1: Chilled Water Distribution System

The cooling towers at these plants are a combination of packaged induced draft counter flow and cross flow designs. One forced draft counter flow tower is located at the West Plant. These cooling towers are located at grade beside the chiller plant, except for those at the West Plant, which are located in a large pit beside the plant. The useful life of these types of cooling towers is usually 15-20 years. As expected, these cooling towers are nearing the end of their useful life.

The majority of the primary and secondary pumps located in the plants are base mounted double suction vertical split case type. The primary pumps are constant speed. The distribution pumps are variable speed.

The chilled water distribution piping is field constructed and insulated, direct buried welded steel. The normal maximum differential temperature of the loop (ΔT) is 10^oF. In contrast, the pumps and chillers in the North Chiller Plant and all but one chiller at the South Chiller Plant are sized for a 16^oF ΔT, which results in less than optimal plant performance and higher than necessary energy consumption.

Table I-1: Existing Chiller Data

Chiller Plant	Item Number	Make/ Model	Cooling Tower Type	Year Installed/ Expected Failure Year	Refrigerant Type	Name-plate Capacity (Tons)
North	CH-1	Trane	Induced Draft, Packaged, Cross-Flow	1994/2019	HCFC-123	600
	CH-2	Trane		1994/2019	HCFC-123	600
South	CH-1	Trane	Induced Draft, Packaged, Cross-Flow	1996/2021	HCFC-123	600
	CH-2	Trane		1996/2021	HCFC-123	600
	CH-3	Trane		2003/2028	HCFC-123	1200
West	CH-1	Trane	Forced Draft, Packaged, Counter-Flow	1996/2021	CFC-11	485
	CH-2	Trane		2001/2026	HCFC-123	600
Worrell	CH-1	Trane	Induced Draft, Packaged, Cross-Flow	1990/2015	CFC-11	400
	CH-2	Trane		1990/2015	CFC-11	400
					Total Peak Capacity	**5,485**
					Firm N+1 Capacity	**4,285**

Currently between all 4 plants, there is 5,485 tons of nameplate cooling capacity. At this time, the cooling needs of the campus are satisfied. In terms of redundancy, University staff believes that the campus cooling needs on a design day would be satisfied if one 600 ton chiller were to fail. Table I shows the existing chiller data.

As future loads come online, additional cooling capacity will be required. The existing South Plant has been designed to allow for a single 1,200 ton chiller to be added with minor additions to the plant. Conversely, the North plant does not have any additional capacity within its walls, but has a good amount of land surrounding it for a building expansion to allow for increased chiller capacity. Currently, the design of the West Plant makes it difficult to provide additional cooling capacity to the campus loop, as it was originally designed as a local plant serving adjacent buildings. Finally, the Worrell Plant does not contain pumps of adequate size to provide much additional capacity to the campus loop.

A deficiency of the existing chilled water system is that the return water temperature is too cold, preventing the existing chillers from operating at peak efficiency, as well as increasing the pumping energy on the chilled water distribution system. Minor reconfiguration of the buildings mechanical rooms and two-way cooling coil control valves may allow for a more efficient use of chilled water.

Current and Future Load Projections

Data received from the University show that the current peak load is nearly 5,000 tons, with a maximum chilling capacity from the four existing chiller plants of 5,485. A failure of the current 1,200 ton chiller (largest single chiller on campus) at peak load would result in insufficient cooling capacity for the University on a peak design day. Based on this information, the University does not have the necessary N+1 redundancy, or enough capacity to provide adequate cooling if the largest chiller were to fail. As new buildings are constructed and connected to the existing cooling system, additional cooling equipment will be required.

The load growth is based on the phasing of the new building construction, the expected type of building, and its size. Each building type was given a factor for cooling load per square foot. These values come from historical data for buildings of this type located in similar climates. The product of this value and the buildings square footage gives a peak load for each building. The sum of all of the peak loads is then multiplied by a diversity factor. As these buildings are connected to a centralized plant system, it is not expected that all of the buildings will see maximum load all at the same time. This diversity factor represents the expected amount of cooling required at a point in time over the entire campus. Table A-1 follows this report and provides a detailed summary of the existing campus loads.

Table I-2: Chilled Water Load Densities per Building Type

	Estimated SF/Ton
Academic	325
Admissions	325
Athletics	375
Housing	350
Recreation Center	350
Student Life	300
Laboratory	300
Miscellaneous	400
Diversity	0.75

As mentioned previously, the expected load growth will require additional cooling capacity and infrastructure. The ultimate Phase 3 load is approximately 8,500 tons, a 50% increase in the current load. To better understand the areas on campus that have the largest increase in load, see Figure I-3 which shows the increase in load per phase at each area on campus. It can easily be seen that the North and South Zones have the greatest increase of load and a concentration of additional cooling in these areas may be optimal.

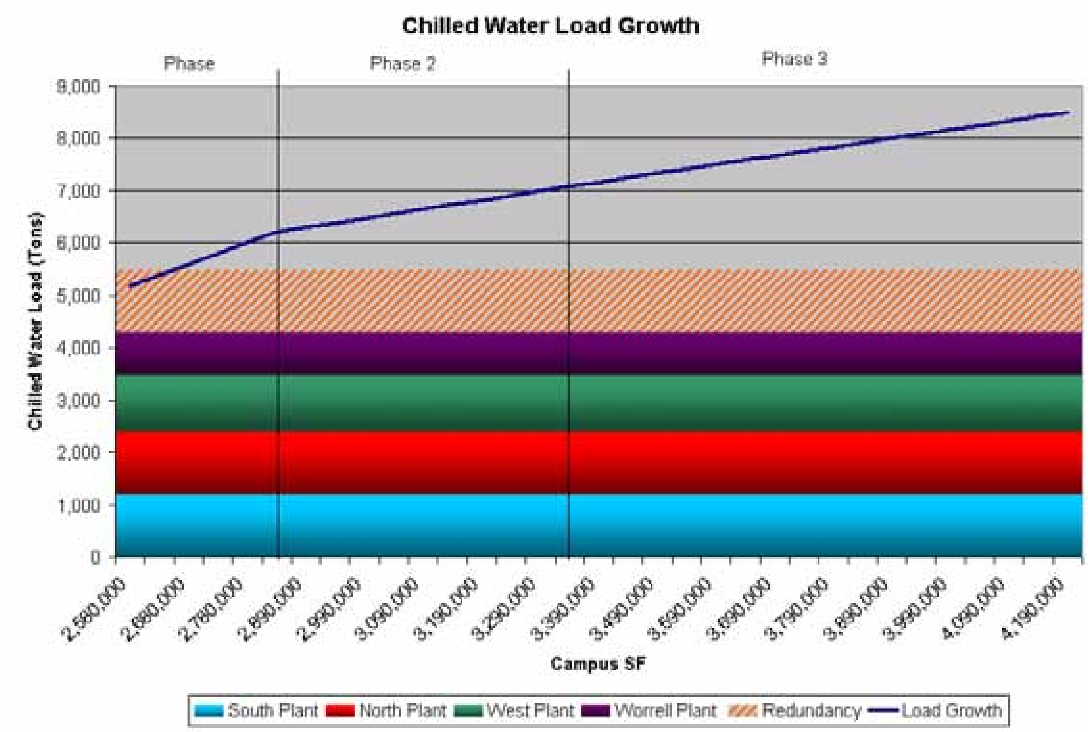


Figure I-2: Chilled Water Load Growth with Existing Plant Capacities

Options for Expansion and Improvement

The load projections indicate a 50% increase in cooling load over the full build-out of the master plan. The most immediate need is to provide additional cooling equipment for redundancy to reduce the risk of an outage in the event of equipment failure.

The existing South Chiller Plant has two 600 ton chillers, and one 1,200 ton chiller, for a total of 2,400 tons. It has been designed to be able to add one more 1,200 ton unit installed with very minor modifications to the existing plant.

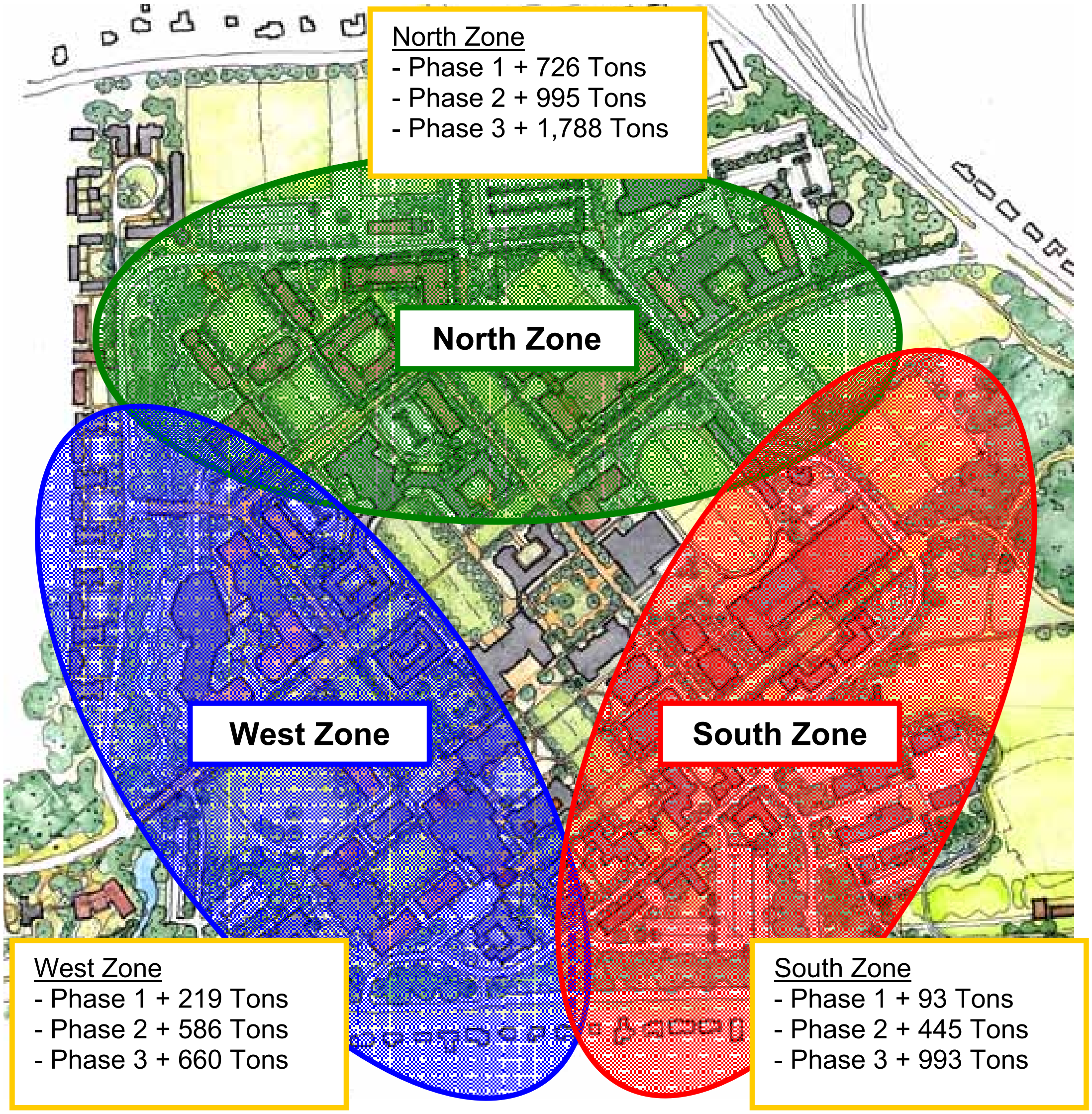


Figure I-3: Chilled Water Load Growth with Existing Plant Capacities

The North Chiller Plant has two 600 ton chillers, but does not have space within the existing footprint for additional equipment. The existing plant is in an excellent location to serve future loads, and it would be advantageous to expand the North Plant building and create more capacity.

The West and Worrell plants are the most deficient plants in the system, both in terms of equipment and location. It is recommended that these plants be phased out of service over time and demolished.

There are two viable options for phasing additional capacity to the chilled water system. The general shape of the campus allows for chilled water plants located at the periphery, with a central loop for circulation. Option 1 proposes that the South and the North Chiller Plants are renovated and each increased in capacity to 3,600 tons, while the existing West Chiller Plant is replaced with a new plant capable of delivering 3,600 tons to campus. The deficient Worrell plant will be demolished. This allows for 3 plants, equally spaced around campus, to pump into the loop.

Option 2 proposes renovating and increasing the capacity of the South Chiller Plant and North Chiller Plant to 6,000 tons and 4,800 tons, respectively. This option centralizes the chilled water equipment along Wingate Road.

Typically, additional chiller plants will allow for a lower quantity and smaller size piping to be installed. As can be seen in Figure I-3, the load growth on campus is largely in the South and North precincts of campus. A relatively low load growth occurs in the West Zone. If a chiller plant is installed in the West Zone, its impact to the pipe size and location is minor compared to the two plant option. A disadvantage of the three plant option is the increased maintenance required by dispersed chilling equipment. Option 1 has additional disadvantages and no significant benefits, therefore Option 2, the two plant option, is recommended.

As described in the previous section, the load is predicted to grow as new buildings come online. The timing for when these buildings' loads are connected into the central loop can be found in Table A-2 at the end of this report. As the load grows, it is important to determine when new chilled water equipment or new chilled water plants are required. Figure I-4 and I-5 represent two sub-options for the ultimate build-out of Option 2.

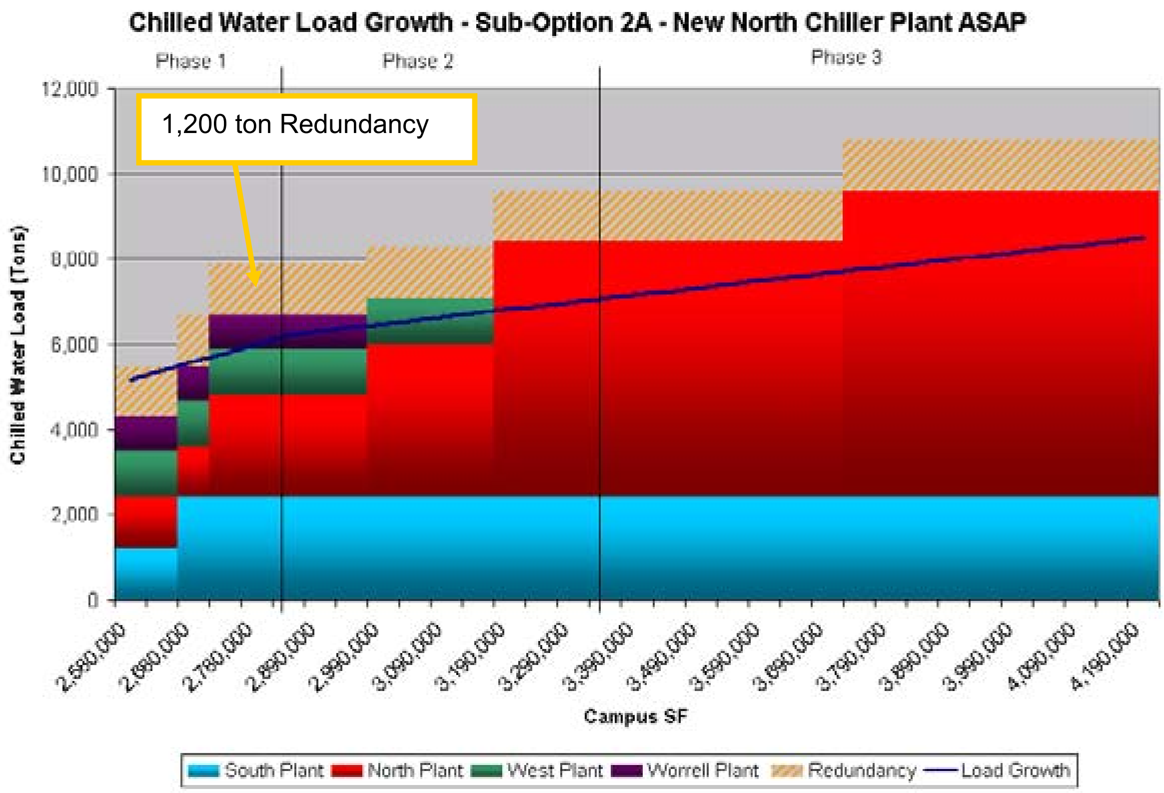


Figure I-4: Chilled Water Load Growth with Expedited Capacity Increase Option

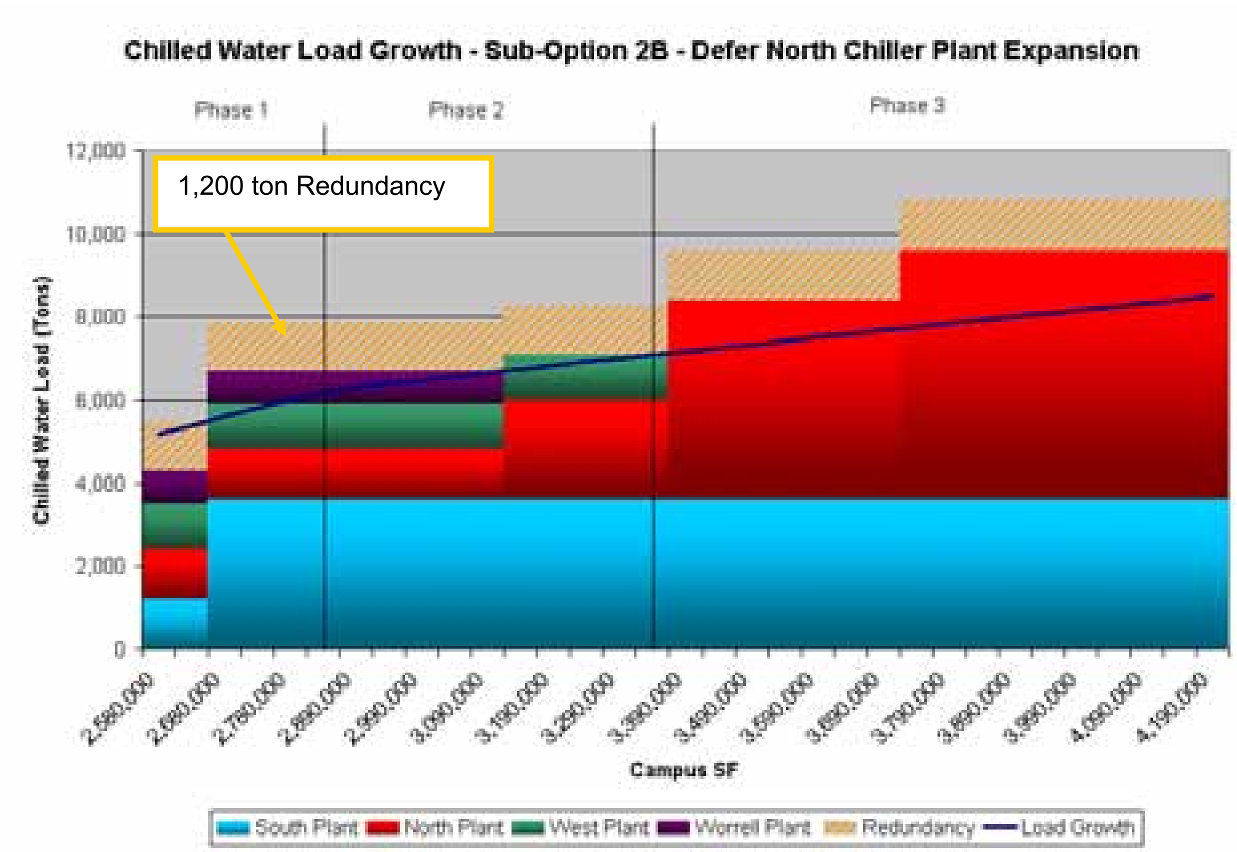


Figure I-5: Chilled Water Load Growth with Deferred Capacity Increase Option

Sub-option 2A proposes installation of a 1,200 ton chiller into the South Chiller Plant where there is an open bay for this equipment. When additional cooling capacity is required, the North Chiller Plant will be renovated to allow for additional chillers to be installed in phases as the load grows to a projected capacity of 7,200 tons.

Sub-option 2B defers the renovation of the North Chiller Plant to Phase 2. This requires a renovation and expansion of the South Chiller Plant to allow for four 1,200 ton chillers to be installed. The North Chiller Plant ultimate capacity in this sub-option would be 6,000 tons.

As can be seen in Figure I-4 for sub-option 2A, the projects for installing additional capacity in the South Chiller Plant to increase its capacity to 3,600 tons (1,200 ton redundancy), as well as the project to renovate the North Chiller Plant must occur almost immediately to keep up with the load growth. In Figure I-5 for sub-option 2B, the South Chiller Plant is expanded immediately to 4,800tons, allowing for the North Chiller Plant renovation to be deferred until Phase 2. The existing West and Worrell Chiller Plants will be required to stay active for a longer time in sub-option 2B than with sub-option 2A. This may reduce the reliability of the system as the equipment in these existing plants age.

However, sub-option 2B seems the most appropriate for the future growth of the chilled water system. This option is advantageous from a cash flow perspective, provides for more even distribution of equipment between the two plants, and best matches the projected load increase adjacent to each chiller plant.

Chiller Plant Renovations

In Sub-option 2B, both the North and South Chiller Plants are to be renovated. The South Chiller Plant needs to be renovated almost immediately. Currently the South Chiller Plant has two 600 ton chillers, and one 1,200 ton chiller. These chillers are connected to a primary-secondary pumping system. There are 3 primary pumps located beside each chiller. There are 3 distribution pumps located on the west end of the plant. The three existing condenser water pumps are located on the east end of the plant. Three cooling towers are located outside, each sized to handle the three chillers located in the South Chiller Plant. Figures I-6 and I-7 show the layout of the existing South Chiller Plant and the cooling tower yard, respectively.

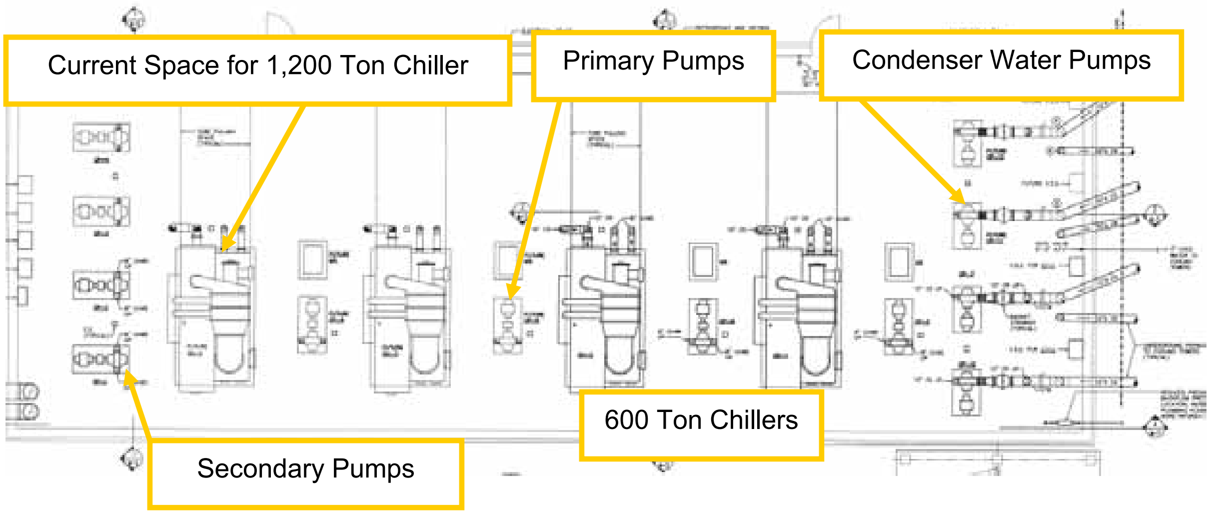


Figure I-6: South Chiller Plant Floor Plan

The South Chiller Plant can be renovated in two phases. The first phase can be quite simple, by adding a 1,200 ton chiller in the space that was reserved for the additional build-out. Also, an additional 1,200 ton (3,600 gpm) cooling tower can be installed in the location provided for it, as shown on Figure I-7. The chilled water primary and secondary pumps will be sized for 2880gpm/50ft and 2880gpm/127ft, respectively. This is identical sizing as the pumps that currently serve the existing 1,200 ton chiller. Also, there is a location left to install a 4th 3,600 gpm pump for the cooling tower. It is recommended that a valve be installed in the main chilled water piping in order to segment the 1,200 ton chiller installed in 1999 and proposed chiller in this first phase to facilitate the installation of the replacement chillers proposed in the second phase.

The second phase will replace the existing 600 ton units, and will not be as simple. After the first phase, there will be 4 cells total in the cooling tower yard, two 600 ton cells and two 1,200 ton cells. An existing transformer and other electrical equipment are located just to the east of the existing cooling towers. This equipment will need to be relocated, and its feeders to the plant extended. The equipment can be moved further to the east, which currently is a lay down area for equipment for the adjacent steam plant.

With the electrical equipment relocated, this leaves space available to install a new 1,200 cooling tower. The two existing 600 ton cooling towers and one of the existing 1,200 ton cooling towers must be removed for installation of below ground condenser water piping to the new 1,200 ton cooling tower. Once the pipe is run to the new tower, two new 1,200 ton cooling towers can be installed in place of the existing 600 ton cells, for a total of four 1,200 ton cooling towers located in the yard outside of the South Chiller Plant. Figure I-8 shows the approximate location of the proposed cooling towers. The plant will consist of four pumps; each sized at 3600gpm/87ft and dedicated to serve one of the four cooling.

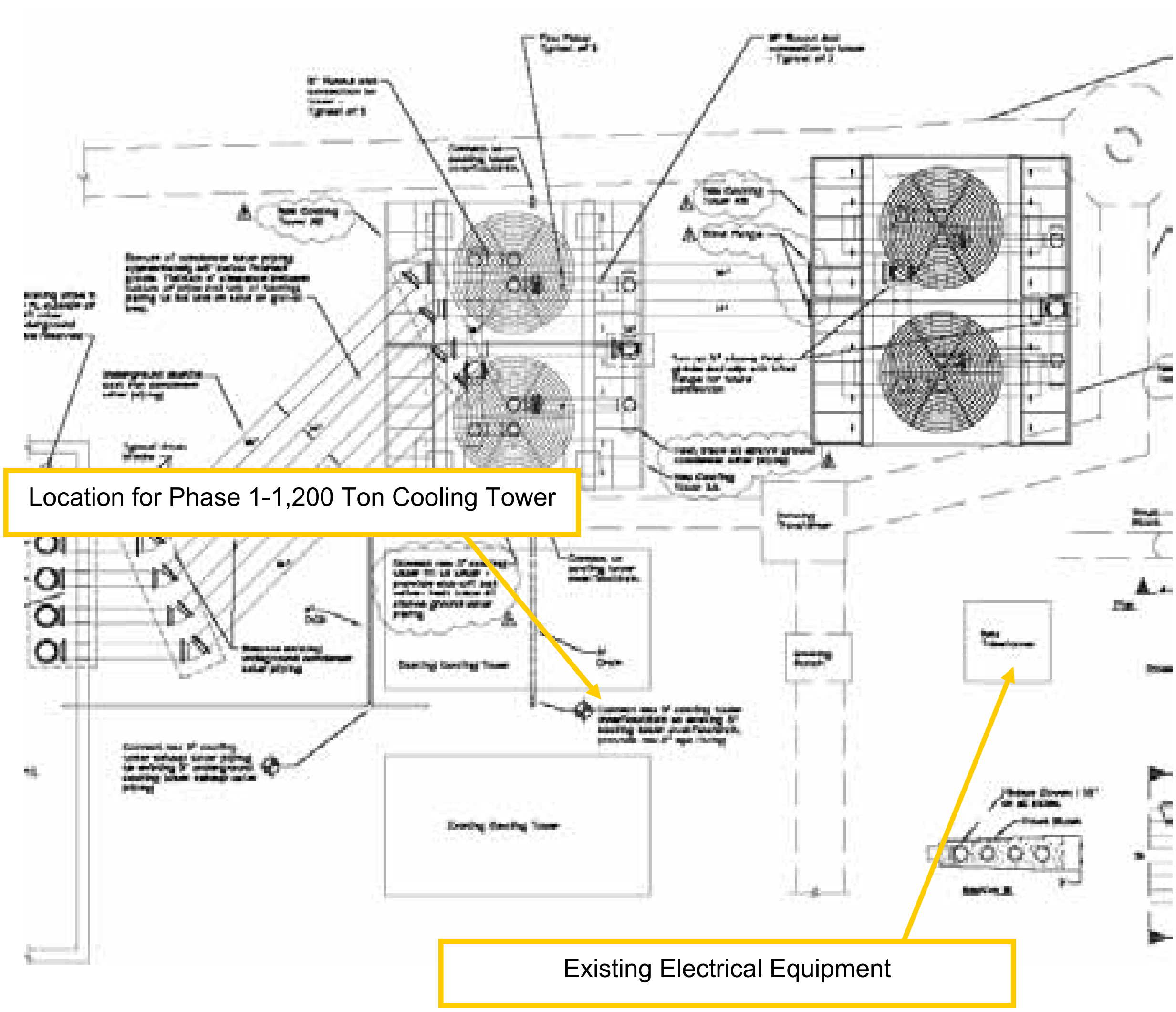


Figure I-7: South Chiller Plant Cooling Tower Layout

Figure I-8: Proposed Cooling Tower Layout at the South Chiller Plant

Also, to optimize the performance of the new cooling towers, it is suggested that the brick wall shown in Figure I-9 be removed to reduce the chance of impeding air flow to the towers and limiting their capacity.

Due to the increase in capacity, much of the piping inside the South Chiller Plant connecting to the existing 600 ton chillers will require upsizing for the installation of the new 1,200 ton units. The existing 20" pipe leaving the plant is of adequate capacity to deliver 4,800 tons.

Figure I-9: Existing Cooling Tower Layout at the South Chiller Plant

Two of the existing distribution pumps are sized at 900gpm/112ft and will not be adequate for the additional capacity of the plant. These two pumps should be replaced with pumps sized at 2880gpm/127ft to match the existing pump installed in 1999 for the 1,200 ton chiller addition and the proposed Phase 1 pump addition. The plant will then have four equally sized 2880gpm/127ft distribution pumps. When the building's low chilled water return temperature is corrected, this arrangement will allow for three pumps to handle the full plant capacity, and one fully redundant pump for standby should one distribution pump fail.

The existing primary pumps for the 600 ton units will also need to be upgraded. They should be replaced with new pumps rated at 2880gpm/50ft, to match the existing 1,200 ton chilled water primary pumps. It is also recommended that these pumps be connected in a common piping header so that they can serve any chiller as required. At 2880gpm/50ft, and a correction of the water return temperature, only 3 pumps will be required to actively serve the four 1,200 ton chillers, leaving one redundant pump for standby should one pump fail.

Performing this work will allow the South Chiller Plant to produce 4,800 tons of chilled water. As the load increases on campus when new buildings come online and are connected to the existing chilled water loop, the North Chiller Plant will require renovation.

The North Chiller Plant currently has two 600 ton chillers. The plant itself is located well away from any buildings or roads, and is well hidden. As part of the overall campus master plan, some road realignment will bring roads closer to the plant. Renovation will expand the plant to deliver adequate cooling to the central chilled water loop, as well as improve its appearance. Figure I-10 shows a site plan of the existing plant, as well as a possible expansion plan of the North Chiller Plant.

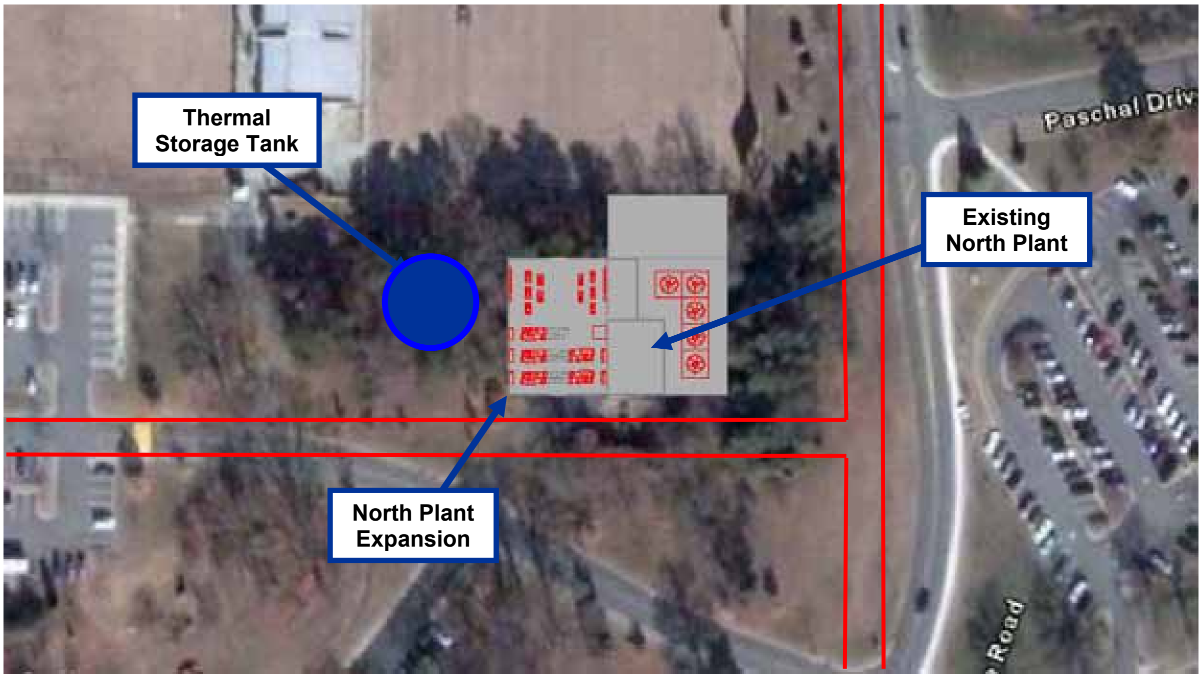


Figure I-10: Proposed Layout for the North Chiller Plant

Figure I-10 shows a possible layout of the North Chiller Plant. A larger, more attractive addition can be constructed around the existing building to house new chillers, towers, and pumps. This will allow the existing plant to remain in operation until the site utility piping can be connected to the new plant for service. Once the new equipment is operational, the existing North Chiller Plant can be renovated for use as a centralized chilled water operation center.

The proposed full build-out of the new North Chiller Plant will consist of five 1,200 ton chillers and towers, redundant pumps, and a thermal storage tank for load shedding.

<u>Chilled Water Distribution</u>

In order to accommodate the added cooling capacity, the existing underground distribution system will require modifications. The proposed routing of future piping can be found at the end of this report.

There are only a few buildings coming online in Phase 1, but one of these, the Campus Recreation Center, has a significant heating and cooling demand. This building will be located in the northeast area of campus where there is a bottleneck in the existing chilled water system; supply and return piping size is reduced to 6" pipe. This will not be adequate to satisfy the load of this new building. A new loop is proposed as part of Phase 1 to bring chilled water to this new building, as well as to be a new main artery between the North and South Chiller Plants to serve the new loads located in the North and South Zones of campus. This new main artery will run from the South Chiller Plant, up the east side of campus, to the North Chiller Plant, and continue to the west to serve the new Upper Class Residence Halls.

Other major distribution mains to be installed as part of Phase 1 construction would be on the west side of campus, as the new Library Quad is developed. This piping will allow for additional capacity on the west side campus, and replace the existing 6" and 8"piping in this area, which is not adequate to serve the new loads.

As part of Phase 2, new chilled water piping is proposed to be added from the South Chiller Plant to the West Zone to serve the new loads in this area.

Phase 3 work will consist of installation of new distribution piping on the North Zone of campus, where the new residence halls are planned to be constructed. This piping will close the loop on campus to provide adequate and redundant paths for chilled water to be delivered throughout the campus.

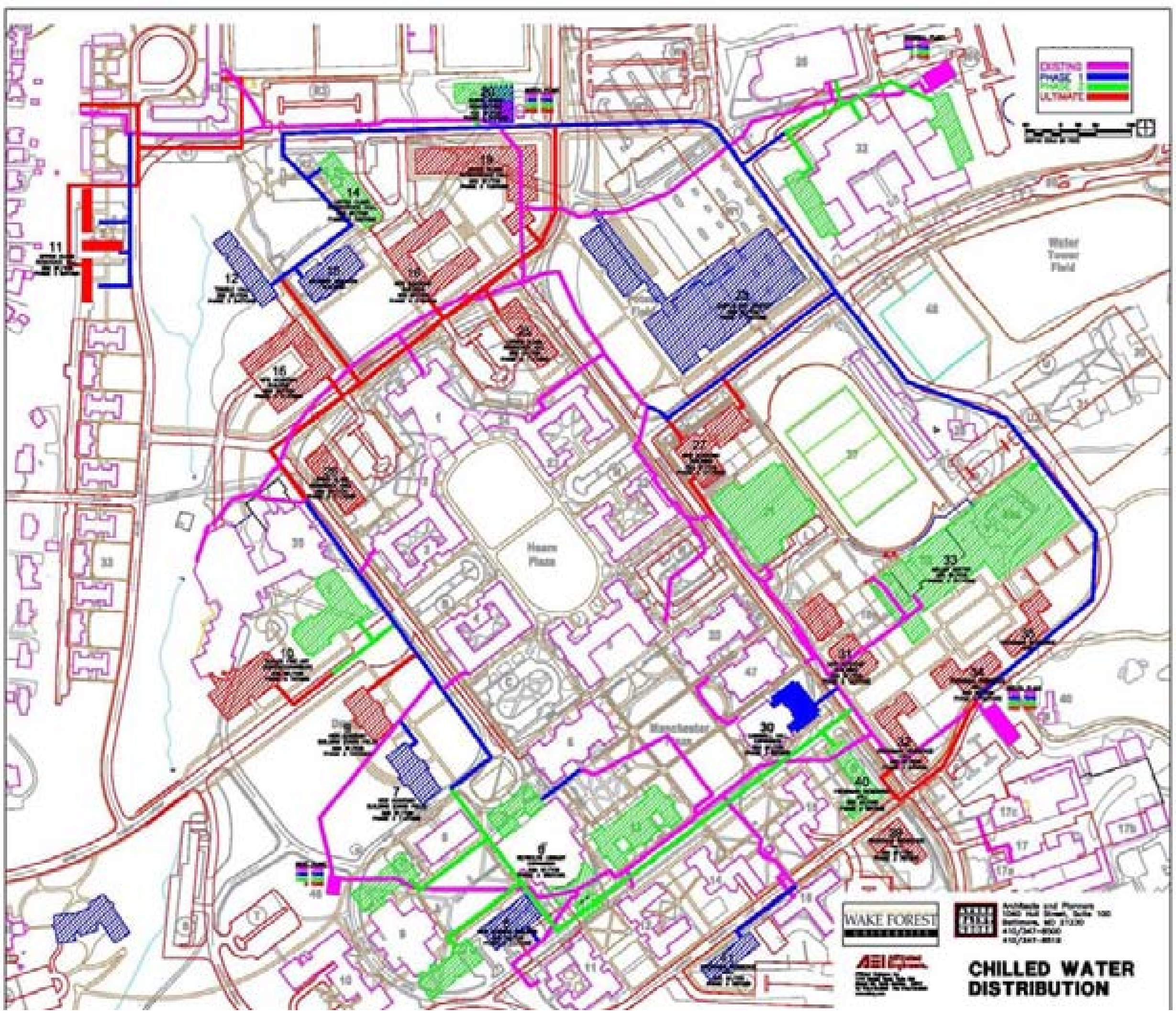


Figure I-11: Future Chilled Water Distribution

Recommendations for Separate Projects

The following projects are recommended during the various Phases of the masterplan.

Phase 1 - Immediate Need Projects (0-5 Years)

Project Description	Reason for Implementation	Projected Cost
Provide building chilled water upgrades to improve campus wide Delta-T	Increase system efficiency and reduce distribution pumping requirements.	$500,000
First Phase South Chiller Plant Additions – 1,200 Tons	To increase the capacity of the chilled water system.	$2,000,000
Second Phase South Chiller Plant Additions – 2,400 Tons	To increase the capacity of the chilled water system.	$5,000,000
Distribution on East Campus to Student Recreation Center	To provide chilled water to Student Recreation Building and North Campus	$2,500,000
Distribution on North Campus to Upper Class Residence Halls	To provide chilled water to the Upper Class Residence Halls, North Chiller Plant and North Campus	$2,500,000
Distribution on West Campus	To provide chilled water to the West Zone of campus	$1,500,000

Total Cost: $ 14,000,000

Phase 2 - Short Term Projects (6-15 Years)

Project Description	Reason for Implementation	Projected Cost
First Phase North Chiller Plant Expansion	To increase the capacity of the chilled water system.	$18,000,000
North Plant - Thermal Storage Tank	To increase the capacity of the chilled water system.	$4,000,000
Distribution to West Campus from South Chiller Plant	To provide chilled water to the West Zone of campus	$2,000,000
Distribution to Worrell Chiller Plant Area and Demo of Existing Worrell Plant	To provide chilled water to the Information Systems and Worrell Professional Center Buildings	$1,000,000

Total Cost: $ 25,000,000

Phase 3 - Long Term Projects (15-40 Years)

Project Description	Reason for Implementation	Projected Cost
Second Phase North Chiller Plant Expansion	To increase the capacity of the chilled water system.	$3,000,000
Distribution to North Campus for Upper Class Residence Halls	To provide chilled water to the North Zone of Campus	$1,500,000
Distribution to North Campus Faculty Apartments Area	To provide chilled water to the Northwest corner of campus	$1,500,000

Total Cost: $6,000,000

Note that the cost projections include (construction cost x 1.2) for total project cost. All costs are October 2008 dollars.

II. Heating System

Existing Conditions and System Assessment

The majority of the Wake Forest University campus is heated with steam generated at a single central heating plant located on the southeast corner of campus. This central heating plant contains two boilers rated at 250 psig. The boilers were constructed in 1954, and were originally designed to fire coal with a nominal steam output of 60,000 lbs per hour each. They have since been converted to fire natural gas and No. 2 fuel oil.

Each boiler is fitted with a finned tube economizer designed to operate at a flue gas temperature of 450° F.

Currently, the fuel oil system consists of two 20,000 gallon single wall underground tanks. In 2005, these tanks were fitted with inventory and spill monitoring systems. Natural Gas is provided from a metering station in the service yard adjacent to the plant. The deaerator is a vertical tray type that has been designed for 100,000 lbs per hour feed water capacity.

The existing steam distribution system consists of a network of tunnels of various sizes. These tunnels range in size from 6'x5' inside dimensions, to 4.5' by 4'.Many of the steam tunnels are walkable. Some portions of the tunnels contain IT cabling and chilled water, along with the steam.

There is a district heating loop that serves the residence halls on the northwest part of campus. Hot water for heating is created by a steam to hot water converter in Taylor Residence Hall.

In the future, as the campus constructs more buildings that require heating, the steam load will increase. Dependent on the amount of future heating required, it is expected that additional steam capacity will be required.

Current and Future Load Projections

Data was received from the University showing peak loads for the year 2007. The maximum steam demand that year was approximately 50,000PPH. With the current pair of boilers, the total maximum nameplate capacity for the steam plant is 120,000PPH.

The load growth is based on the phasing of the new building construction, the expected type of building, and its size. Each building type was given a factor estimating heating load per square foot. These values come from historical data for buildings of each type located in similar climates. The product of this value and each building's square footage gives a peak load for each building. The sum of the peak loads is then multiplied by a diversity factor. While these buildings are connected to a centralized steam plant system, it is not expected that all of the buildings will see maximum load all at the same time. This diversity factor represents the expected amount of heating required at a point in time varied over the entire campus. The table for the expected future loads can be found in Table A-2 at the end of this report, and load densities found below in Table II-1.

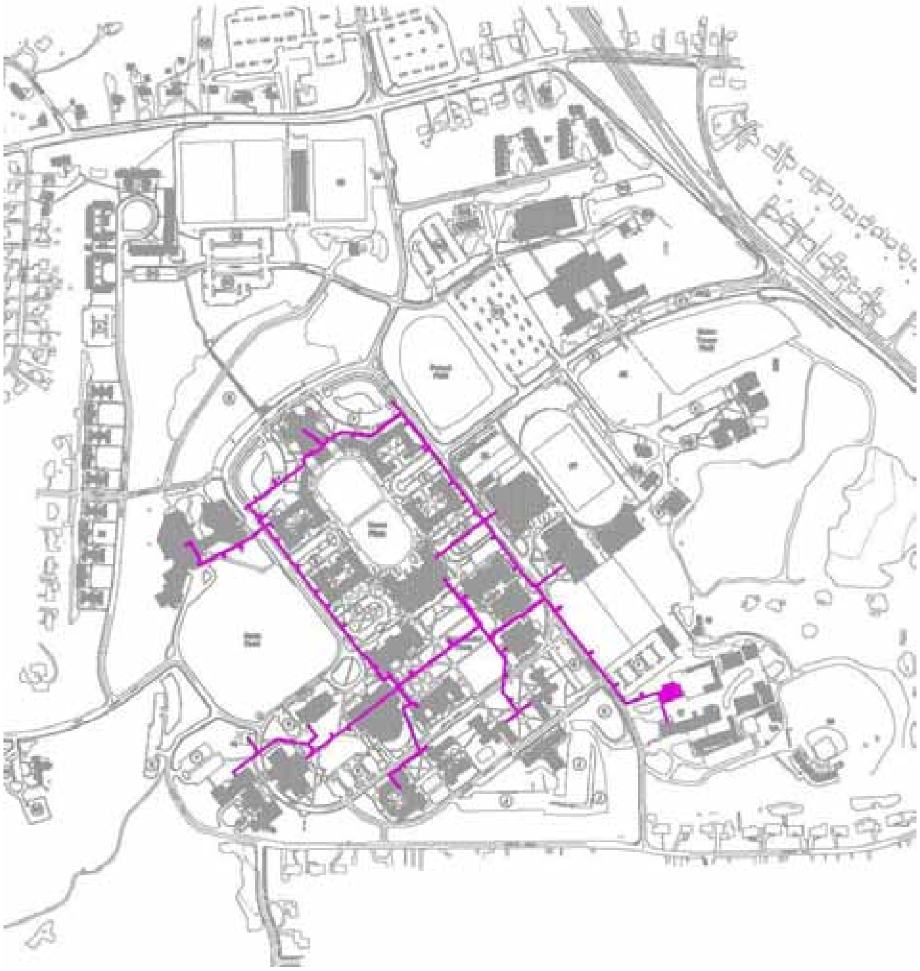


Figure II-1: Steam Distribution System

	Estimated BTU/HR-SF
Academic	40
Admissions	40
Athletics	45
Housing	40
Rec Center	45
Student Life	45
Laboratory	55
Miscellaneous	40
Diversity	0.75

Table II-1: Steam Load Densities per Building Type

As shown on Table A-2, the expected load growth will require additional heating capacity for redundancy, as well as additional infrastructure. The ultimate Phase 3 load is approximately 115,000PPH. To better understand the areas on campus that have the largest increase in load, see Figure II-2 which shows the increase in load per phase at each area on campus. The North and South Zones have the greatest increase of heating load. The total load growth of the campus can be found in Figure II-4.

Options for Expansion and Improvement

The majority of buildings are heated by a central plant in the southeast corner of the campus. This plant currently contains two (2)-60,000 PPH boilers with space for a third 60,000 PPH boiler. The installation of the third boiler will require the removal of some existing tool storage space. The installation of the third boiler will allow for N+1 redundancy throughout the entire master plan, and since the existing boilers have been recently tuned, their turndown is greatly increased, allowing for one of the existing 60,000 PPH boiler to be able to handle the low summertime loads found on campus, eliminating the need for a smaller "summertime boiler". See Figure II-3 for the proposed location of the new 60,000 PPH boiler.

With the increase in loads and the boiler plant capacity, the existing deaerator must be replaced. The existing is sized to handle 100,000PPH. With a boiler nameplate firm capacity of 120,000PPH and total capacity of 180,000PPH, the de-aerator should be replaced with a larger one. A deaerator sized at 120,000PPH and with a higher total capacity would handle the total load from the plant, and should utilize a dual head vertical tray type unit.

From discussions with University personnel, there seems to be a lack of backflow prevention. Under certain circumstances the makeup water for the boilers could flow back into the campus water system. It is recommended that proper backflow prevention be installed to remedy this.

Other deficiencies found in the boiler plant that should be addressed, but are not viewed to be immediate concerns are the inspection and possible replacement of the surge tank and the fuel oil tanks. The surge tank is the same age as the boiler plant (built 1954), and may have deterioration or corrosion due to acids produced in the condensing of steam. The fuel tanks, although newer than the plant, should also have regular inspections and testing of the leak monitoring systems. To accommodate an expected increase in back-up fuel requirements, the fuel tanks will need to be replaced.

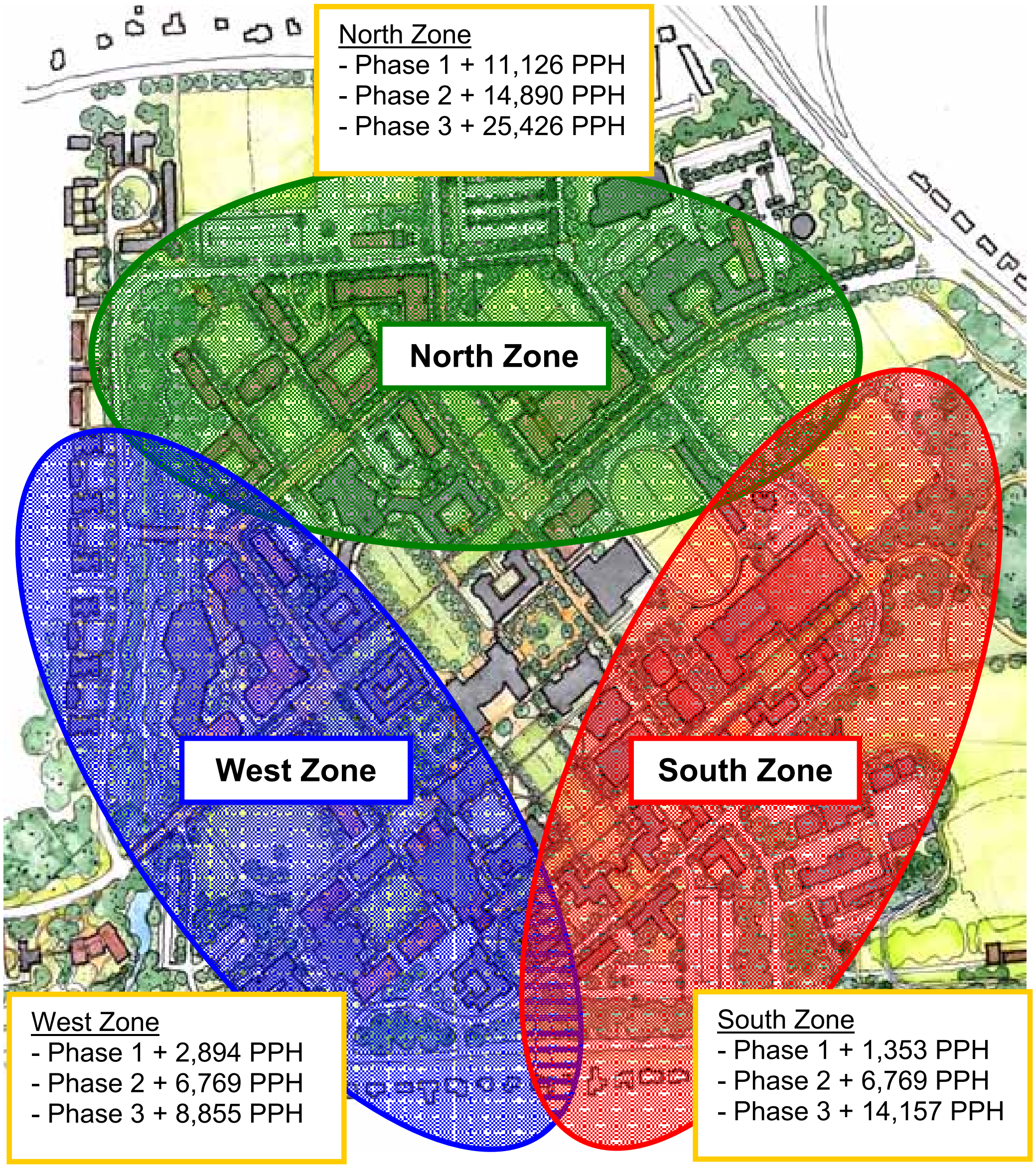


Figure II-2: Steam Load Growth with Existing Plant Capacities

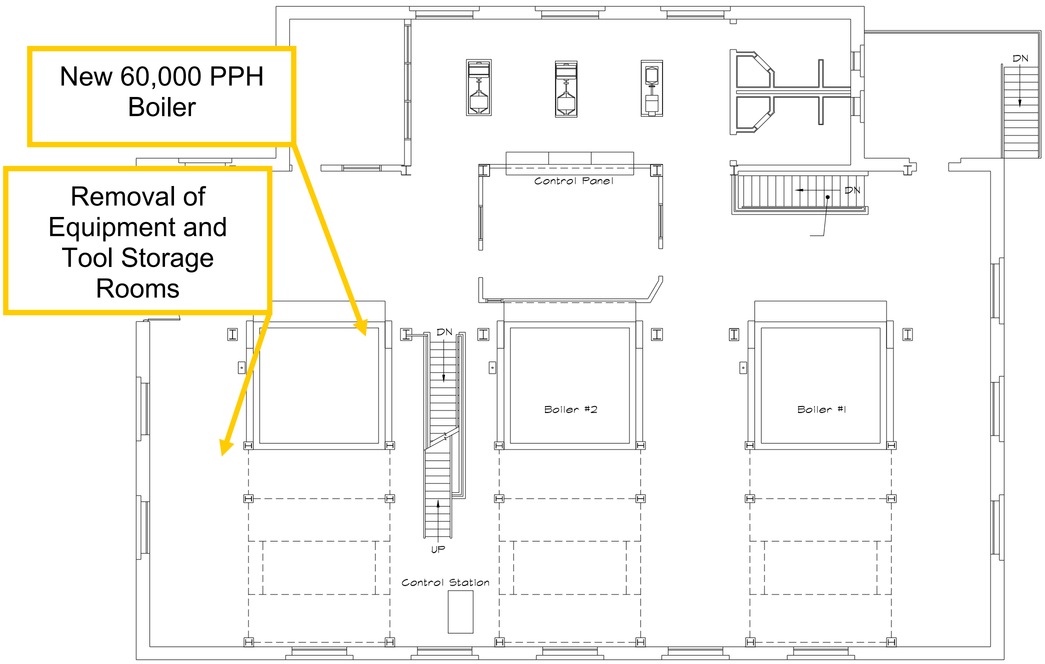


Figure II-3: Boiler Addition at Existing Steam Plant

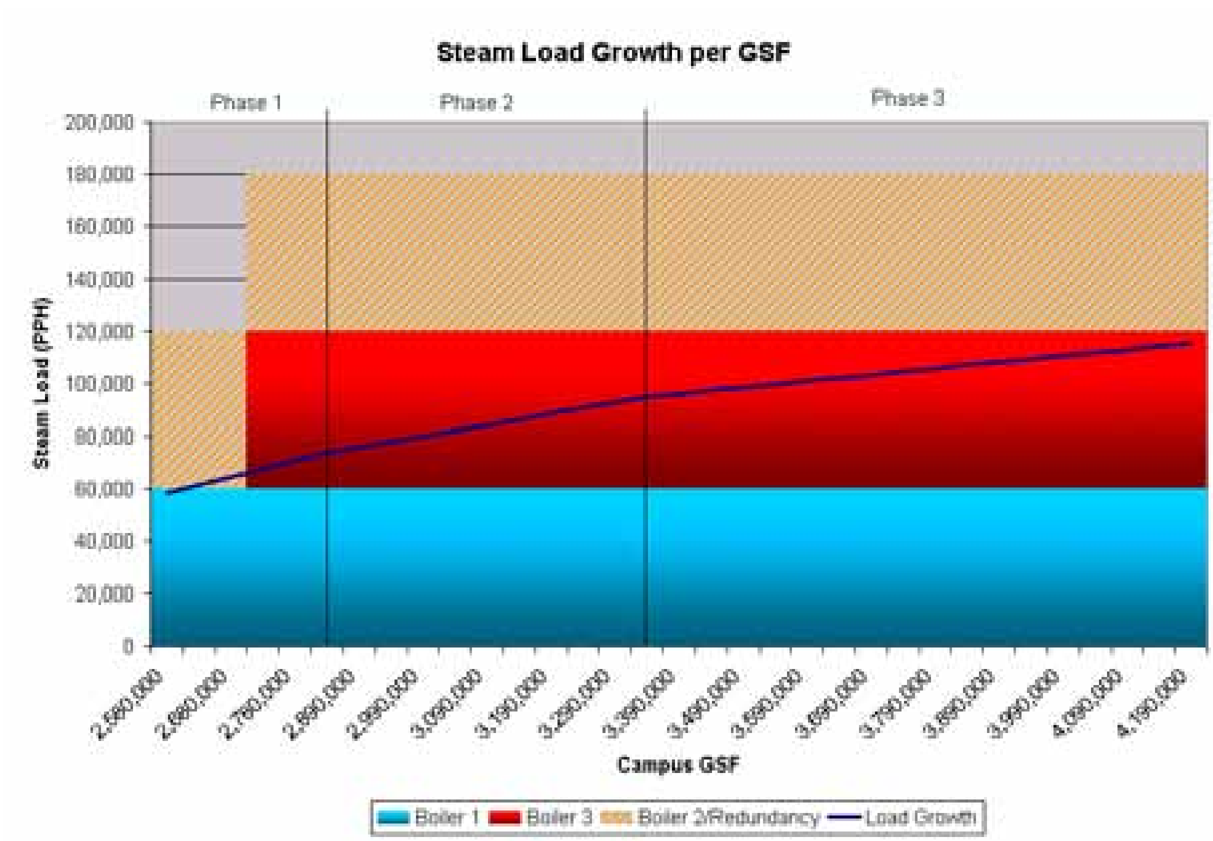


Figure II-4: Steam Load Growth

Steam Distribution

To accommodate the recommended additional heating capacity, the existing underground distribution system will require modifications. The proposed routing of future is shown below in Figure II-5, and in a larger drawing at the end of this report.

Similar to the chilled water system, the Phase 1 building requiring the greatest amount of heating is being installed at an existing distribution bottleneck. The new Student Recreation Center will require an additional steam line for heating. This steam line can parallel the route of the proposed chilled water loop. Also, this new steam feed on the east side of campus will allow for a new main artery for steam distribution to the campus as it expands. Lastly, it is recommended that this new piping be connected into the main header at the boiler plant, thus increasing the redundancy and reliability of the system should an outage occur in the existing 12” piping leaving the steam plant.

It is recommended that installation of a new steam main parallel to the chilled water line on the west side of campus be coordinated with Phase I implementation of the Library Quad. This upsized steam tunnel will improve steam delivery to this part of campus. The existing steam piping can then be removed from the small steam tunnel that runs under Wake Forest Road, creating space for new IT wiring in this location. For more information on the Telecommunication distribution requirements, see Section IV.

Also proposed as part of Phase 1 is new steam piping from the Boiler Plant to the West Zone to serve the new loads in this area. This will also free up space in the existing steam tunnel for the installation of telecommunications conduit (see IV. Telecommunications System).

In Phase 2, the existing Worrell Plant is proposed for demolition as part of the chilled water portion of this master plan. New piping from the existing steam loop to both the Worrell Professional Center and the Information Technology Systems buildings is proposed to be added as part of Phase 2.

Phase 3 will consist of work on the North Zone of campus, where the new residence halls are planned to be constructed. During Phase 3 it is recommended that new piping and tunnel be installed to close the loop on campus to provide adequate and redundant paths for steam to be delivered throughout the campus.

Lastly, as part of Phase 3, new Upper Class Residence Halls are planned for construction on the far northwest corner of campus. When this building construction occurs, a new steam tunnel is proposed to connect the existing loops, out to these new buildings, as well as feed the existing North Campus and Student Apartments and replace the existing hot water loop that originates at Taylor Residence Hall.

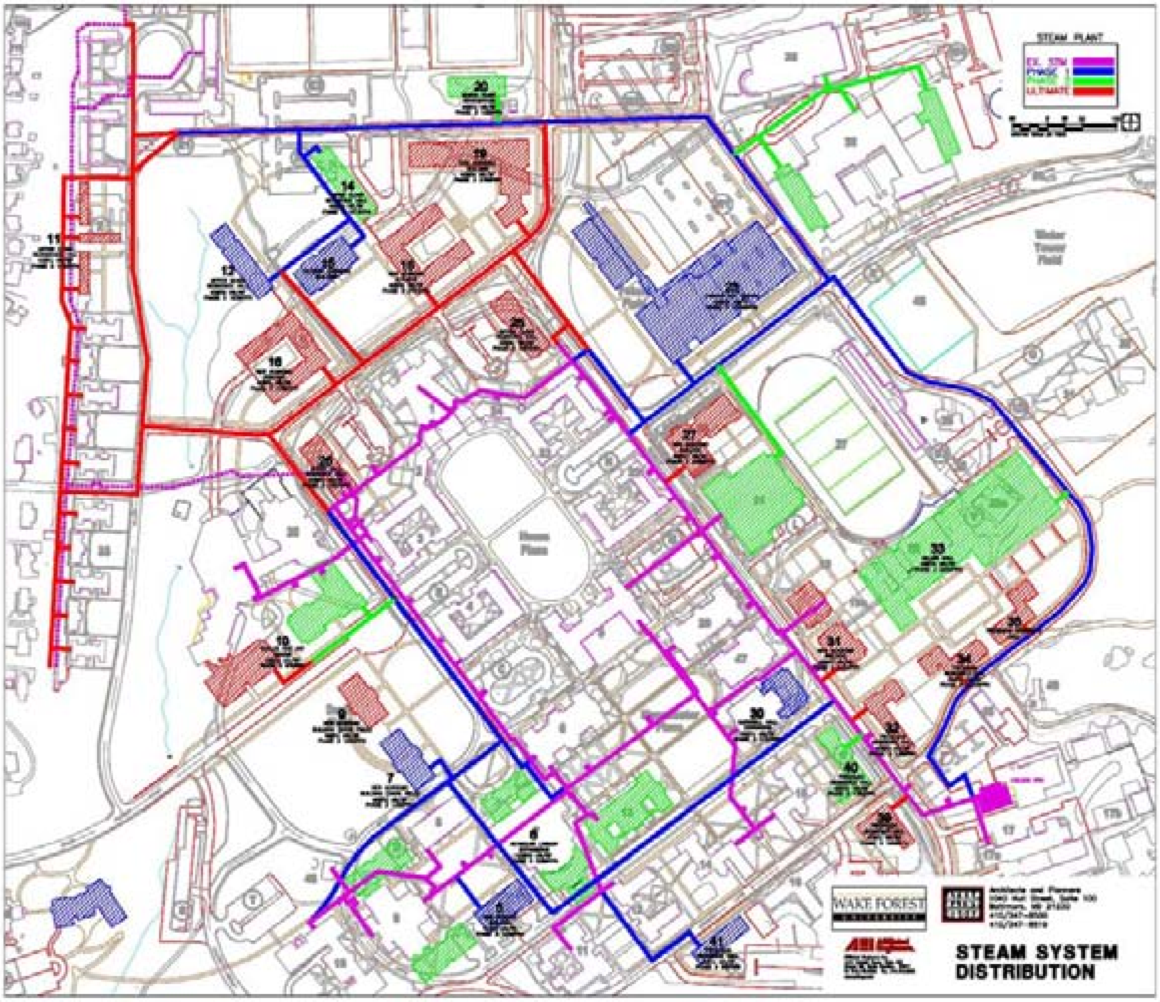


Figure II-5: Future Steam Distribution

Recommended Projects

The following projects are recommended during the various Phases of the masterplan.

Phase 1 - Immediate Need Projects (0-5 Years)

Project Description	Reason for Implementation	Projected Cost
Add Make-Up Water Backflow Preventer	To protect the City water system	$25,000
Check and Replace Steam Traps and Valves	General Maintenance of Steam System	$10,000
Add Third 60,000PPH Boiler	To increase the capacity of the steam system.	$3,000,000
Replace Surge Tank	To improve the reliability of the condensate system.	$50,000
Distribution on East Campus to Student Recreation Center	To provide steam to Student Recreation Building and North Campus	$6,000,000
Distribution on North Campus to Upper Class Residence Halls	To provide steam to the Upper Class Residence Halls, North Chiller Plant and North Campus	$6,000,000
Distribution on West Campus	To provide steam to the West Zone of campus	$4,000,000
Distribution on West Campus from South Chiller Plant	To provide steam to the West Zone of campus	$7,000,000

Total Cost: $ 26,085,000

Phase 2 - Short Term Projects (6-15 Years)

Project Description	Reason for Implementation	Projected Cost
Replace Deaerator	To increase the capacity of the steam system.	$150,000
Distribution to Worrell Chiller Plant Area and Demo of Existing Worrell Plant	To provide steam to the Information Systems and Worrell Professional Center Buildings	$4,000,000

Total Cost: $ 4,150,000

Phase 3 - Long Term Projects (15-40 Years)

Project Description	Reason for Implementation	Projected Cost
Distribution to North Campus for Upper Class Residence Halls	To provide steam to the North Zone of Campus	$5,000,000
Heating Hot Water to Steam Conversion at North Campus/Student Apartments	To remove the existing hot water system, and provide steam.	$100,000
Distribution to North Campus Apartments Area	To provide steam to the Northwest corner of campus	$4,000,000

Total Cost: $9,100,000

Note that the cost projections include (construction cost x 1.2) for total project cost. All costs are October, 2008 dollars.

III. Electrical System

Existing Conditions and System Assessment

The Reynolda Campus is served by one 20MVA utility transformer owned and operated by Duke Energy at the Duke Energy Substation. That transformer feeds three 15kV switchgear line-ups owned and operated by the University and located in the Cherry Street Substation, which is a switchgear utility yard directly adjacent to the Duke Substation. The switchgear line-ups serve three main loads:

- Reynolda North Substation
- Reynolda South Substation
- University Corporate Center (UCC) building

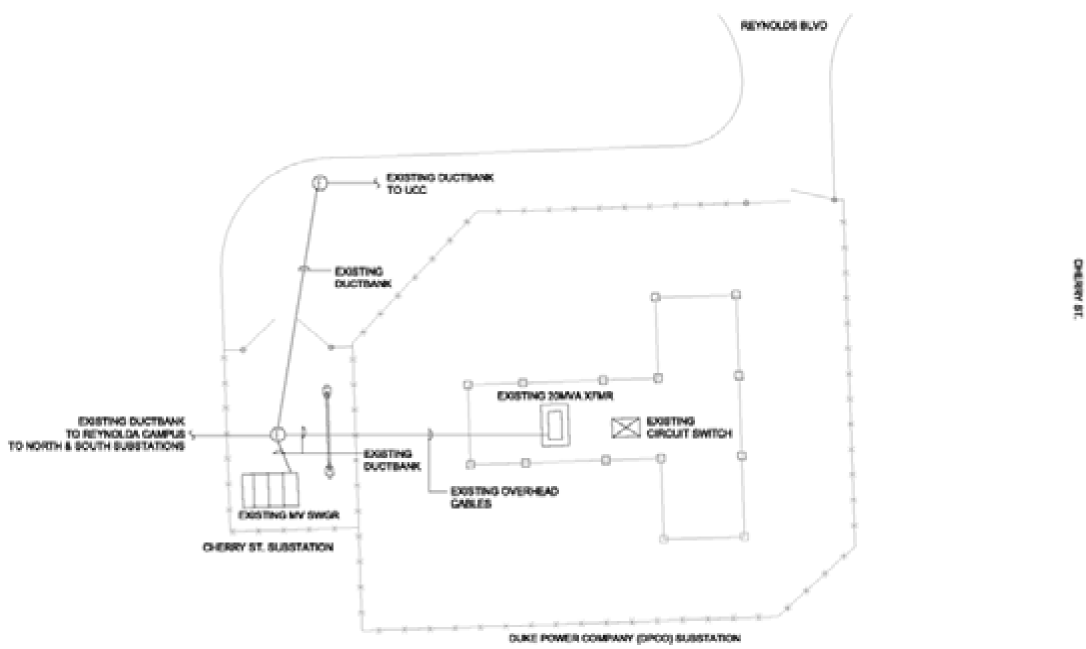


Figure III-1: Existing Plan of Cherry Street Substation

The Cherry Street Substation provides nearly all of the power consumed by the Reynolda campus. There are two main feeder circuits from the Cherry Street Substation that are routed below grade in ductbank to two separate switchgear line-ups. Each feeder circuit from Cherry Street is rated to carry 830Amps, approximately 9MVA. The two switchgear line-ups at the Reynolda campus, called the North Substation and the South Substation each have three distribution circuits:

- West Feeder Loop (sized for 6.6MVA capacity per the NEC)
- Central Feeder Loop (sized for 4.5MVA capacity per the NEC)
- East Feeder Loop (sized for 6.6MVA capacity per the NEC)

Each circuit is connected back to the other switchgear in a loop configuration such that any building on a certain circuit could be served from either switchgear. Figure III-2 diagrams the electrical distribution at the Reynolda campus.

Figure III-2: Reynolda Campus Electrical Distribution

Based on a recent electrical infrastructure assessment conducted by the Facilities Management Department in April 2007, the electrical distribution equipment and cabling is in good working order and is approximately 10 years old. The report further states that the building transformers are properly loaded and do not require replacement. The North Chiller Plant would require replacement transformers if additional load is introduced to the building (which is scheduled for Phase 2).

The electrical infrastructure is adequate for the existing campus and there are no deficiencies to be corrected. However, modifications to the system should be made for overall improvement to better accommodate campus expansion.

Current and Future Load Projections

Based on the recent electrical infrastructure assessment conducted by the Facilities Management Department in April 2007 and Duke Energy meter reports, the total Wake Forest demand load is approximately 13.4MVA, which is 70% of the full capacity of the utility transformer. Note that the utility transformer also serves the University Corporate Center (UCC) located off campus which draws approximately 30-35% of the current total power consumption of utility transformer, suggesting a demand load of approximately 9MVA on the Reynolda campus. This equates to an average of 3.5 watts/square foot currently being consumed by the Reynolda Campus.

Existing Electrical Load Summary

Equipment	Demand Load
North Substation	4.5 MVA
South Substation	4.5 MVA
UCC	4.4 MVA
Utility Transformer	13.4 MVA

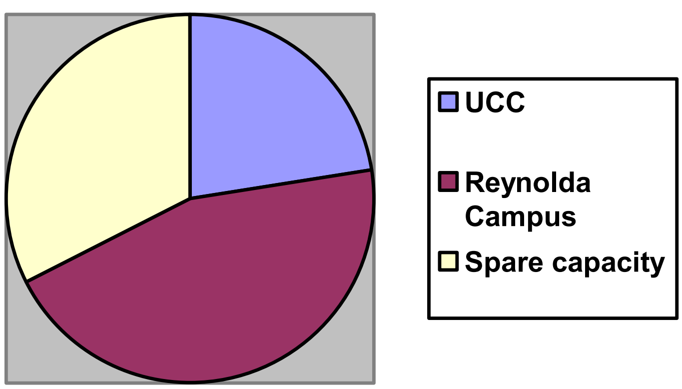


Figure III-3: 20 MVA Utility Transformer Loading

The UCC plans to add 2MVA of load for a data center in the near future. Also, it would be beneficial to serve other WFU loads near the UCC from the Cherry Street Substation from a central meter. Those buildings include the Athletics facilities in the vicinity (Groves Stadium, Deacon Tower, Ernie Shore Field, Indoor Tennis Center), as well as future construction in the area. The Reynolda campus is planned for expansion to include 41 separate construction projects including 30 new and renovated buildings totaling over an additional 1,500,000 square feet of academic, athletic, and housing facilities.

Table III-1: Master Plan Impacts on Electrical Distribution

New Reynolda Campus Loads									
			Building	Estimated	Electrical (kVA)				
Bldg Number	Bldg Name	GSF	Type	W/SF	Existing	Phase 1	Phase 2	Phase 3	Phase #
2	Admissions Building	46,800	Admissions	5	0	234	234	234	1
4	Salem Hall Expansion	50,140	Academic	5	0	0	251	251	2
5	New Science Building	36,000	Academic	5	0	180	180	180	1
6	Reynolds Library Expansion	84,640	Academic	5	0	0	423	423	2
7	New Academic Building (Davis Field)	36,300	Academic	5	0	182	182	182	1
9	New Academic Building (Davis Field)	32,370	Academic	5	0	0	0	162	3
10	Scales Fine Arts Center (Expansion)	159,810	Academic	5	0	0	0	799	3
11	Upper Class Residence Hall	27,990	Housing	4	0	0	0	112	3
12	Upper Class Residence Hall	81,975	Housing	4	0	328	328	328	1
14	Upper Class Residence Hall	37,800	Housing	4	0	0	151	151	2
15	Upper Class Residence Hall	0	Housing	4	0	0	0	0	1
16	New Academic Building	69,960	Academic	5	0	0	0	350	3
18	New Academic Building	69,780	Academic	5	0	0	0	349	3
19	New Academic Building	105,630	Academic	5	0	0	0	528	3
20	North Plant Renovation	0	N/A	0	0	0	0	0	2
21	Worrell Professional Center	54,680	Academic	5	0	0	273	273	2
23	Campus Rec Center	256,800	Rec Center	4	0	1,027	1,027	1,027	1
25	Upper Class Residence Hall	38,925	Housing	4	0	0	0	156	3
26	Upper Class Residence Hall	38,925	Housing	4	0	0	0	156	3
27	New Academic Building	62,211	Academic	5	0	0	0	311	3
30	Carswell Hall Expansion	28,680	Housing	4	0	115	115	115	1
31	New Academic Building	60,840	Academic	5	0	0	0	304	3
32	Freshmen Residence Hall	33,150	Housing	4	0	0	0	133	3
33	Miller Center	129,750	Rec Center	4	0	0	519	519	2
34	Freshmen Residence Hall	31,950	Housing	4	0	0	0	128	3
35	Freshmen Residence Hall	31,950	Housing	4	0	0	0	128	3
38	Golf Practice Facility	14,600	Rec Center	4	0	58	58	58	1
39	Freshman Residence Hall	26,160	Housing	4	0	0	0	105	3
40	Freshman Residence Hall	34,560	Housing	4	0	0	138	138	2
41	Freshman Residence Hall	24,180	Housing	4	0	97	97	97	1
				Additional Reynolda Campus Load Subtotal	0	2,220	3,976	7,695	
				Additional Reynolda Campus Load Diversified Total	0	1,998	3,578	6,926	
				Wake Forest University Totals	14,867	21,668	27,938	31,658	
				Wake Forest Univeristy Diversified Total	13,380	19,501	25,144	28,492	

Note the following:

1. Only the construction projects that involve additional electrical load have been considered.
2. The building names, tags, and sizes correspond to the associated architectural masterplan.
3. The red font for the kVA is to assist in identifying which Phase the building is scheduled for construction.
4. Any building shown with zero load growth indicates an existing building; work is only to renovate existing space.
5. The additional load for the renovated North Chiller Plant (≈4,880kVA) and South Chiller Plant (≈2100kVA) is accounted for in the Wake Forest University total load. That total load includes the UCC, upgrades to existing utility buildings (i.e. Plants) and the demolition of existing buildings proposed by the master plan.
6. The demand factor is assumed to be 0.9.

Figure III-4 follows the projected load growth in relation to the phases of the master plan. As shown, a modification at the substation level is necessary prior to the beginning of Phase 2. That effort should be initiated two years prior to the beginning of Phase 2, to allow enough time for the coordination with Duke Energy and the completion of the work.

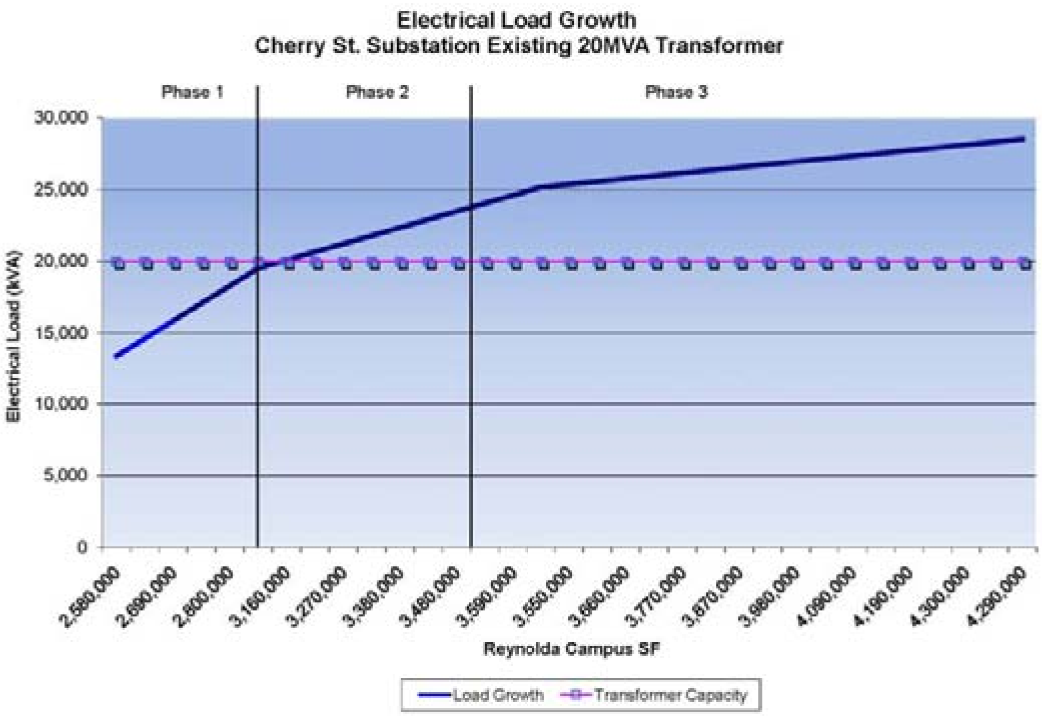


Figure III-4: Electrical Load Growth

Options for Expansion and Improvement

Cherry Street Substation Upgrade:

As noted above, the 20MVA utility transformer (owned by Duke Energy) needs to be upgraded prior to Phase 2 to accommodate the growth. The two upgrade options are as follows:

- Option #1 – Install a second 25MVA utility transformer dedicated to the Reynolda Campus. The two transformers would back-feed each other (through the Duke Energy 1200A busses with disconnects) to provide partial redundancy. Also, there would be much greater capacity for the UCC circuits to add loads and possibly consolidate all existing and future WFU loads adjacent to the UCC from one central meter. Note that the second transformer could possibly be selected to a more common size of 20MVA, which would accommodate most of Phase 3 and possibly the entire masterplan if the load growth is slower than projected.

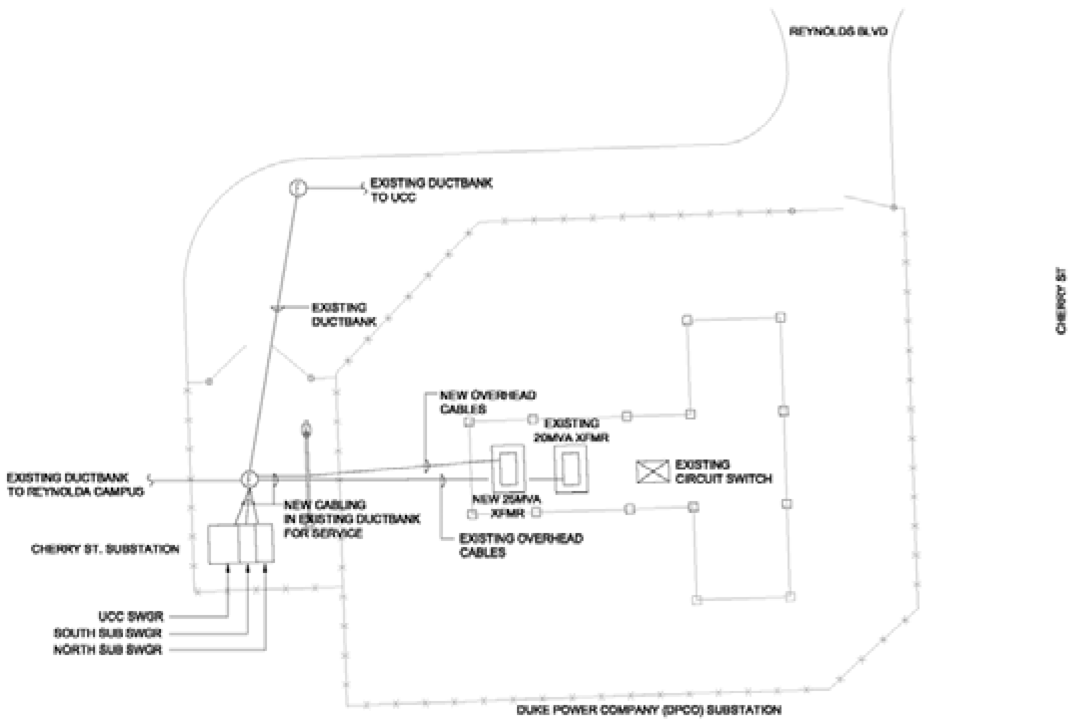


Figure III-5: Option #1 Equipment Arrangement at Cherry Street Substation.

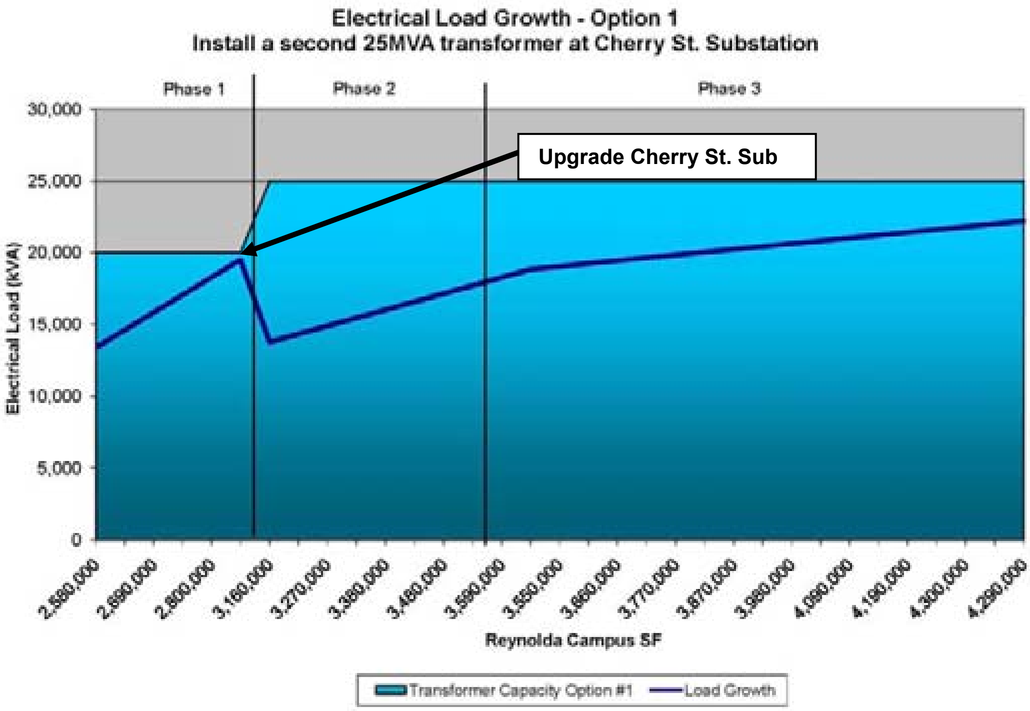


Figure III-6: Option #1 Projected Load Growth

- Option #2 –Replace the utility transformer with a 50MVA transformer. There would be no redundancy, but there would be much greater capacity for the UCC circuits to add loads and possibly consolidate all existing and future WFU loads adjacent to the UCC from one central meter. The capacity of the 50MVA transformer will be enough to accommodate the Reynolda Campus masterplan and accommodate the foreseeable UCC load.

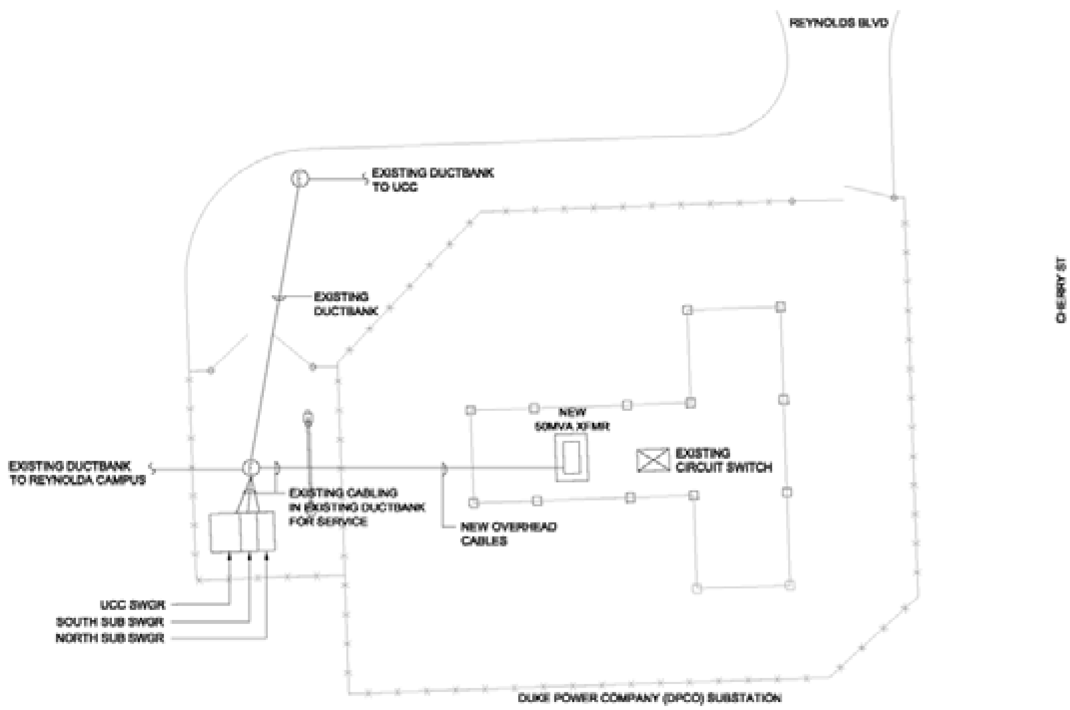


Figure III-7: Option #2 Equipment Arrangement at Cherry Street Substation.

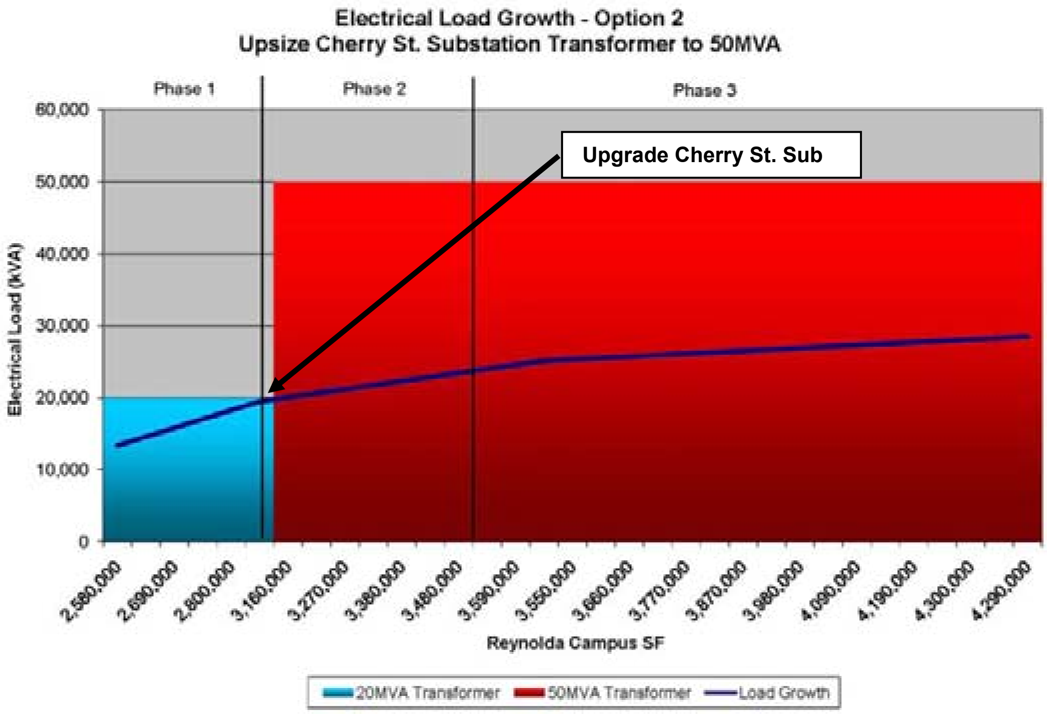


Figure III-8: Option #2 Projected Load Growth

Option #1 is recommended for implementation and includes a second 25MVA transformer. This provides the greatest level of system redundancy for the Reynolda campus. If Duke Energy is unwilling to provide a second transformer or would charge a high premium that would not pay back within 10 years, Option #2 is an alternative scheme.

Distribution Switchgear Submetering:

As noted above, there are two distribution switchgear line-ups that serve the Reynolda Campus in a redundant loop configuration. The "North Substation" and "South Substation" switchgear line-ups each have three feeder circuit breakers. Each feeder circuit breaker should be retrofitted to be submetered to monitor the power quality and the kVA demand. The meters should be integrated into the existing campus SCADA system. This metering will assist in monitoring each loop circuit for load balancing, overloading, and to determine spare capacity. This is critical in the planning of new loads to the system to determine which loop to serve a new building from. Also, the metering will determine the breakpoint at which the loop should be disconnected between the North and South Substations. This is important during times of maintenance and transition to ensure that the cabling will accommodate the load. This work can be performed at any time during implementation of the master plan, but is recommended to be implemented during Phase 1.

Distribution Feeder Circuit Upgrades:

The Reynolda campus Central Feeder Loop has six separate cabling segments that are undersized. Once the Central Feeder Loop becomes more heavily loaded (≥ 4MVA), that cabling should be replaced with #500KCMIL cabling to provide full circuit capacity. This will expand overall system redundancy and flexibility. This work is recommended to be implemented when deemed necessary by the Facilities Management Department based on measured circuit loading, most likely during Phase 2. Upsize the cabling segment to #500KCMIL between the following loop switches:

- LS-CF-300 and LS-CF-400
- LS-CF-400 and LS-CF-500
- LS-CF-500 and LS-CF-600
- LS-CF-600 and LS-CF-700
- LS-CF-700 and LS-CF-800
- LS-CF-800 and LS-CF-900

This is estimated to be approximately 135,000 feet of new cabling. The existing ductbank and manhole system is expected to be adequate for the new cabling.

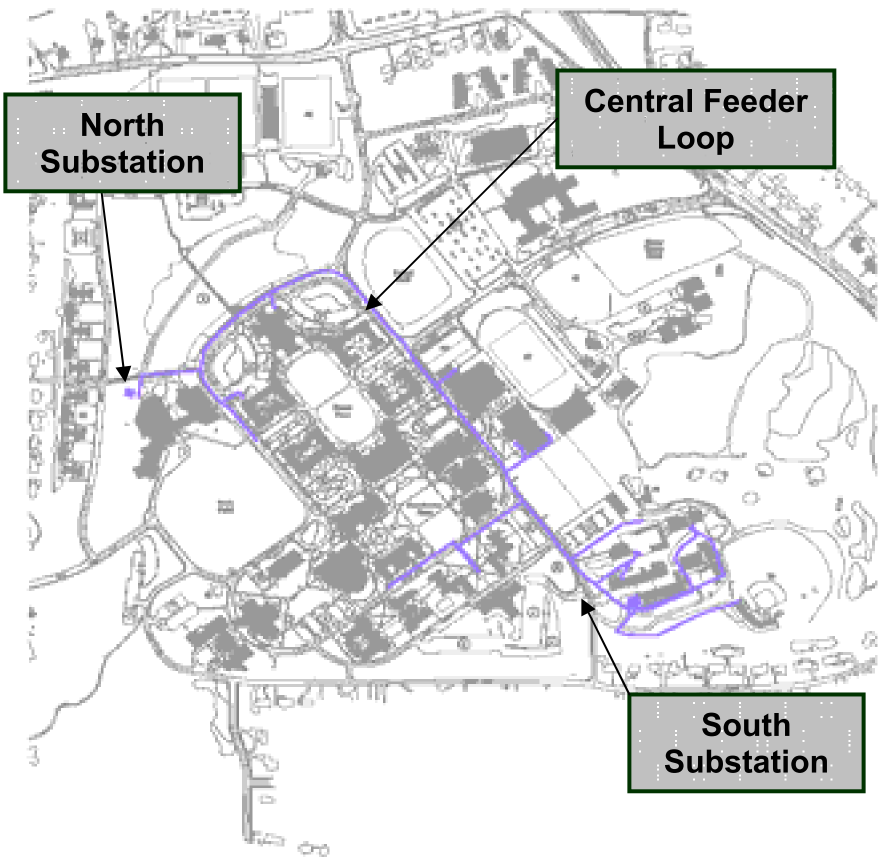


Figure III-9: Central Feeder Loop

This effort will improve the Central Feeder Loop to its full circuit capacity. This will expand the overall system redundancy and flexibility. This improvement can be performed sequentially, opening/closing the Central Feeder Loop switch main disconnect to serve the buildings from the opposite Substation during the work, to minimize downtime.

General Electrical Upgrades:
It is recommended to compile all electrical distribution infrastructure drawings and record documents into a single document for a complete system condition survey. This will help to plan for campus expansion and facilitate transfer of information within the Facilities Management Department. This should be implemented as early as possible in Phase 1.

A preventative maintenance plan should be instituted for the main distribution equipment such as MV switchgear, loop switches, and transformers. The plan should include full testing per industry standards such as ANSI, ASTM, NECA, and IEEE. The preventative maintenance plan should be implemented as early as possible in Phase 1. All distribution equipment should be tested within the first three years of Phase 1. The last year of Phase 1 should begin a 5-year cycle of preventative maintenance for the system that schedules each piece of equipment for testing once every five years.

Recommended Projects

Phase 1 - Immediate Need Projects (0-5 Years)

Project Description	Reason for Implementation	Projected Cost
Provide submetering at all feeder circuit breakers at the North and South Substations. Metering shall integrate metering into the existing campus SCADA system.	To monitor and assess distribution circuit loading.	$40,000
Compile a document of all electric infrastructure record drawings and files.	To create accurate, consolidated record of the existing system conditions to assist with planning of campus expansion.	$15,000
Test all MV equipment such as switchgear, loop switches, and transformers.	Preventative maintenance of system.	$200,000
Upgrade electrical service transformer and provide new electrical equipment at the South Chiller Plant.	The South Chiller Plant is being upgraded to provide 2400 tons of additional chiller capacity. This requires another 2500kVA transformer and 480V, 3000A Switchboard and other misc. electrical work to accommodate new equipment.	$720,000
Initiate process of upgrading Cherry Street Substation.	Additional capacity is needed for Phase 2 and this process may take at long as 2 years.	$0

Subtotal Cost: $ 975,000

Phase 2 - Short Term Projects (6-15 Years)

Project Description	Reason for Implementation	Projected Cost
Upgrade the utility transformer (by Duke Energy) at Cherry Street Substation.	Load growth on Reynolda Campus and at UCC.	Primarily Incurred by Duke Energy
Upgrade electrical service transformers and provide new electrical equipment at the North Chiller Plant.	The North Chiller Plant is being upgraded to provide 4800-tons of additional chiller capacity. This requires two 2500kVA transformers and 480V, 3000A Switchboards and other miscellaneous electrical work to accommodate new equipment.	$1,500,000
Upgrade the electrical cabling segments in the Central Feeder Loop only once one side of the loop exceeds 50% capacity.	To provide full circuit capacity for the Loop. Note that this work should be done only as deemed necessary by Facilities Management dept.	$350,000
Test all MV equipment such as switchgear, loop switches, and transformers. (every 5 years)	Preventative Maintenance	$200,000/test (five year cost)

Subtotal Cost: $ 2,250,000

Phase 3 - Long Term Projects (15-40 Years)

Project Description	Reason for Implementation	Projected Cost
Install a 3rd parallel feeder to the North and South Substation to obtain full capacity of the switchgear once the Reynolda load exceeds 18MVA.	Necessary system redundancy for Reynolda Campus	$1,500,000
Test all MV equipment such as switchgear, loop switches, and transformers. (every five years)	Preventative Maintenance	$200,000/test (five year cost)

Subtotal Cost: $2,500,000

Total Cost of all phases: $5,725,000

Note that the cost projections include (construction cost x 1.2) for total project cost. All costs are October, 2008 dollars.

IV. Telecommunications System

Existing Conditions and System Assessment

The telecommunications cabling throughout the campus is mainly routed underground, either through the steam tunnels or direct buried in innerduct or ductbank. There are three central locations for the Wake Forest telecommunications infrastructure. Those Central Locations are:

- Reynolda Hall (core switches)
- Reynolds Library (core switches)
- Information Systems building (server farm)

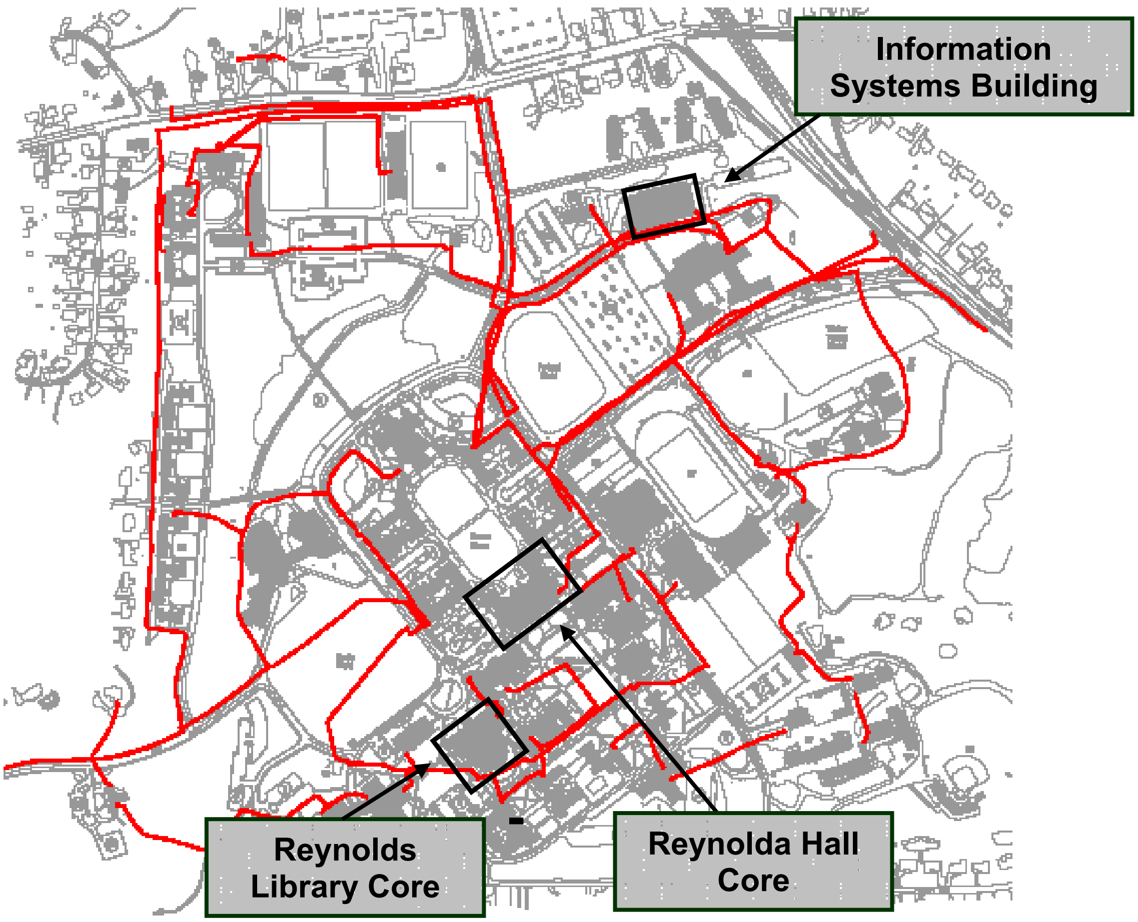


Figure IV-1: Telecommunications Cabling and Infrastructure

The telecommunications system is designed in a redundant connection system such that each building router is connected to two separate, local distribution routers. A distribution router can serve numerous buildings. Each distribution router has two separate connections to the two core routers (located in Reynolda Hall and Reynolds Library). The telecommunications infrastructure is designed such that information can be received and transmitted at each building from two separate electrical pathways. Note that often times the physical layer (cabling) is routed in the same raceway system.

Current and Future Load Projections

The existing telecommunications pathways are almost completely full. There is no room for expansion. Also, some current building pathways are not ideal. New infrastructure should be provided to accommodate the campus expansion. The infrastructure should be sized to accommodate at least a 24-strand singlemode fiber cable and a 24-strand multimode fiber cable to each building.

The central plant locations are also at full capacity. As new buildings are brought online, the central plants should be upgraded with additional racks for equipment such as termination equipment and electronics. These racks can be installed by Wake Forest personnel if budget allowances are made for the purchase of the necessary equipment.

The future of telecommunications systems and information transportation is gravitating towards increased use of fiber optic cabling. However, there is still a need for other types of cabling including copper CAT-3 UTP and coaxial cable. Due to the fast-growing technology and uncertainty of what telecommunications medium will be needed, the upgraded telecommunications raceway should, at a minimum, include six 4" conduits in all segments. Two conduits should have four 1" innerducts each and the other four conduits should be empty, see Figure IV-2. All conduits should have pullstrings. This will serve the immediate campus needs and create flexibility to adapt to changing technological needs.

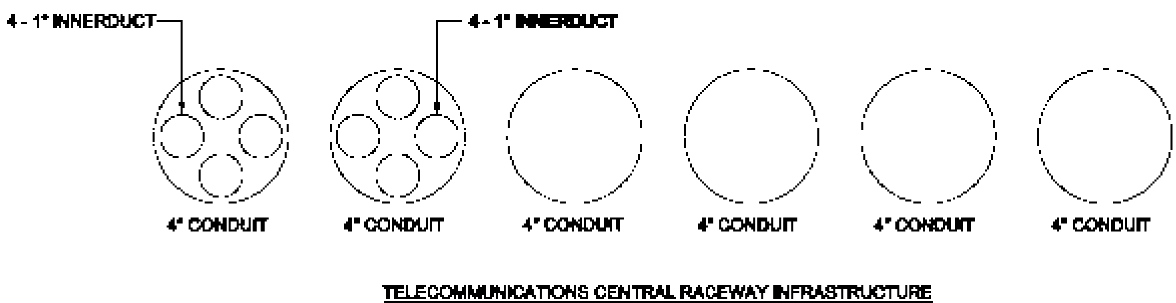


Figure IV-2: Telecommunications Cabling and Infrastructure

Options for Expansion and Improvement

New underground conduits in ductbank should be installed where new roads are being built outside of the campus core. They will connect the Information Systems building back to the campus core as well as provide pathways to the core for buildings on the campus perimeter. That work should be implemented early in Phase 1 and coordinated with the projects for new roadways, steam tunnel, and other infrastructure expansion where the ground is already being disturbed.

The campus core is not being disturbed significantly, thus new underground ductbank in that area is not practical. The recommended strategy is to use existing and refurbished steam tunnels to route new conduits around the entire core and back into Reynolda Hall and Reynolds Library. Telecommunications cabling is already routed through sections of those tunnels; however, the raceways should be upgraded to rigid aluminum conduit throughout the tunnel structure and sized such that new buildings through Phase 3 can connect into the tunnel.

Pullboxes in the tunnel with handholes for top access should be strategically placed to conform with BICSI and EIA/TIA standards as well as for easy connection from new buildings.

Figure IV-3 shows the new ductbank and tunnel raceway telecommunications system layout. A larger drawing is included at the end of this report.

Legend

New ductbank
New telecommunications manhole
New conduit raceway in existing steam tunnel
New handhole/pullbox location in the tunnel
New Phase 1 construction
New Phase 2 construction
New Phase 3 construction
Existing central/core building for telecommunications

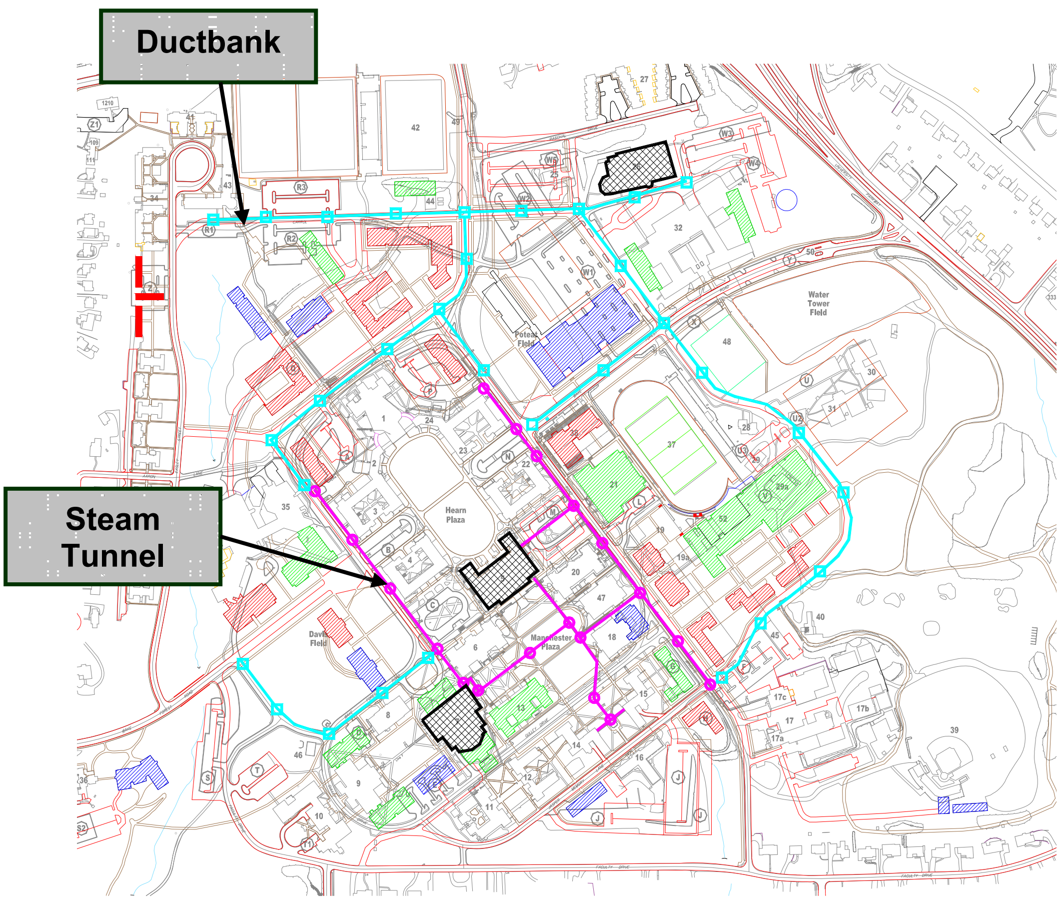


Figure IV-3: Proposed Telecommunications System Layout

Depending on the location, the conduits routed through the steam tunnel may be co-located with steam piping. In other instances, the steam piping may be removed and the tunnel will be occupied only by the telecommunications conduits. The pullboxes with handhole covers should be located approximately every 250ft, and strategically located to connect to ductbanks as shown for future buildings. Figure IV-4 details the proposed layout of the raceway in the steam tunnel or in ductbank.

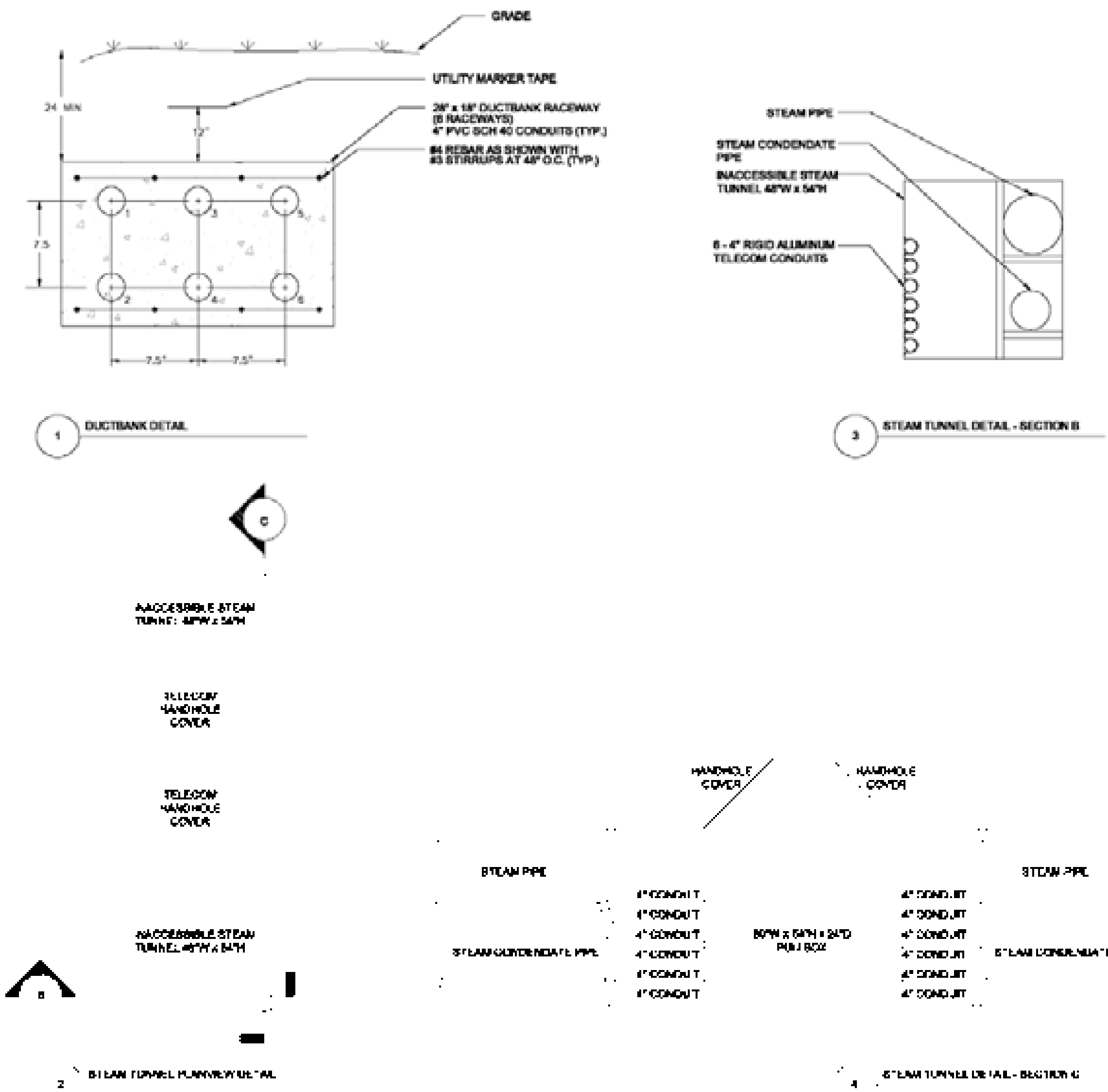


Figure IV-4: Proposed Raceway in Layout

The expansion will require additional distribution routers in some of the new buildings. These routers should be strategically located to accommodate a cluster of new buildings and should be provided in Phase 1. Figure IV-5 shows the proposed location of the new distribution routers.

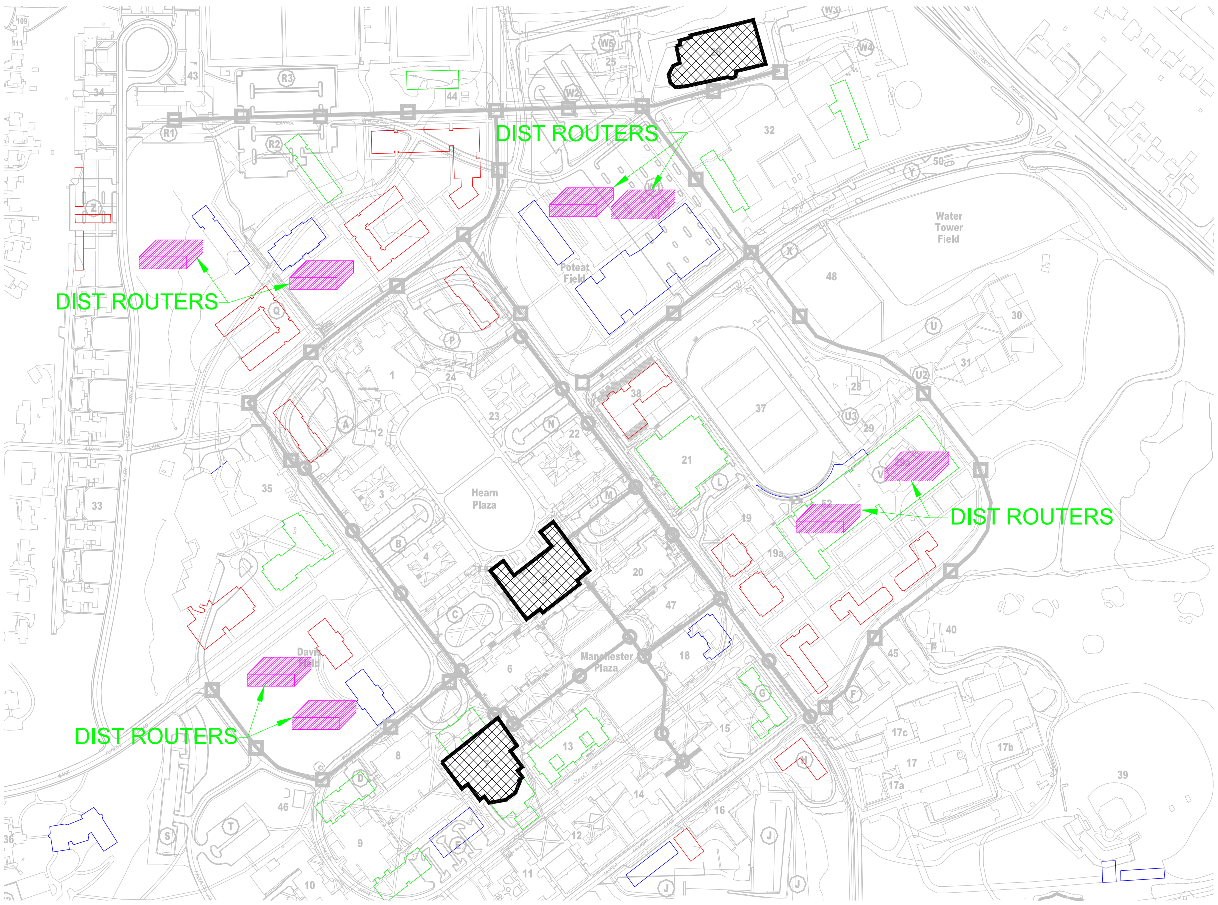


Figure IV-5: Proposed New Distribution Route Locations

General Telecommunications Upgrades:
Telecommunication equipment upgrades at central locations should be coordinated with the implementation of the campus master plan. This includes equipment upgrades in the cores, the server farm, and the new distribution routers. This effort entails system modification to integrate new racks of equipment to augment the network. Telecommunications equipment for individual buildings should be pursued and funded as part of that construction project.

There are several locations where new construction may interfere with existing telecommunications pathways. Each construction project should investigate the impact to the campus telecommunications infrastructure and which buildings would be affected. If conflict exists, the telecommunications should be modified to communicate through the alternate connection back to the cores. If the physical pathways are the same for the redundant connections, the new central infrastructure should be installed prior to the work and the cabling should be re-routed through that pathway. See the drawing below for the most likely locations of conflict with the campus expansion.

Legend

Existing underground telecommunications raceway
Location of conflict

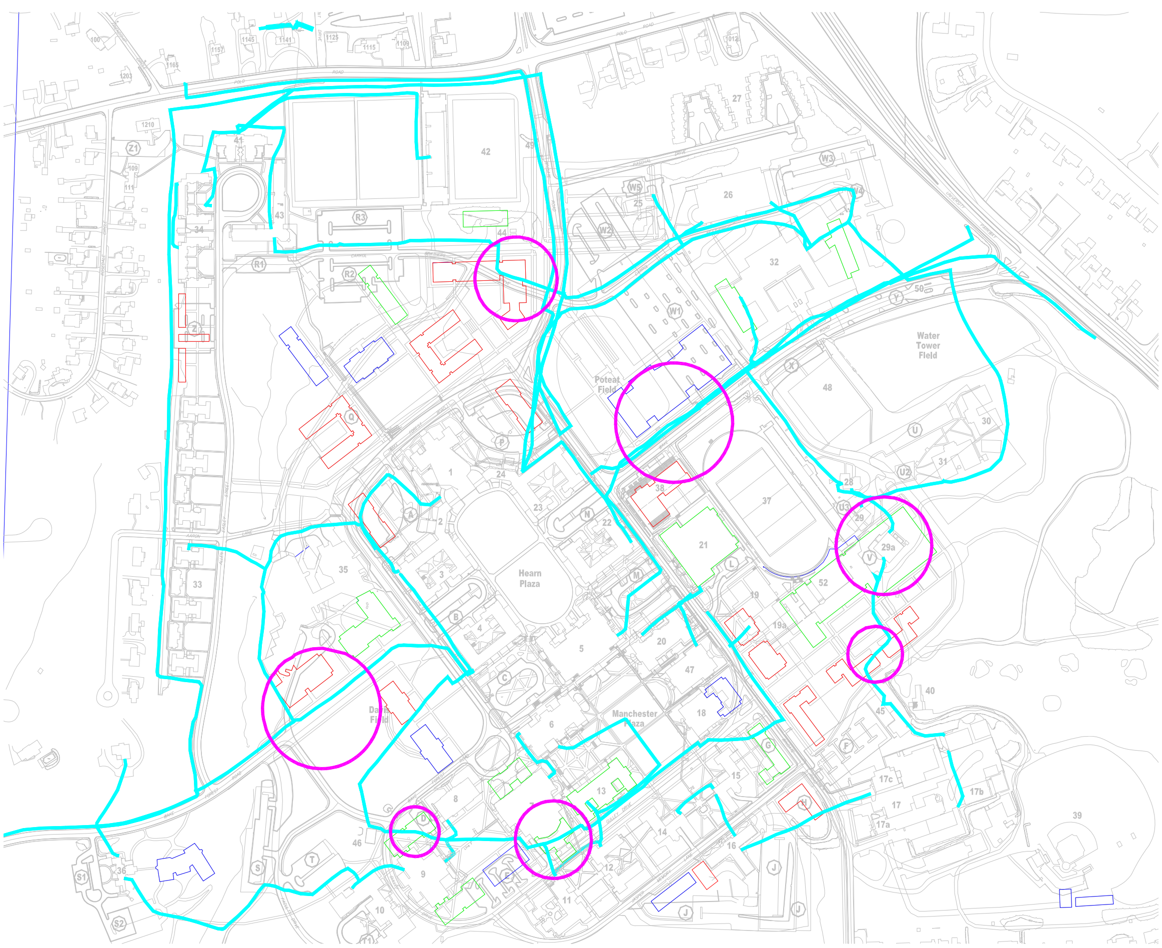


Figure IV-6: Conflicts between New Construction and Telecommunications System

Recommended Projects

The following projects are recommended during the various Phases of the masterplan. Note that most of the raceway infrastructure upgrades should occur in Phase 1. Figure IV-7 indicates different "segments" of work for the infrastructure that should be provided in coordination with the roadway and other utility work in that area.

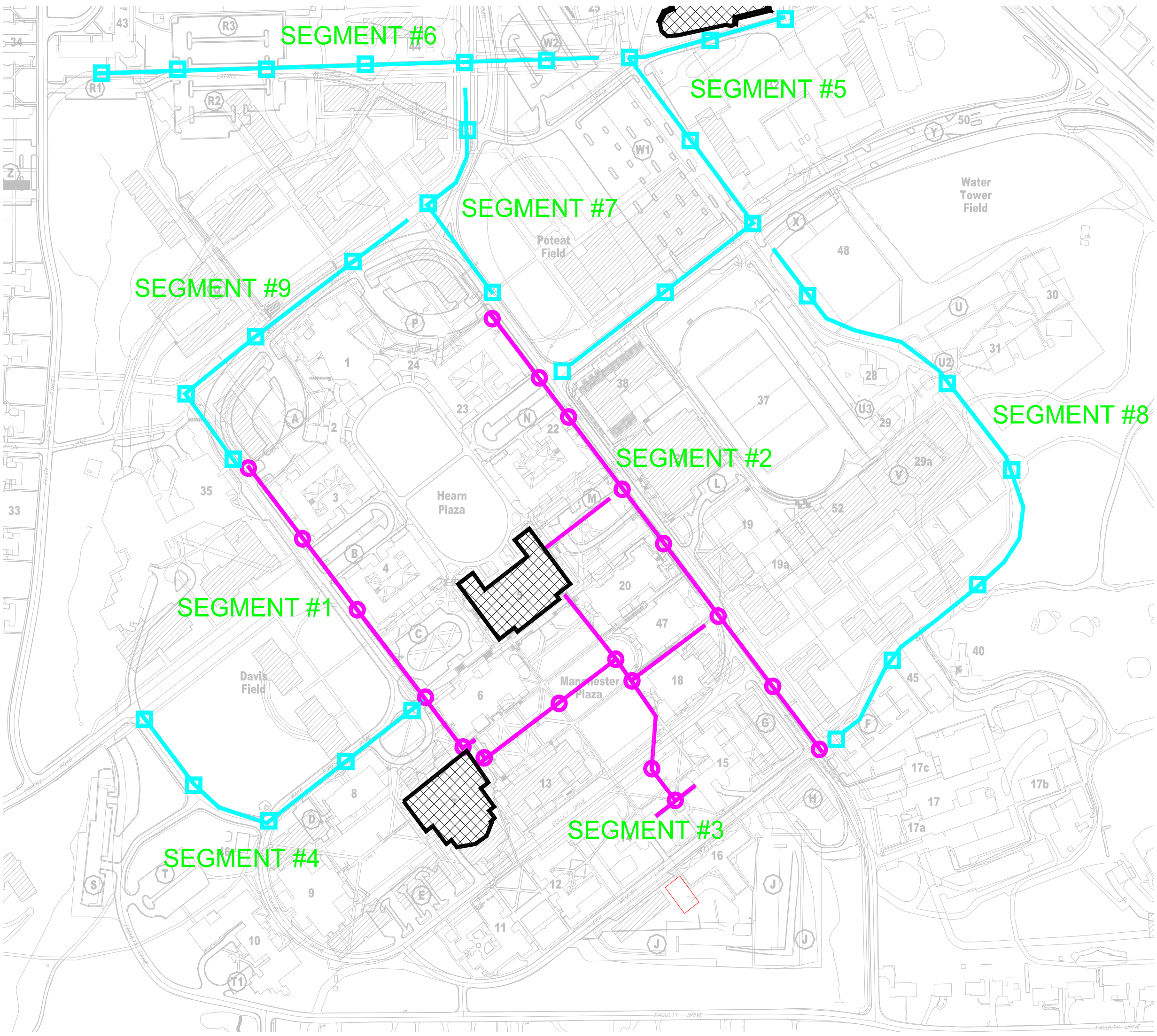


Figure IV-7: Infrastructure Projects to Coordinate with Telecommunications

Phase 1 - Immediate Need Projects (0-5 Years)

Project Description	Reason for Implementation	Projected Cost
Provide raceway infrastructure inside steam tunnel for Segment #1. Coordinate steam pipe is being removed in Phase 1.	To accommodate additional demand.	$600,000
Provide raceway infrastructure inside steam tunnel for Segment #2. The conduits will be co-located with steam pipe.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$1,150,000
Provide raceway infrastructure inside steam tunnel for Segment #3. The conduits will be co-located with steam pipe during Phase 1. Coordinate with steam pipe being removed in Phase 2.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$750,000
Provide raceway infrastructure in ductbank and manholes for Segment #4 in conjunction with roadway work across Davis field.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$775,000
Provide raceway infrastructure in ductbank and manholes for Segment #6 in conjunction with roadway and steam tunnel work south and east of Poteat Field.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$1,130,000
Provide raceway infrastructure in ductbank and manholes for Segment #6 in conjunction with roadway and steam tunnel work south of the Soccer Practice Field.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$975,000
Provide raceway infrastructure in ductbank and manholes for Segment #7, to connect Segment #2 and Segment #6 in conjunction with roadway work in that area.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$630,000

Provide raceway infrastructure in ductbank and manholes for Segment #8. Provide this in conjunction with steam tunnel work south and east of Kentner Stadium.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$1,500,000
Provide distribution routers and associated work south of Carroll Weathers Dr.	Provide active electronics, terminations, and other telecommunications work for new buildings to accommodate additional demand.	$10,000
Provide distribution routers and associated work at Poteat Field.	Provide active electronics, terminations, and other telecommunications work for new buildings to accommodate additional demand.	$10,000
Budget allotment for telecommunications network upgrades	Central telecommunications plant upgrades to expand the network to accommodate additional demand.	$50,000

Subtotal Cost: $ 7,580,000

Phase 2 - Short Term Projects (6-15 Years)

Project Description	Reason for Implementation	Projected Cost
Provide raceway infrastructure in ductbank and manholes for Segment #9, to connect Segment #7 to Segment #1. Provide this in conjunction with steam tunnel work south and east at Wake Forest Rd.	Provide central telecommunications raceway infrastructure to accommodate additional demand.	$850,000
Provide distribution routers and associated work south of Kentner Stadium.	Provide active electronics, terminations, and other telecommunications work.	$10,000
Budget allotment for telecommunications network upgrades	Central telecommunications plant upgrades to expand the network.	$50,000

Subtotal Cost: $ 910,000

Phase 3 - Long Term Projects (15-40 Years)

Project Description	Reason for Implementation	Projected Cost
Budget allotment for telecommunications network upgrades	Central telecommunications plant upgrades to expand the network to accommodate the campus expansion	$100,000

Subtotal Cost: $100,000

Total Cost of all phases: $8,590,000

Note that the cost projections include (construction cost x 1.2) for total project cost. All costs are October, 2008 dollars.

V. Water and Sewer Systems

Existing Conditions and System Assessment

A. Domestic Water System

The domestic water system was installed in the 1950's during the construction of the campus. A majority of the existing pipe in the system is cast iron. Recently, portions of the existing cast iron pipes have been removed for analysis and little wear or erosion was been found. Research suggests cast iron pipe used in water supply systems may have a life expectancy of over 100 years.

City water mains come into campus from Wake Forest Road to the east and across University Parkway to the west. These water mains bisect the University. There are two other connections to the city water system along Long Drive/Wingate Road. Currently, work has begun to meter the water consumption for every building on campus.

A large water tower is located on the eastern edge of the campus. This water tower is not dedicated to the University's water supply. There have been requests by the University to dedicate the water tower to the University's needs in order to increase water pressure on campus, but this course of action does not fit the city's plan for the water distribution system.

In August 2007, fire hydrants were tested for pressure and flow throughout the campus. The compilation of this data showed that overall; the campus supply of domestic water was adequate, with some areas of under performance. The area of campus that has the lowest supply pressure is the area around Polo Residence Hall at the Northwest edge of campus. In fact, Polo Residence Hall is equipped with a domestic and fire booster pump in order to achieve adequate pressure and flow inside the building. In this area, the water pressure is approximately 30psi, about half the pressure found on other parts of campus. It is suspected that the elevation at the building coupled with the relatively small piping serving this area contributes to this reduction in pressure. Figure V-1 shows the location of the low water pressure on campus.

B. Sanitary Sewer System

Two public sanitary sewer systems run though the campus, both originating on Polo Road and flowing from north to south. The system that serves the west side of campus parallels Allen Easley Drive and the creek. The system to the east side of campus roughly follows Wingate Road all the way south to Faculty Drive. Multiple private lines transport waste from University facilities to the public mains.

The original sewer system was installed in the 1950's. The original manhole structures are brick and mortar type with hand formed concrete inverts and the original piping is vitrified clay pipe. Since that time, the piping system has been repaired and expanded using cast iron and polyvinyl chloride (PVC) pipe.

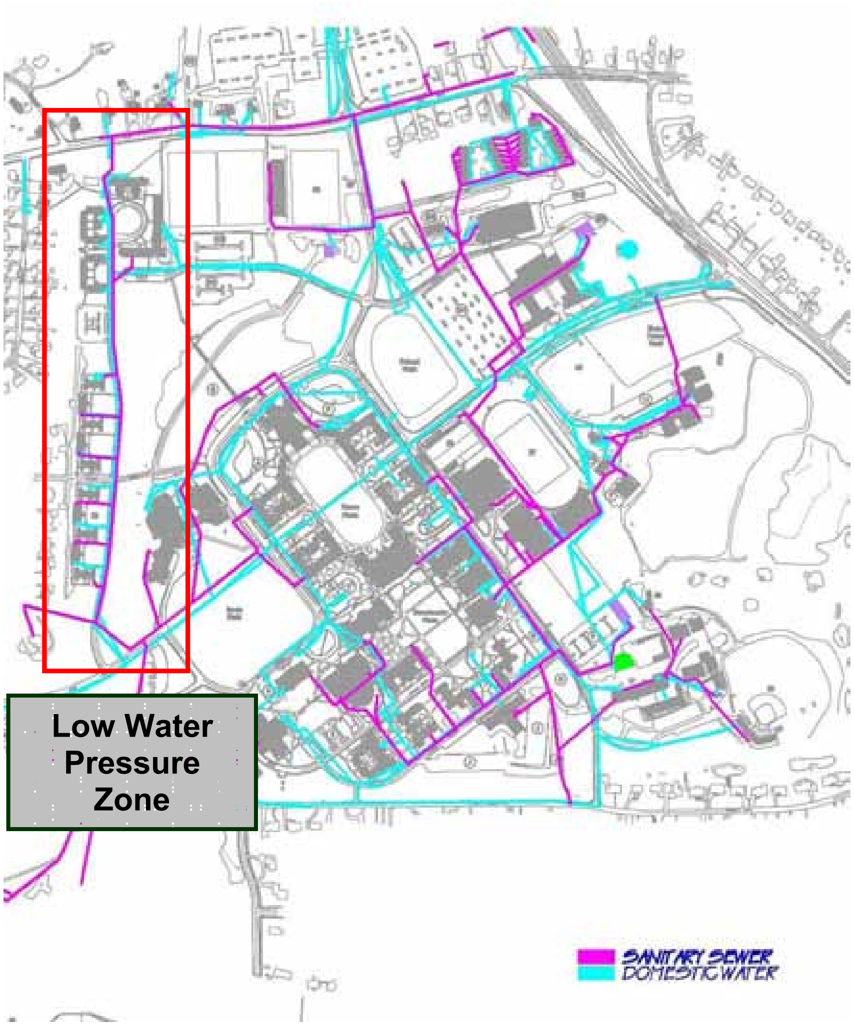


Figure V-1: Low Water Pressure Location

In previous reports it has been stated that the University's private sanitary sewers are in fair to good condition. There are severed areas of piping in need of repair and one section of piping that is installed at a very shallow pitch that does not allow for additional capacity. The most deficient area is located at the corner of Jasper Memory Lane and Wingate Road, where a damaged pipe creates a bottleneck of sewer flow. This circumstance will only be exasperated by additional buildings. In general, it was observed that the majority of the main lines are below 25% capacity.

Current and Future Load Projections

The water and sewer load growth projection is based on the phasing of the new construction, the expected type of building, and its size. Each building type was given a factor for gallons of water used per day per square footage. These values come from historical data for buildings of this type. The product of this value and the buildings square footage gives a peak demand for each building. Table A-1 follows this report and provides a detailed summary of the existing campus loads and the water and sewer densities can be found in Table V-I.

Table V-I: Water/Sewer Densities per Building Type

	Estimated GPD/GSF
Academic	0.22
Admissions	0.22
Athletics	0.25
Housing	0.15
Rec Center	0.22
Student Life	0.22
Laboratory	0.25
Miscellaneous	0.30
Diversity	1.00

Much of the infrastructure is already in place for to allow for an increase in water and sewer demand. In the domestic water system, the campus's lowest pressure is located within the area of largest increase in demand.

As for the sewer system, the capacity of the existing infrastructure is adequate and the future load will be handled by the system. As was stated previously, the existing deficiencies in the system will require repair as additional buildings are constructed.

Options for Expansion and Improvement

The load projections indicate a 45% increase in water and sewer demand on campus as shown on Table A-1 and A-2 at the end of this report. Figure V-2 shows the increase in demand for the zones on campus. As was shown in the previous sections, the majority of the increased demand is in the North Zone, while the West Zone has the least increase.

A. Domestic Water System

Information provided by the University, as well as data received from previous studies of the campus water system have both shown that the Northwest corner of campus has very low pressure. The low pressure is mainly a result of the elevation of this area on campus. To a lesser extent, the pipe size in this area is causing the low pressures seen at the buildings.

From the report generated by Engineering Tectonics (dated October 2007), hydrants were tested for flow to obtain data that could be used to determine possible bottlenecks in the system. The Northwest corner of campus had the lowest residual pressure reading on campus, determining that this area that would have the most benefit from an increase in pipe size. Other areas on campus didn't seem to have any measurable benefit for an increase in pipe size.

The recommendation to solve the low water pressure problems and allow the existing system to handle the increased flow as new buildings are added would be twofold. First, the existing domestic water piping on Carroll Weathers and Wingate Road should be upsized, as this area has a reduction of pressure due to the flow though the existing pipe. Due to the proposed relocation of this portion of Wingate road, the water main replacement should be coordinated with the new road construction.

Second, the University should coordinate with the Winston-Salem Water Utility for an additional connection to the city water main where the system pressure may be higher. Also, a review of the metering and backflow prevention at the campus's connections to the city mains is recommended. It may be possible to replace the metering equipment with equipment with less pressure drop, which will result in a greater overall pressure on campus.

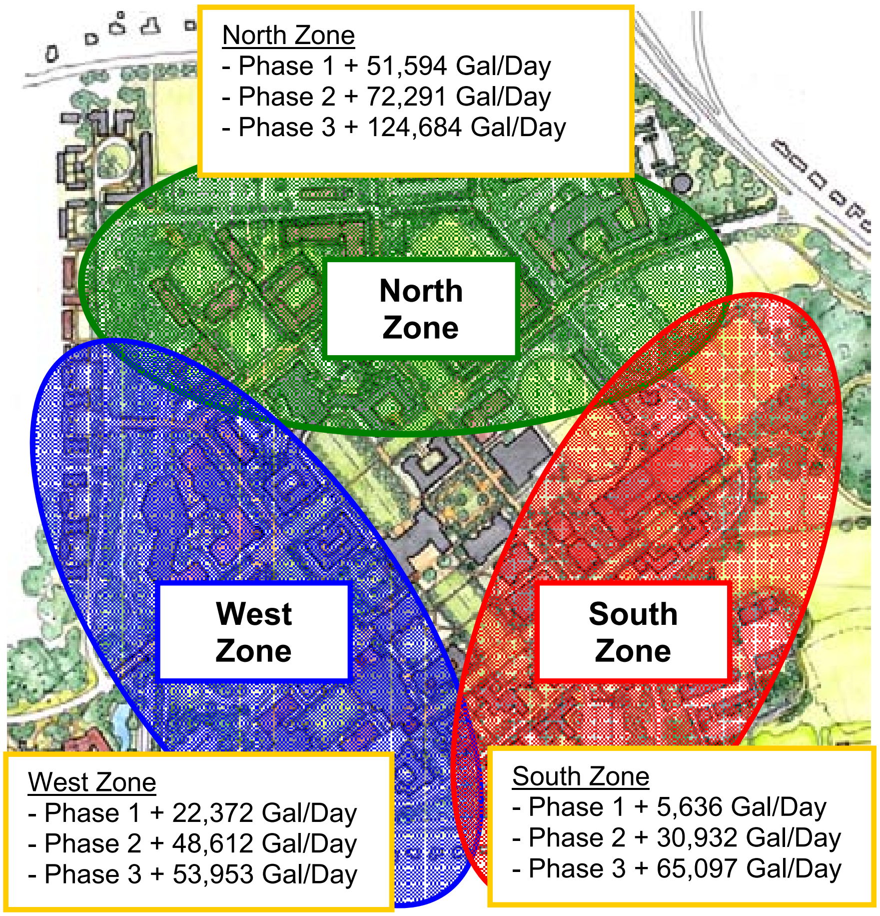


Figure V-2: Water/Sewer Demand Growth

Some proposed future buildings are located on top of existing water mains. These mains will require relocating. This occurs in two locations, one at the Campus Recreation Center, and the other at the Miller Center. It is recommended that these mains be relocated to the east, along a new road that is proposed to connect Wingate Road to Wake Forest Road.

Figure V-3 below, shows the phasing of the work on the water system as described above.

B. Sanitary Sewer System

Similar to the domestic water system, information on the sanitary sewer system was provided by University personnel and additional data was received from previous studies of the campus system. Overall, it was noted that the system was running at 25% capacity, but specific areas of campus have major deficiencies, as the existing pipe has been blocked or damaged.

The report by Engineering Tectonics and University personnel both note that the intersection of Jasper Memory Lane and Wingate Road has major sanitary sewer deficiencies. In this area, the existing 12" main has collapsed. It is recommended that this pipe be replaced with ductile iron. Other areas of the system that have major deficiencies include the existing 8" pipe by Wait Chapel, 8" pipe outside of Kitchin Residence Hall down to Green Hall, and the manhole between Taylor and Davis Residence Halls. These areas are damaged, and are recommended to be replaced with ductile iron pipe and new manholes. These repairs should be made prior to the addition of more buildings on the system.

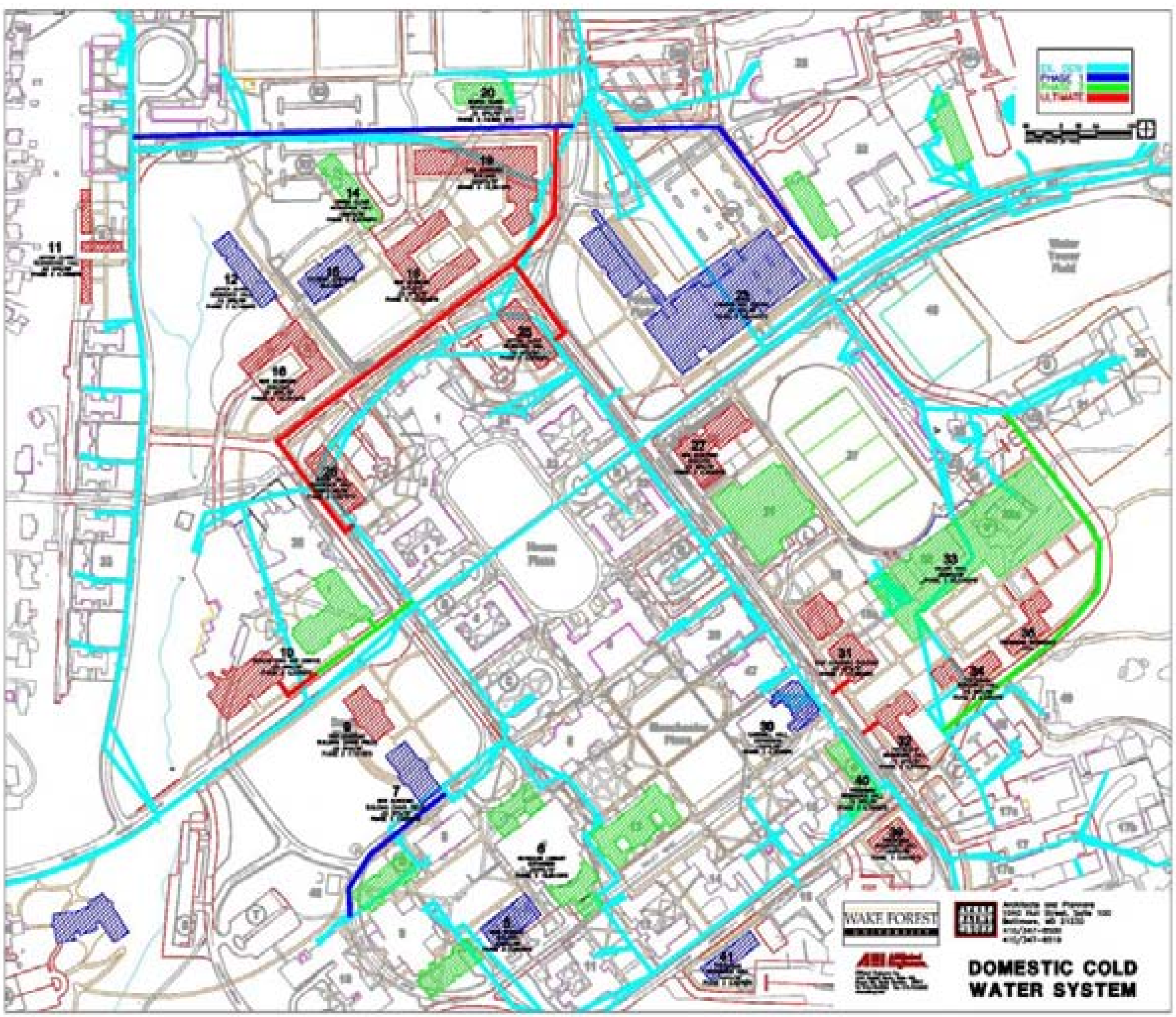


Figure V-3: Future Domestic Cold Water Distribution

As with the domestic water system, new buildings will require new mains for connection to the sanitary sewer system. Also, new buildings proposed to be constructed on top of small sections of the existing system will require relocation of the existing mains.

A new sanitary sewer main to the new residence halls located on the North side of campus will be required to serve the buildings. The location where the sanitary piping is in conflict with a new building would be at the Miller Center. As with the domestic water system, this main should be rerouted out into the new proposed street to the east. Figure V-4, shows the phasing of the work for the sewer systems.

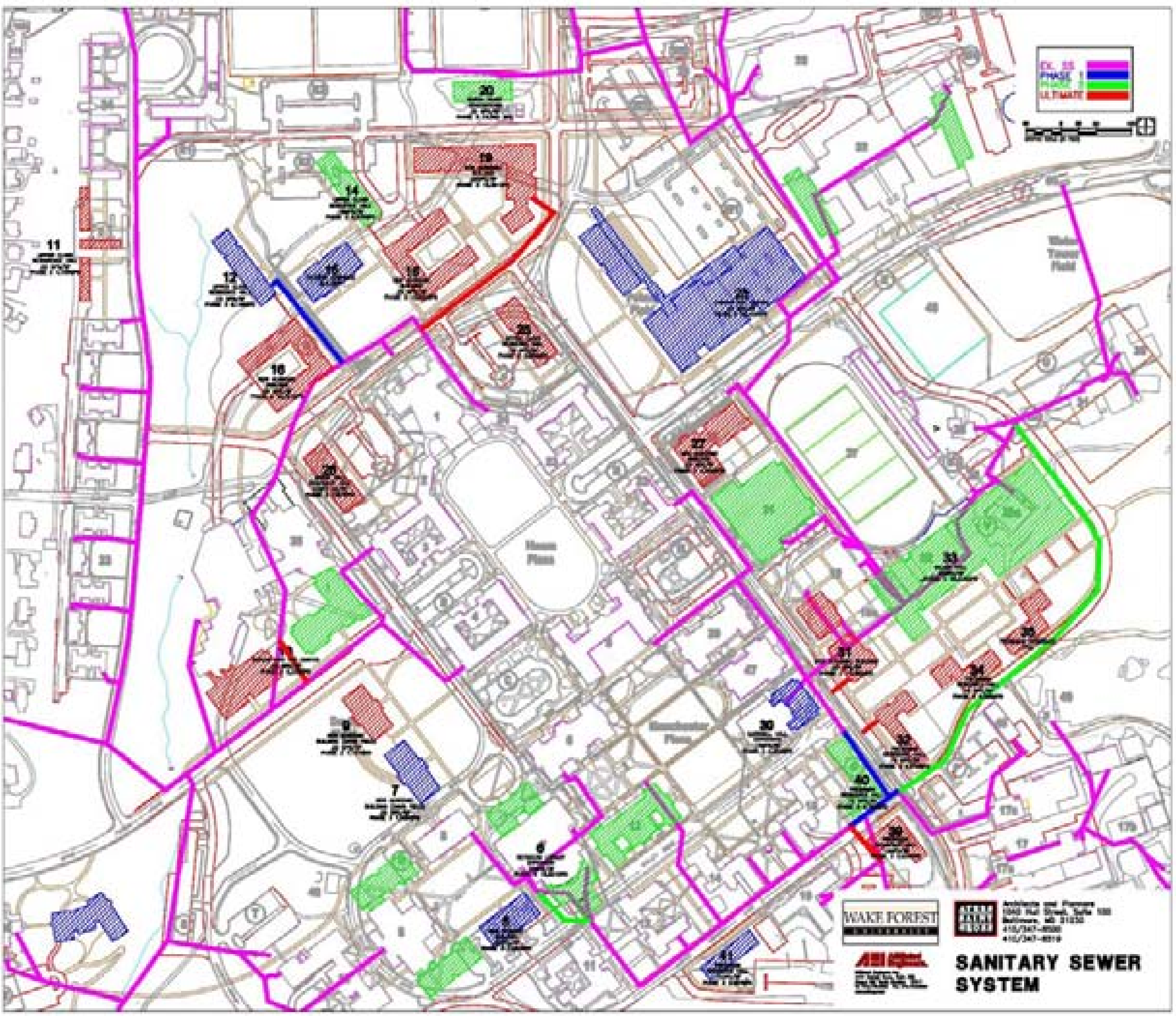


Figure V-4: Future Sanitary Sewer Water Distribution

Recommendations for Separate Projects

The following projects are recommended during the various Phases of the masterplan.

Phase 1 - Immediate Need Projects (0-5 Years)

Project Description	Reason for Implementation	Projected Cost
Inspect/Replace Water Meters/Backflow Preventers at City Main Connections	Increase campus water pressure.	$50,000 (Coordinate with City)
Annually Flush and Inspect System	Keep the existing system clean.	$5,000
Connect to Additional City Main	Increase campus water pressure.	$200,000 (Coordinate with City)
Upsize main on Carroll Weathers Drive	Increase campus water pressure.	$600,000
Repair Damaged Sewer at Wait Chapel	Repair existing system.	$50,000
Repair Damaged Sewer at Kitchin Hall	Repair existing system.	$50,000
Repair Damaged Sewer at Taylor Residence Hall	Repair existing system.	$50,000
Relocate Water Main at Campus Recreation Center	Moving Utility from under the proposed building's footprint.	$500,000
Relocate Water Main at New Academic Building #7	Moving Utility from under the proposed building's footprint.	$200,000

Total Cost: $ 1,705,000

Phase 2 - Short Term Projects (6-15 Years)

Project Description	Reason for Implementation	Projected Cost
Relocate Water Main from the Miller Center to New Road	Moving Utility from under the proposed building's footprint.	$700,000
Relocate Sewer Main from the Miller Center to New Road	Moving Utility from under the proposed building's footprint.	$500,000
Relocate Sewer Main from the Reynolds Library Addition to New Road	Moving Utility from under the proposed building's footprint.	$75,000

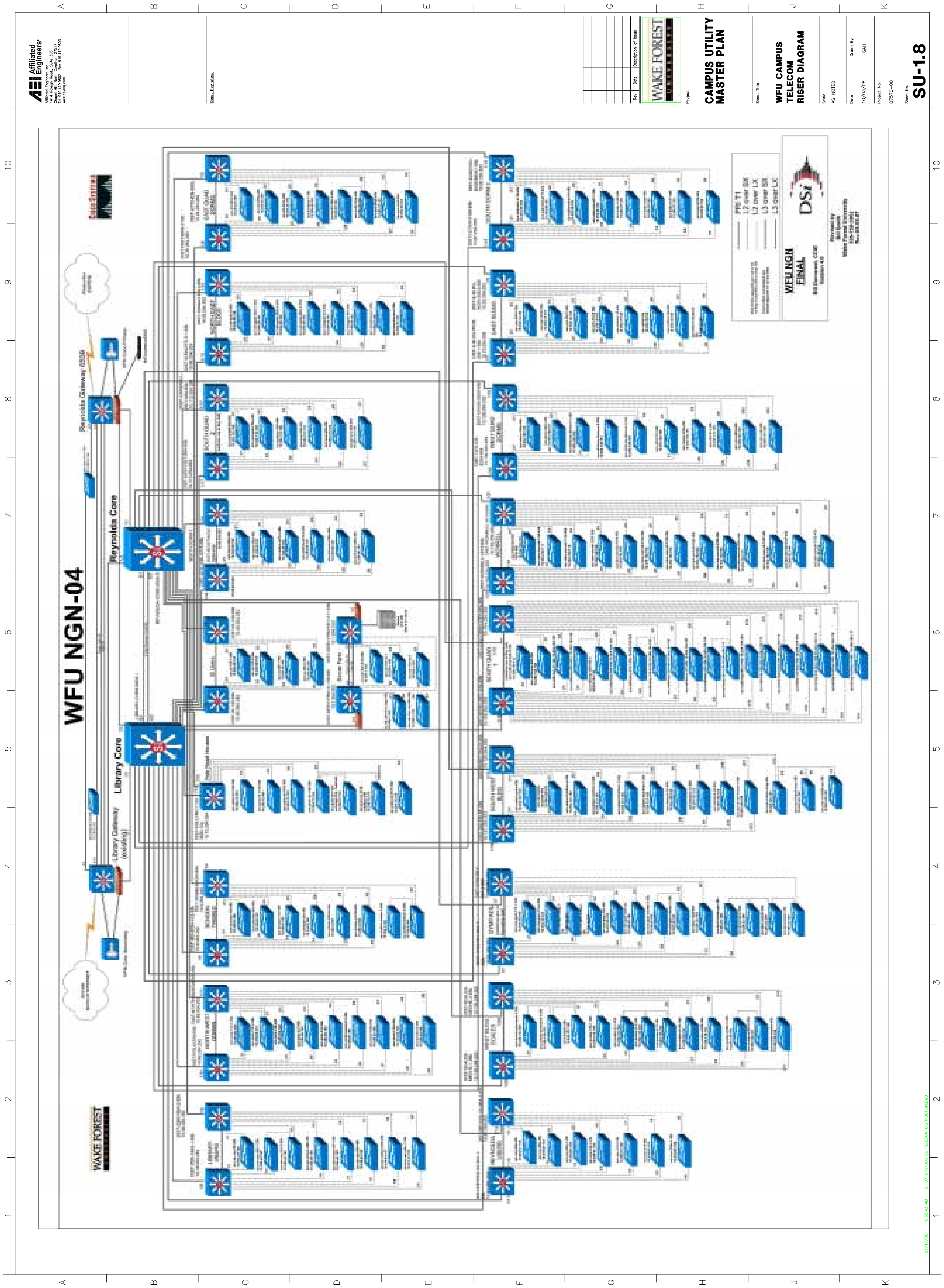
Total Cost: $ 1,275,000

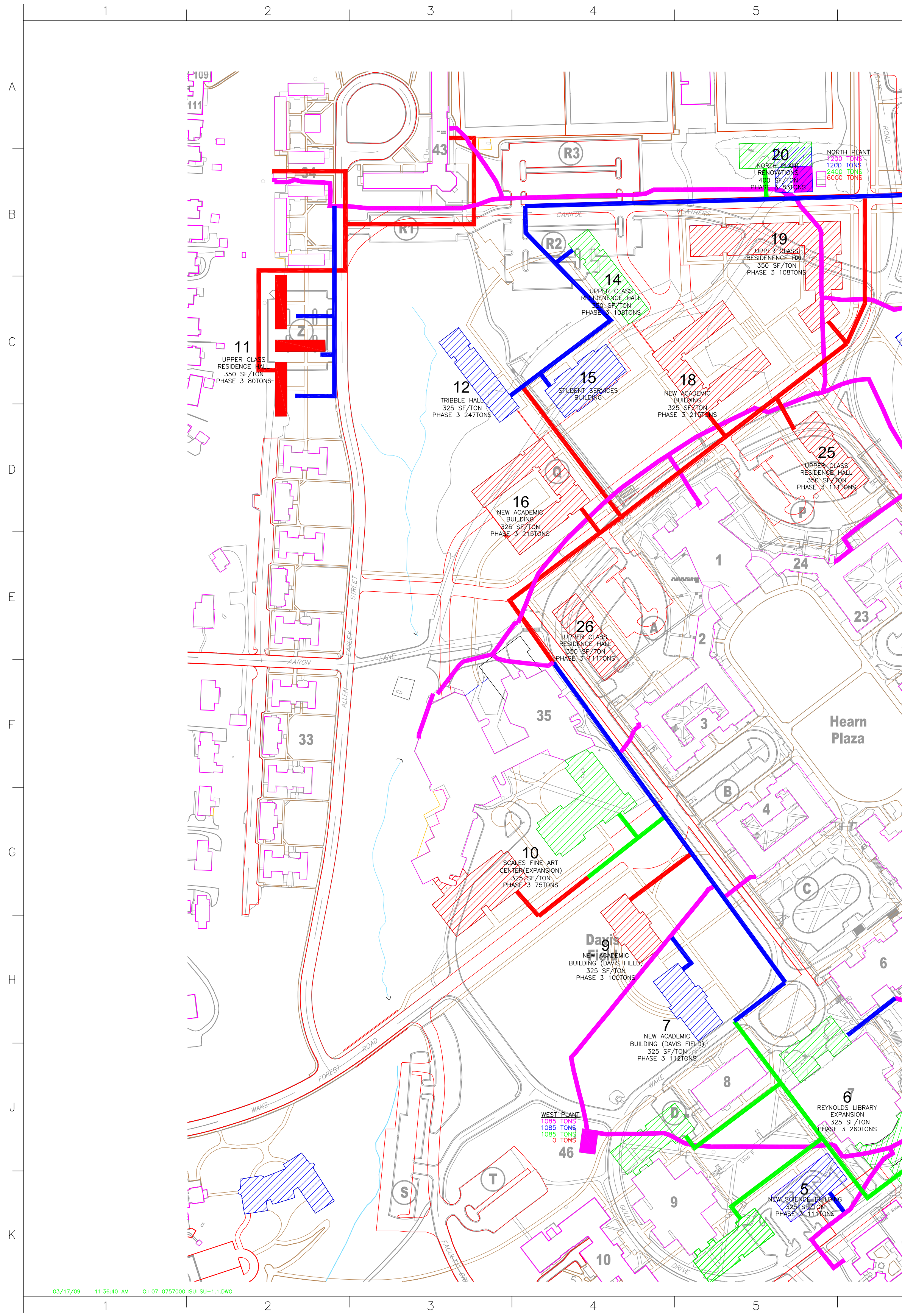
Phase 3 - Long Term Projects (15-40 Years)

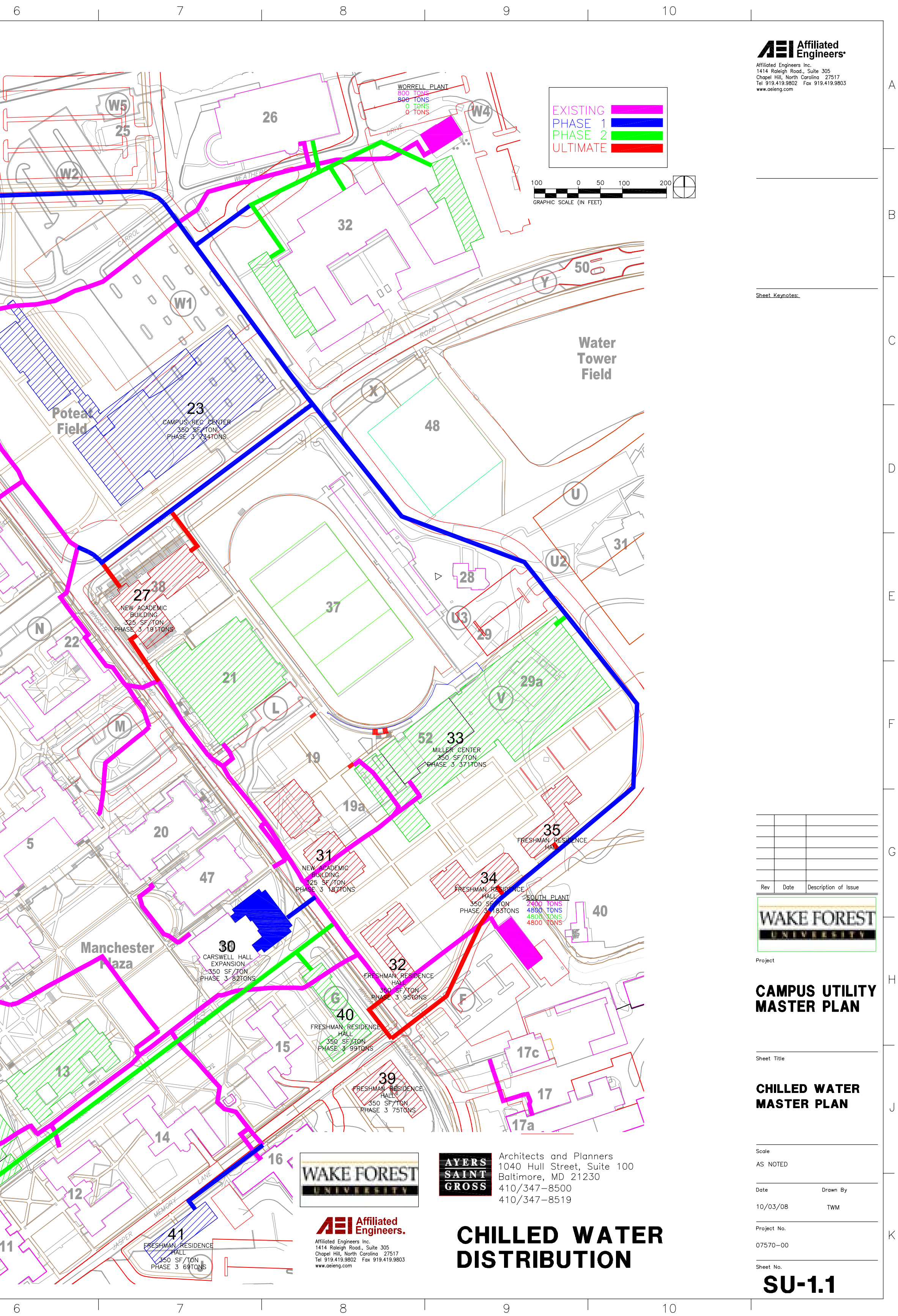
Project Description	Reason for Implementation	Projected Cost
New Water Main by New Academic Buildings	To provide a water main to the new building.	$1,000,000
New Water Main to New Academic Building 16	To provide a sewer main to the new building.	$400,000

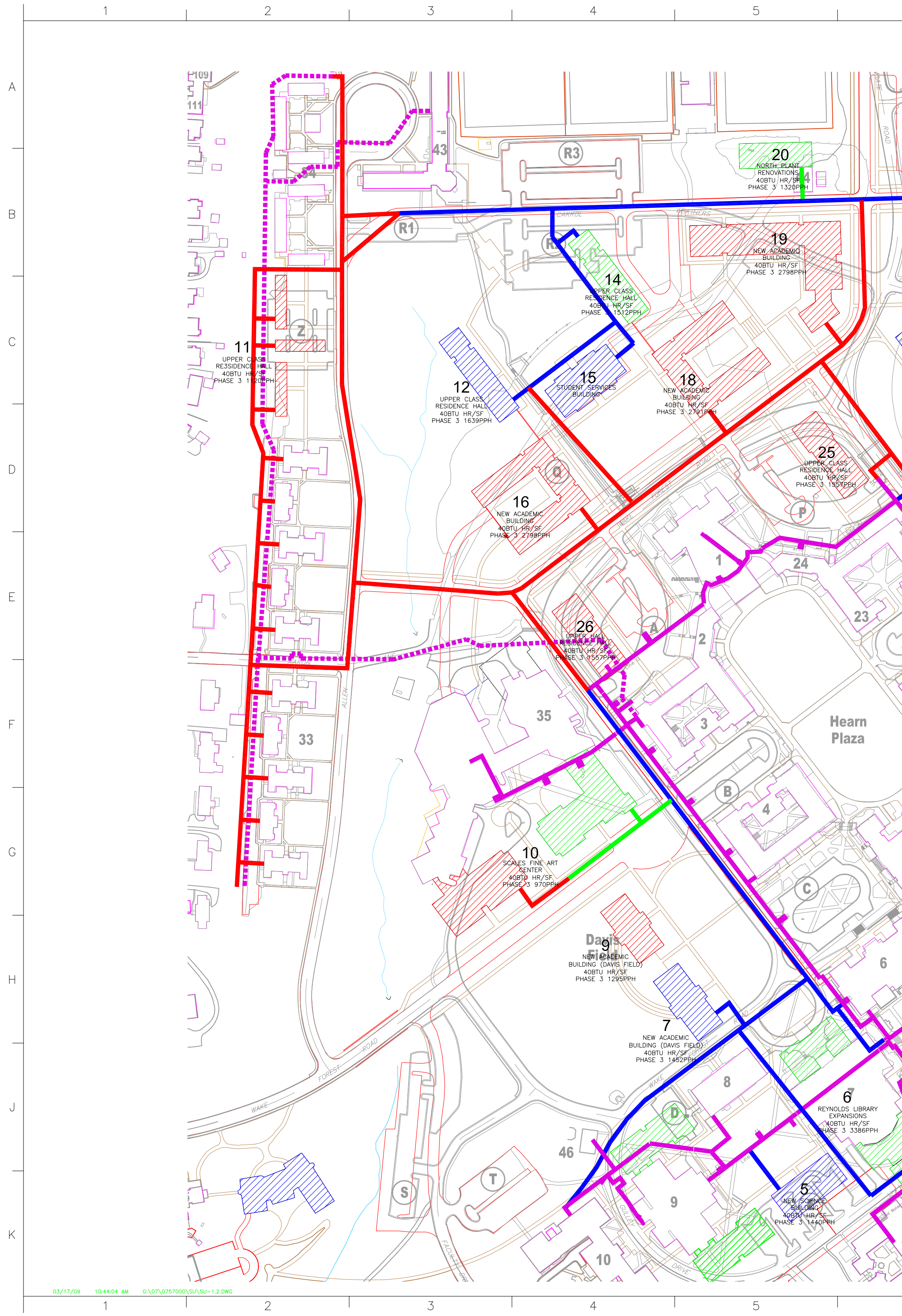
Total Cost: $1,400,000

Note that the cost projections include (construction cost x 1.2) for total project cost. All costs are October 2008 dollars.

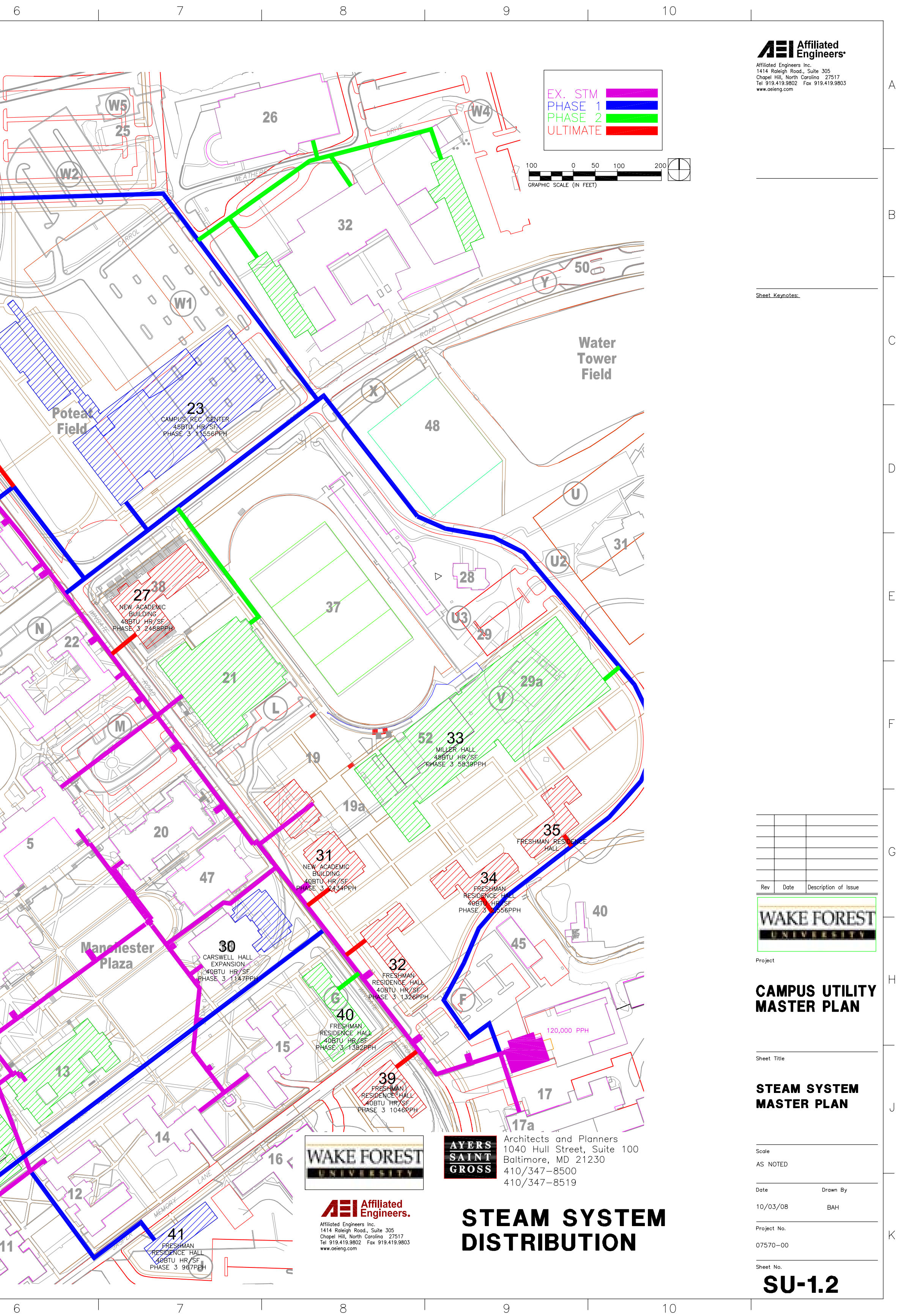

WFU NGN-04
Reynolds Gateway 6509
Reynolds Core
Library Core
Library Gateway (existing)
WAKE FOREST
CAMPUS UTILITY MASTER PLAN
WFU CAMPUS TELECOM RISER DIAGRAM
10/03/08
07570-00
SU-1.8

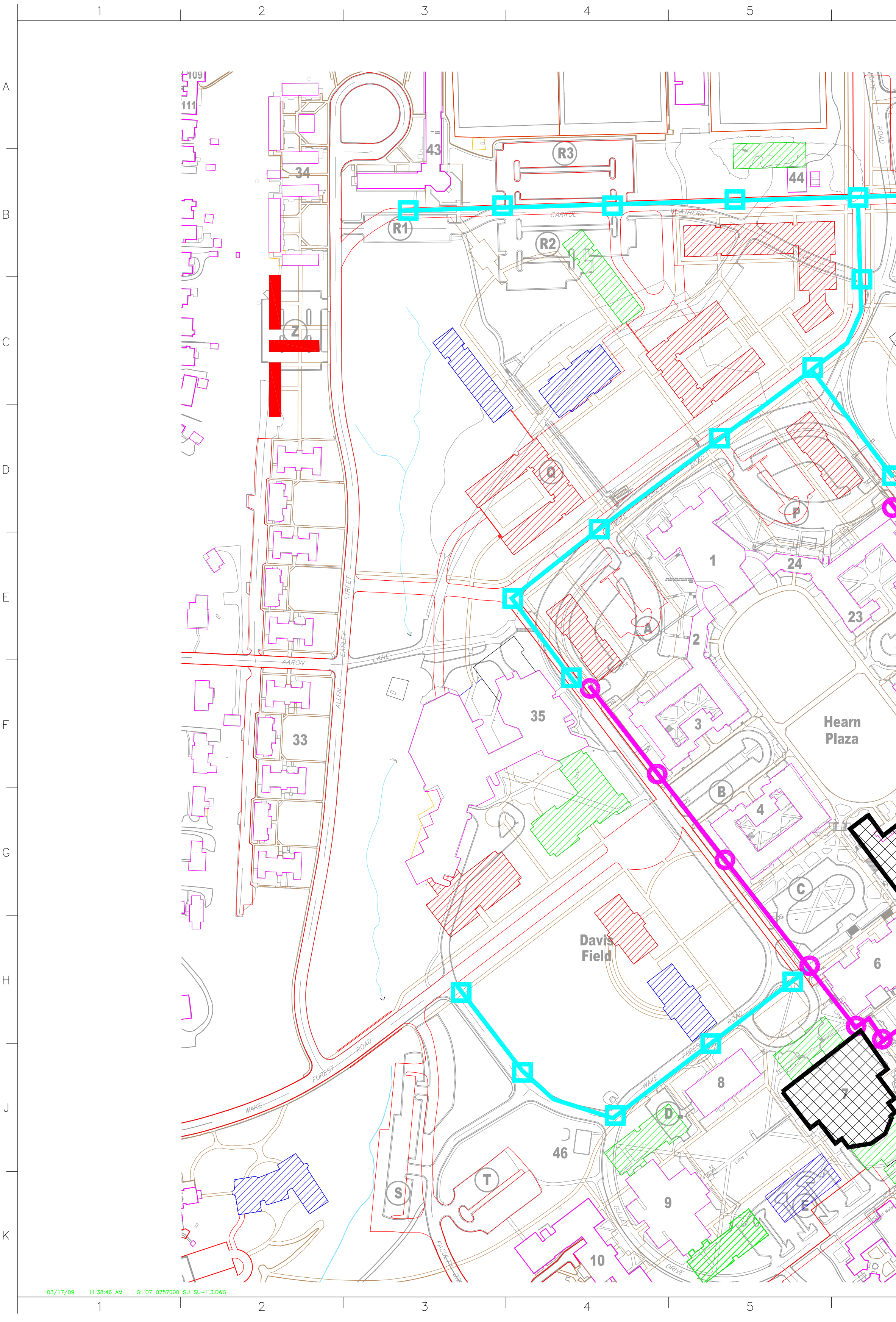

1
2
3
4
5
A
B
C
D
E
F
G
H
J
K
NORTH PLANT
7200 TONS
1200 TONS
2400 TONS
6000 TONS
20
NORTH PLANT RENOVATIONS
19
UPPER CLASS RESIDENCE HALL
350 SF/TON
PHASE 3 108TONS
14
UPPER CLASS RESIDENCE HALL
PHASE 3 108TONS
11
UPPER CLASS RESIDENCE HALL
350 SF/TON
PHASE 3 80TONS
12
TRIBBLE HALL
325 SF/TON
PHASE 3 247TONS
15
STUDENT SERVICES BUILDING
18
NEW ACADEMIC BUILDING
325 SF/TON
PHASE 3 215TONS
25
UPPER CLASS RESIDENCE HALL
350 SF/TON
PHASE 3 111TONS
16
NEW ACADEMIC BUILDING
325 SF/TON
PHASE 3 215TONS
26
UPPER CLASS RESIDENCE HALL
350 SF/TON
PHASE 3 111TONS
10
SCALES FINE ART CENTER(EXPANSION)
325 SF/TON
PHASE 3 75TONS
9
NEW ACADEMIC BUILDING (DAVIS FIELD)
325 SF/TON
PHASE 3 100TONS
7
NEW ACADEMIC BUILDING (DAVIS FIELD)
325 SF/TON
PHASE 3 112TONS
6
REYNOLDS LIBRARY EXPANSION
325 SF/TON
PHASE 3 260TONS
5
NEW SCIENCE BUILDING
PHASE 3 111TONS
WEST PLANT
1085 TONS
1085 TONS
1085 TONS
0 TONS
46
Hearn Plaza
Davis Field
CARROL
AARON
LANE
ALLEN
STREET
EASLEY
FOREST
ROAD
WAKE
DRIVE
R1
R2
R3
Z
Q
P
A
B
C
D
S
T
1
2
3
4
8
9
10
23
24
33
34
35
43
109
111
03/17/09 11:36:40 AM G: 07 0757000 SU SU-1.1.DWG

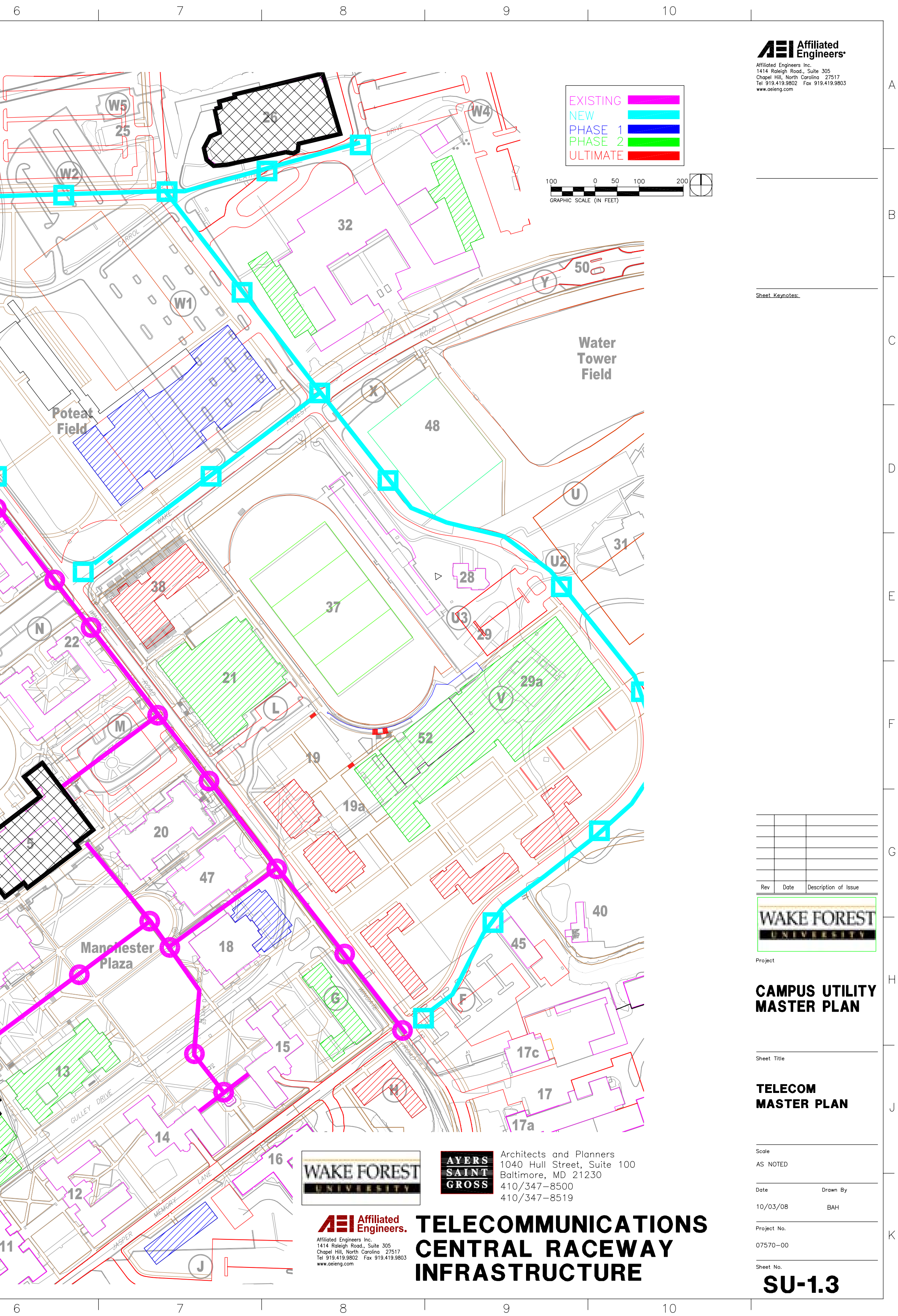

WORRELL PLANT
800 TONS
800 TONS
0 TONS
0 TONS
EXISTING
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
23
CAMPUS REC CENTER
350 SF/TON
PHASE 3 734TONS
27
NEW ACADEMIC BUILDING
325 SF/TON
PHASE 3 191TONS
33
MILLER CENTER
350 SF/TON
PHASE 3 371TONS
31
NEW ACADEMIC BUILDING
325 SF/TON
PHASE 3 187TONS
30
CARSWELL HALL EXPANSION
350 SF/TON
PHASE 3 82TONS
35
FRESHMAN RESIDENCE HALL
34
FRESHMAN RESIDENCE HALL
350 SF/TON
PHASE 3 183TONS
SOUTH PLANT
2400 TONS
4800 TONS
4800 TONS
4800 TONS
32
FRESHMAN RESIDENCE HALL
350 SF/TON
PHASE 3 95TONS
40
FRESHMAN RESIDENCE HALL
350 SF/TON
PHASE 3 99TONS
39
FRESHMAN RESIDENCE HALL
350 SF/TON
PHASE 3 75TONS
41
FRESHMAN RESIDENCE HALL
350 SF/TON
PHASE 3 69TONS
WAKE FOREST UNIVERSITY
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
AEI Affiliated Engineers.
Affiliated Engineers Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
CHILLED WATER DISTRIBUTION
Sheet Keynotes:
Rev
Date
Description of Issue
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
CHILLED WATER MASTER PLAN
Scale
AS NOTED
Date
10/03/08
Drawn By
TWM
Project No.
07570-00
Sheet No.
SU-1.1

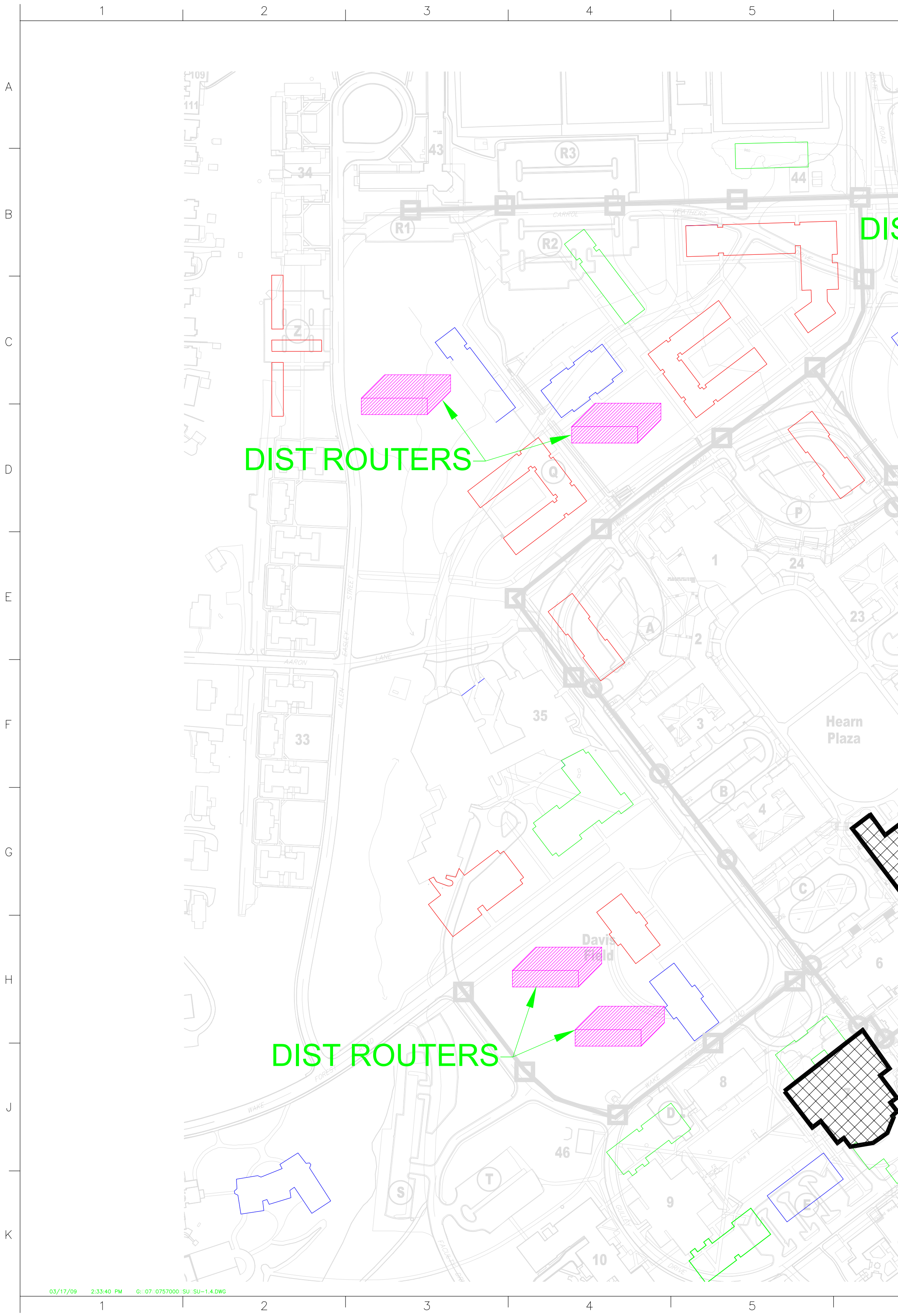


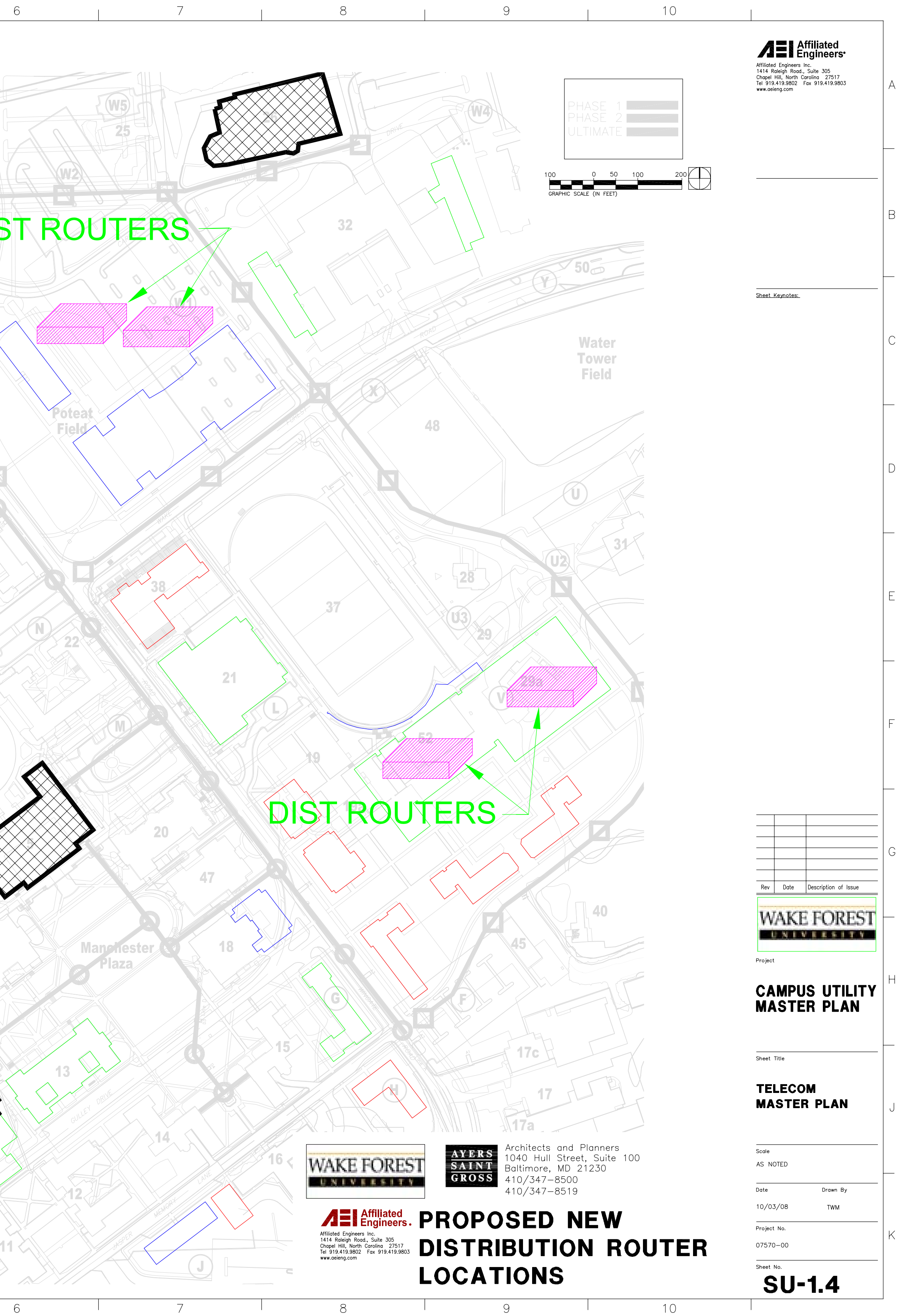
20
NORTH PLANT RENOVATIONS
40BTU HR/SF
PHASE 3 1320PPH
19
NEW ACADEMIC BUILDING
40BTU HR/SF
PHASE 3 2798PPH
14
UPPER CLASS RESIDENCE HALL
40BTU HR/SF
PHASE 3 1512PPH
11
UPPER CLASS RESIDENCE HALL
40BTU HR/SF
PHASE 3 1120PPH
12
UPPER CLASS RESIDENCE HALL
40BTU HR/SF
PHASE 3 1639PPH
15
STUDENT SERVICES BUILDING
18
NEW ACADEMIC BUILDING
40BTU HR/SF
PHASE 3 2791PPH
25
UPPER CLASS RESIDENCE HALL
40BTU HR/SF
PHASE 3 1557PPH
16
NEW ACADEMIC BUILDING
40BTU HR/SF
PHASE 3 2798PPH
26
UPPER HALL RESIDENCE HALL
40BTU HR/SF
PHASE 3 3557PPH
Hearn Plaza
10
SCALES FINE ART CENTER
40BTU HR/SF
PHASE 3 970PPH
9
NEW ACADEMIC BUILDING (DAVIS FIELD)
40BTU HR/SF
PHASE 3 1295PPH
7
NEW ACADEMIC BUILDING (DAVIS FIELD)
40BTU HR/SF
PHASE 3 1452PPH
6
REYNOLDS LIBRARY EXPANSIONS
40BTU HR/SF
PHASE 3 3386PPH
5
NEW SCIENCE BUILDING
40BTU HR/SF
PHASE 3 1440PPH
03/17/09 10:44:04 AM G:\07\0757000\SU\SU-1.2.DWG

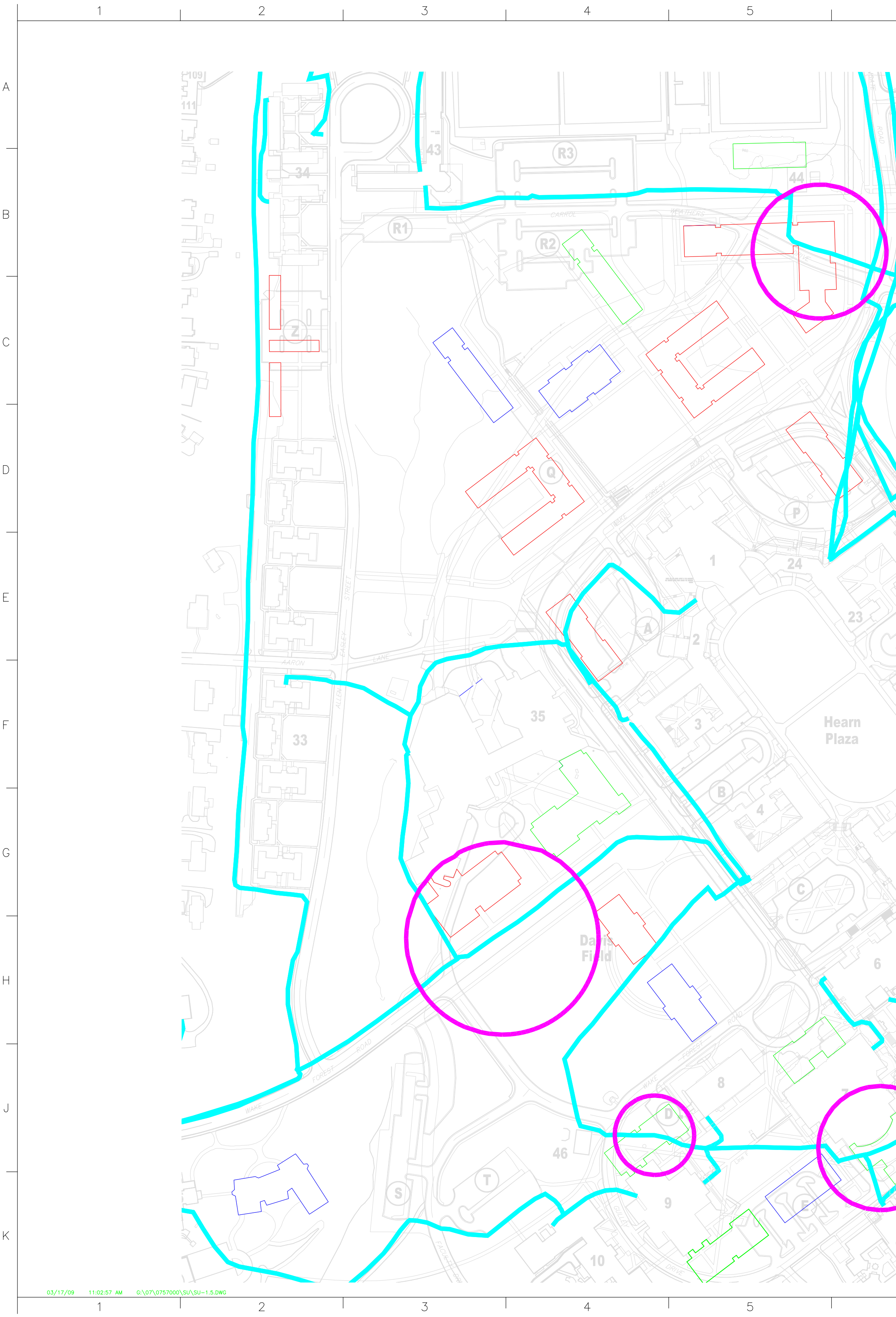

EX. STM
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
23 CAMPUS REC CENTER 45BTU HR/SF PHASE 3 1556PPH
27 NEW ACADEMIC BUILDING 40BTU HR/SF PHASE 3 2488PPH
33 MILLER HALL 45BTU HR/SF PHASE 3 5839PPH
35 FRESHMAN RESIDENCE HALL
31 NEW ACADEMIC BUILDING 40BTU HR/SF PHASE 3 2434PPH
34 FRESHMAN RESIDENCE HALL 40BTU HR/SF PHASE 3 1556PPH
30 CARSWELL HALL EXPANSION 40BTU HR/SF PHASE 3 1147PPH
32 FRESHMAN RESIDENCE HALL 40BTU HR/SF PHASE 3 1326PPH
40 FRESHMAN RESIDENCE HALL 40BTU HR/SF PHASE 3 1392PPH
39 FRESHMAN RESIDENCE HALL 40BTU HR/SF PHASE 3 1046PPH
41 FRESHMAN RESIDENCE HALL 40BTU HR/SF PHASE 3 987PPH
120,000 PPH
WAKE FOREST UNIVERSITY
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
AEI Affiliated Engineers.
Affiliated Engineers Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
STEAM SYSTEM DISTRIBUTION
Sheet Keynotes:
Rev
Date
Description of Issue
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
STEAM SYSTEM MASTER PLAN
Scale
AS NOTED
Date
10/03/08
Drawn By
BAH
Project No.
07570-00
Sheet No.
SU-1.2

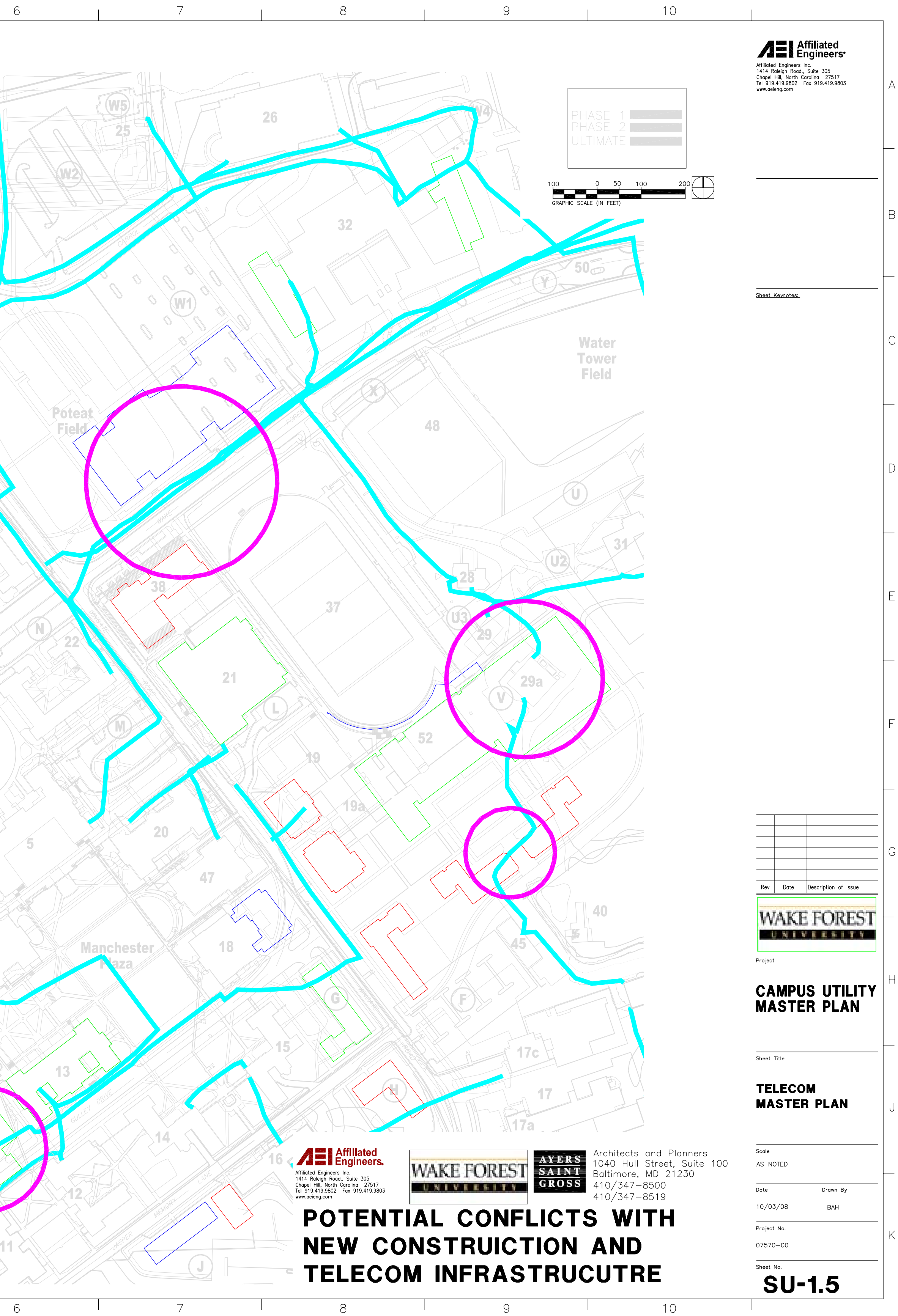

Hearn Plaza
Davis Field
R1
R2
R3
Z
Q
P
A
B
C
D
S
T
1
2
3
4
6
8
9
10
23
24
33
34
35
43
44
46
CARROLL
AARON
LANE
ALLEN
EASLEY
STREET
WAKE
FOREST
ROAD
03/17/09 11:38:46 AM


EXISTING
NEW
PHASE 1
PHASE 2
ULTIMATE
100 0 50 100 200
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
Affiliated Engineers
Affiliated Engineers Inc.
1414 Raleigh Road., Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
Sheet Keynotes:
Rev Date Description of Issue
WAKE FOREST UNIVERSITY
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
TELECOM MASTER PLAN
Scale
AS NOTED
Date
10/03/08
Drawn By
BAH
Project No.
07570-00
Sheet No.
SU-1.3
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
TELECOMMUNICATIONS CENTRAL RACEWAY INFRASTRUCTURE

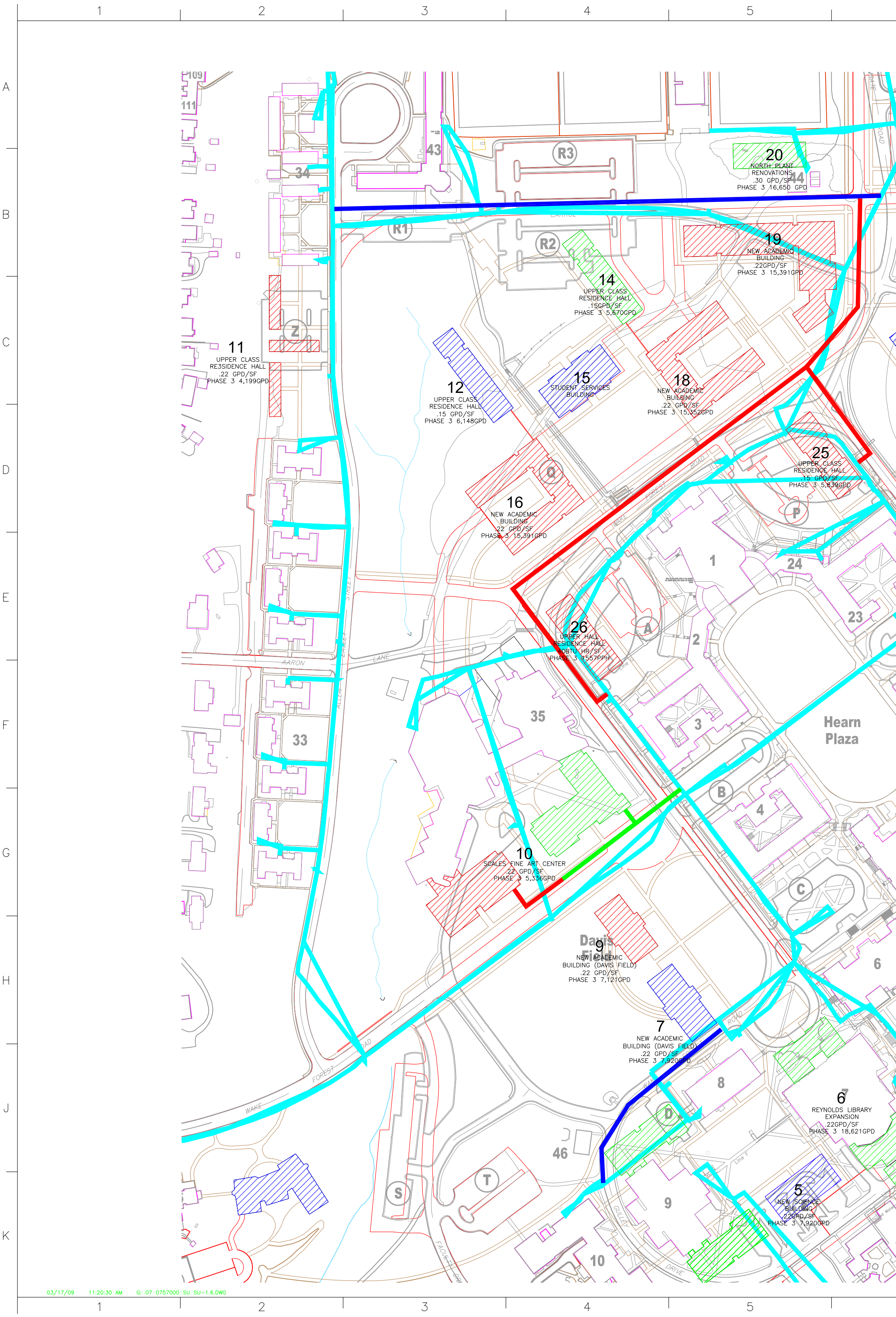

DIST ROUTERS
DIST ROUTERS
Hearn Plaza
Davis
R1
R2
R3
34
43
44
33
35
24
23
46
10

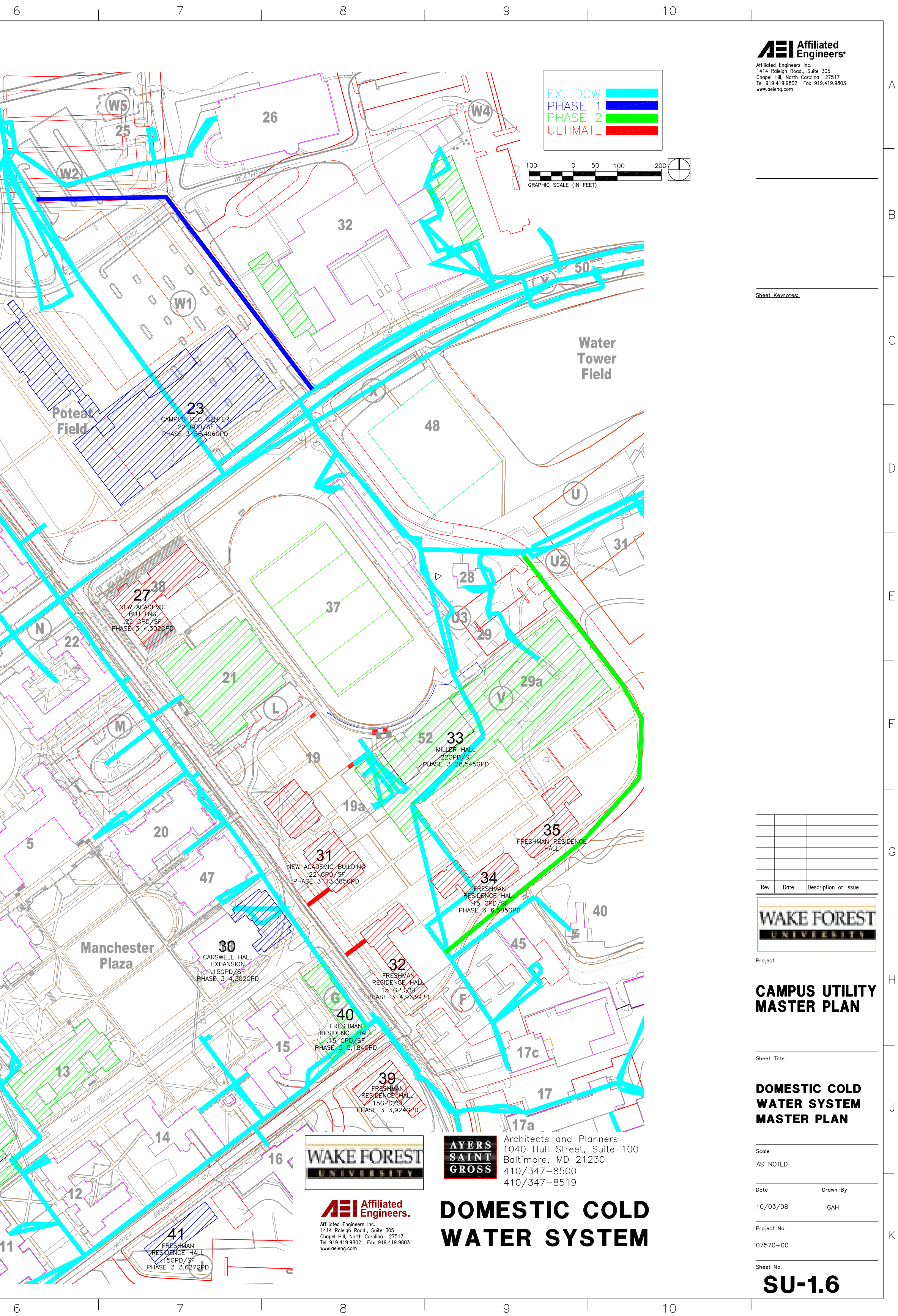

DIST ROUTERS
ST ROUTERS
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
Affiliated Engineers
Affiliated Engineers Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
Sheet Keynotes:
Rev
Date
Description of Issue
WAKE FOREST UNIVERSITY
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
TELECOM MASTER PLAN
Scale
AS NOTED
Date
10/03/08
Drawn By
TWM
Project No.
07570-00
Sheet No.
SU-1.4
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
PROPOSED NEW DISTRIBUTION ROUTER LOCATIONS

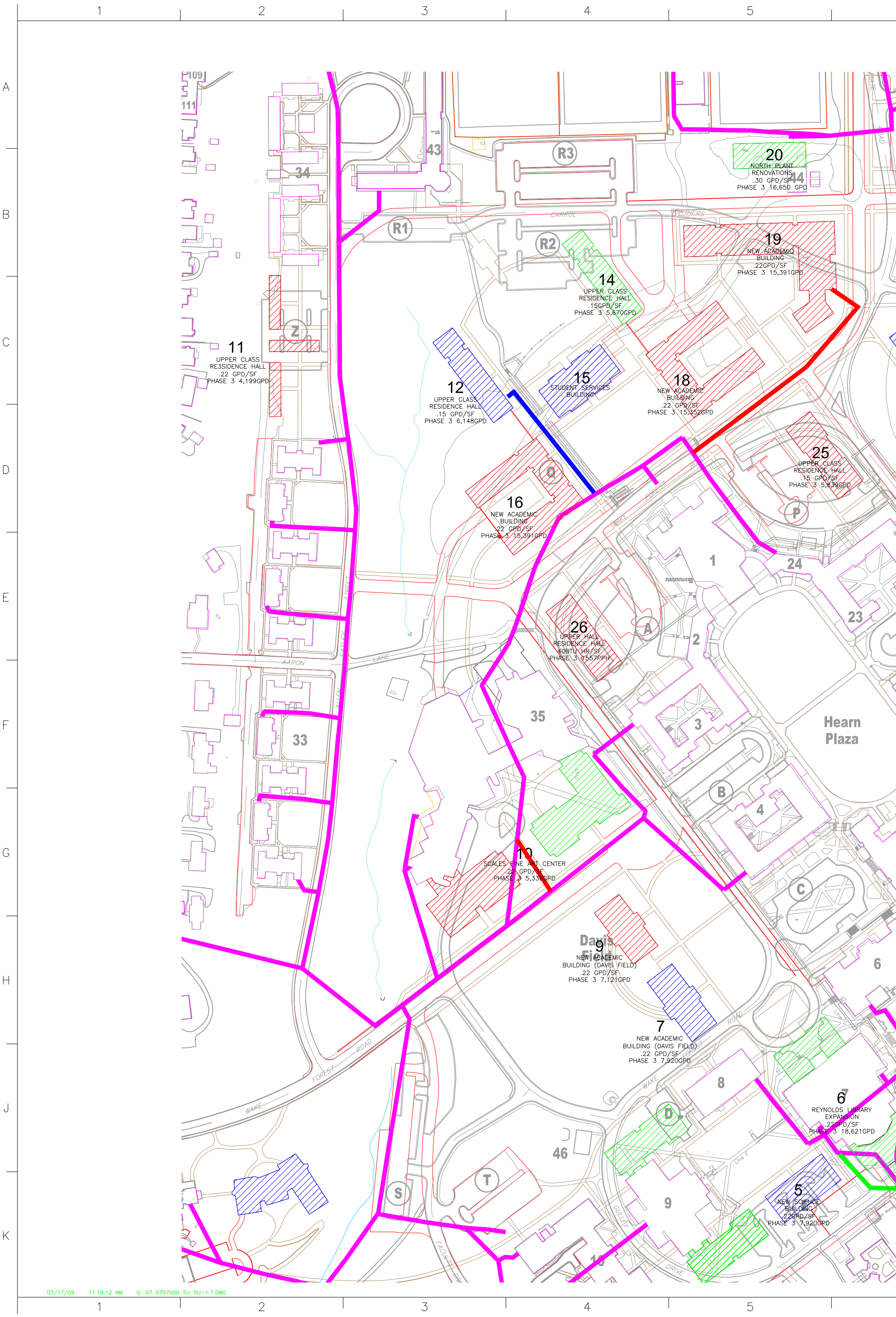

1
2
3
4
5
A
B
C
D
E
F
G
H
J
K
R3
R1
R2
43
44
34
Z
Q
P
24
1
23
A
2
35
33
3
Hearn
Plaza
B
4
C
Davis
Field
6
8
D
46
T
S
9
E
10
03/17/09 11:02:57 AM G:\07\0757000\SU\SU-1.5.DWG



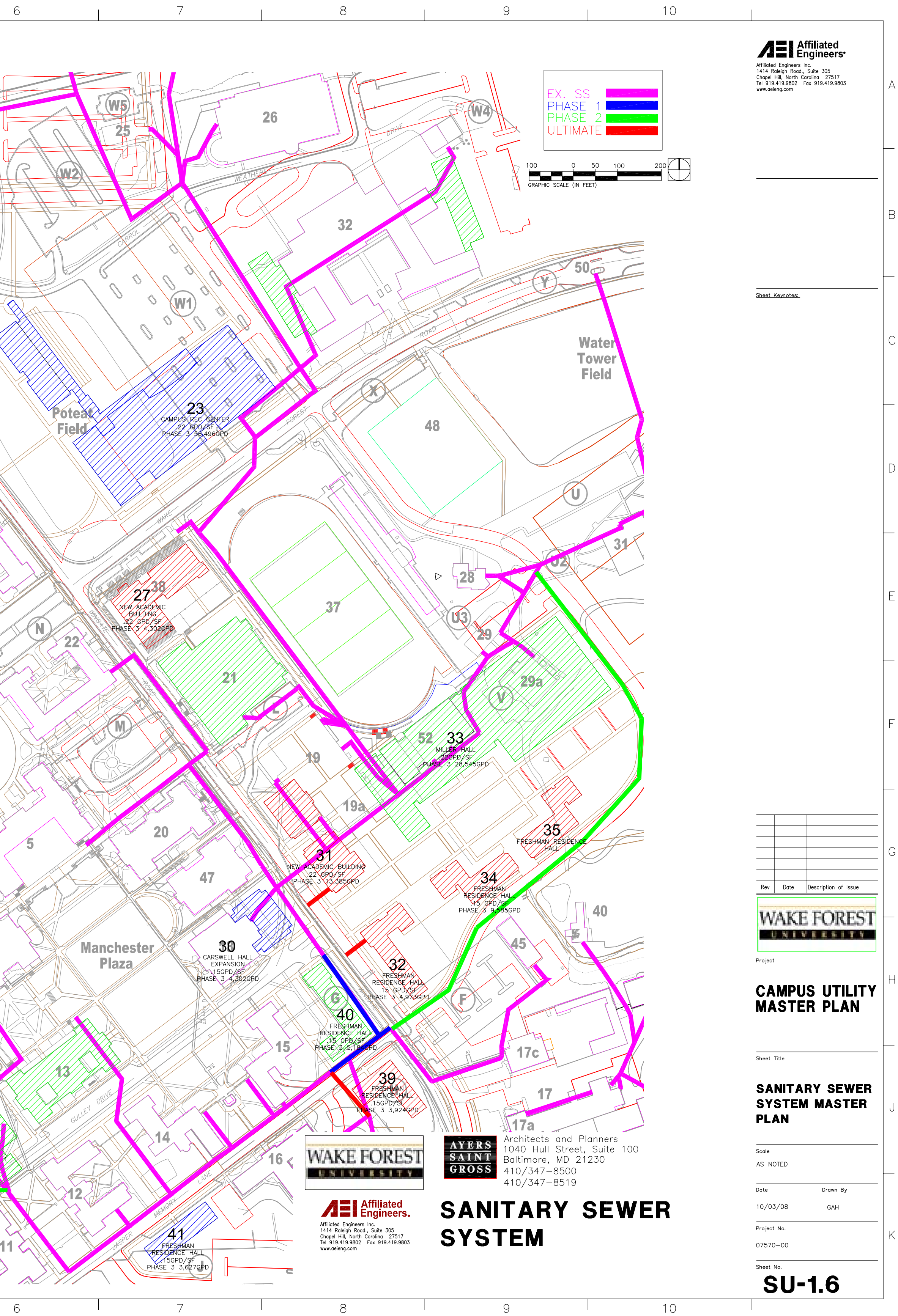
Affiliated Engineers
Affiliated Engineers Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Sheet Keynotes:
Water Tower Field
Poteat Field
Manchester Plaza
Rev
Date
Description of Issue
WAKE FOREST UNIVERSITY
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
TELECOM MASTER PLAN
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
POTENTIAL CONFLICTS WITH NEW CONSTRUICTION AND TELECOM INFRASTRUCUTRE
Scale
AS NOTED
Date
10/03/08
Drawn By
BAH
Project No.
07570-00
Sheet No.
SU-1.5


20
NORTH PLANT
RENOVATIONS
.30 GPD/SF
PHASE 3 16,650 GPD
19
NEW ACADEMIC
BUILDING
.22GPD/SF
PHASE 3 15,391GPD
14
UPPER CLASS
RESIDENCE HALL
.15GPD/SF
PHASE 3 5,670GPD
11
UPPER CLASS
RESIDENCE HALL
.22 GPD/SF
PHASE 3 4,199GPD
12
UPPER CLASS
RESIDENCE HALL
.15 GPD/SF
PHASE 3 6,148GPD
15
STUDENT SERVICES
BUILDING
18
NEW ACADEMIC
BUILDING
.22 GPD/SF
PHASE 3 15,352GPD
25
UPPER CLASS
RESIDENCE HALL
.15 GPD/SF
PHASE 3 5,839GPD
16
NEW ACADEMIC
BUILDING
.22 GPD/SF
PHASE 3 15,391GPD
26
10
SCALES FINE ART CENTER
.22 GPD/SF
PHASE 3 5,336GPD
9
NEW ACADEMIC
BUILDING (DAVIS FIELD)
.22 GPD/SF
PHASE 3 7,121GPD
7
NEW ACADEMIC
BUILDING (DAVIS FIELD)
.22 GPD/SF
6
REYNOLDS LIBRARY
EXPANSION
.22GPD/SF
PHASE 3 18,621GPD
5
NEW SCIENCE
BUILDING
PHASE 3 7,920GPD
Hearn
Plaza
Davis
Field
AARON
LANE
WAKE
FOREST
ROAD
03/17/09 11:20:30 AM


EX. DCW
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
23 CAMPUS REC CENTER 22 GPD/SF PHASE 3 56,496GPD
27 NEW ACADEMIC BUILDING 22 GPD/SF PHASE 3 4,302GPD
31 NEW ACADEMIC BUILDING 22 GPD/SF PHASE 3 13,385GPD
33 MILLER HALL 22GPD/SF PHASE 3 28,545GPD
35 FRESHMAN RESIDENCE HALL
34 FRESHMAN RESIDENCE HALL 15 GPD/SF PHASE 3 6,585GPD
30 CARSWELL HALL EXPANSION 15GPD/SF PHASE 3 4,302GPD
32 FRESHMAN RESIDENCE HALL 15 GPD/SF PHASE 3 4,973GPD
40 FRESHMAN RESIDENCE HALL 15 GPD/SF PHASE 3 5,184GPD
39 FRESHMAN RESIDENCE HALL 15GPD/SF PHASE 3 3,924GPD
41 FRESHMAN RESIDENCE HALL 15GPD/SF PHASE 3 3,627GPD
WAKE FOREST UNIVERSITY
AYERS SAINT GROSS
Architects and Planners
1040 Hull Street, Suite 100
Baltimore, MD 21230
410/347-8500
410/347-8519
Affiliated Engineers.
Affiliated Engineers Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, North Carolina 27517
Tel 919.419.9802 Fax 919.419.9803
www.aeieng.com
DOMESTIC COLD WATER SYSTEM
Sheet Keynotes:
Rev Date Description of Issue
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
DOMESTIC COLD WATER SYSTEM MASTER PLAN
Scale
AS NOTED
Date 10/03/08
Drawn By GAH
Project No. 07570-00
Sheet No.
SU-1.6



20
NORTH PLANT RENOVATIONS
.30 GPD/SF
PHASE 3 16,650 GPD
19
NEW ACADEMIC BUILDING
.22GPD/SF
PHASE 3 15,391GPD
14
UPPER CLASS RESIDENCE HALL
.15GPD/SF
PHASE 3 5,670GPD
11
UPPER CLASS RESIDENCE HALL
.22 GPD/SF
PHASE 3 4,199GPD
12
UPPER CLASS RESIDENCE HALL
.15 GPD/SF
PHASE 3 6,148GPD
15
STUDENT SERVICES BUILDING
18
NEW ACADEMIC BUILDING
.22 GPD/SF
PHASE 3 15,352GPD
25
UPPER CLASS RESIDENCE HALL
.15 GPD/SF
16
NEW ACADEMIC BUILDING
.22 GPD/SF
PHASE 3 15,391GPD
26
UPPER HALL RESIDENCE HALL
40BTU HR/SF
10
SCALES FINE ART CENTER
9
NEW ACADEMIC BUILDING (DAVIS FIELD)
.22 GPD/SF
PHASE 3 7,121GPD
7
NEW ACADEMIC BUILDING (DAVIS FIELD)
.22 GPD/SF
PHASE 3 7,920GPD
6
REYNOLDS LIBRARY EXPANSION
PHASE 3 18,621GPD
5
NEW SCIENCE BUILDING
PHASE 3 7,920GPD
Hearn Plaza
Davis Field
AARON
LANE
CARROL
FOREST
ROAD
WAKE
03/17/09 11:18:12 AM



EX. SS
PHASE 1
PHASE 2
ULTIMATE
GRAPHIC SCALE (IN FEET)
Water Tower Field
Poteat Field
Manchester Plaza
23 CAMPUS REC CENTER 22 GPD/SF PHASE 3 50,496GPD
27 NEW ACADEMIC BUILDING 22 GPD/SF PHASE 3 4,302GPD
33 MILLER HALL 225GPD/SF PHASE 3 28,545GPD
35 FRESHMAN RESIDENCE HALL
34 FRESHMAN RESIDENCE HALL 15 GPD/SF PHASE 3 9,585GPD
31 NEW ACADEMIC BUILDING 22 GPD/SF PHASE 3 13,385GPD
30 CARSWELL HALL EXPANSION 15GPD/SF PHASE 3 4,302GPD
32 FRESHMAN RESIDENCE HALL 15 GPD/SF PHASE 3 4,973GPD
39 FRESHMAN RESIDENCE HALL 15GPD/SF PHASE 3 3,924GPD
41 FRESHMAN RESIDENCE HALL 15GPD/SF PHASE 3 3,627GPD
Affiliated Engineers
Affiliated Engineers Inc. 1414 Raleigh Road, Suite 305 Chapel Hill, North Carolina 27517 Tel 919.419.9802 Fax 919.419.9803 www.aeieng.com
Sheet Keynotes:
Rev Date Description of Issue
WAKE FOREST UNIVERSITY
Project
CAMPUS UTILITY MASTER PLAN
Sheet Title
SANITARY SEWER SYSTEM MASTER PLAN
Scale AS NOTED
Date 10/03/08
Drawn By GAH
Project No. 07570-00
Sheet No. SU-1.6
AYERS SAINT GROSS
Architects and Planners 1040 Hull Street, Suite 100 Baltimore, MD 21230 410/347-8500 410/347-8519
SANITARY SEWER SYSTEM

Table A-1: Existing Building Load Analysis

Bldg Number	Bldg Name	GSF	Building Type	Estimated BTU/HR-SF	Estimated SF/Ton	Estimated GPD/SF	Existing
1	Wait Chapel/Wingate Hall	78,299	Academic	40	325	0.22	3,132
2	Efird Hall	14,270	Housing	40	350	0.15	571
3	Taylor Dorm/Bookstore	63,855	Housing	40	350	0.15	2,554
4	Davis Dorm	64,191	Housing	40	350	0.15	2,568
5	Reynolda Hall	137,637	Academic	40	325	0.22	5,505
6	Benson Center	100,000	Student Life	45	300	0.22	4,500
7	Reynolds Library	187,700	Academic	40	325	0.22	7,508
8	Olin Physics	31,375	Laboratory	55	300	0.25	1,726
9	Salem Hall	51,242	Academic	40	325	0.22	2,050
10	Winston Hall	85,084	Academic	40	325	0.22	3,403
11	Luter Dorm	70,799	Housing	40	350	0.15	2,832
12	Babcock Dorm	55,436	Housing	40	350	0.15	2,217
13	Tribble Hall	80,196	Academic	40	325	0.22	3,208
14	Johnson Dorm	42,332	Housing	40	350	0.15	1,693
15	Bostwick Dorm	42,332	Housing	40	350	0.15	1,693
16	Collins Dorm	51,192	Housing	40	350	0.15	2,048
17A	University Police	**15,000**	Miscellaneous	40	400	0.30	0
17B	University Photographer	**15,000**	Miscellaneous	40	400	0.30	0
17C	Central Heating Plant	15,466	Miscellaneous	40	400	0.30	619
18	Carswell Hall	61,233	Academic	40	325	0.22	2,449
19	Athletic Center	57,948	Athletics	45	375	0.25	0
20	Calloway Hall & Addition	89,000	Academic	40	325	0.22	3,560
21	Reynolds Gymnasium	158,299	Athletics	45	375	0.25	7,123
22	Kitchin Dorm/Deacon Shop	60,911	Housing	40	350	0.15	2,436
23	Poteat Hall	56,328	Housing	40	350	0.15	2,253
24	Huffman Hall	14,270	Housing	40	350	0.15	571
25	Martin Res. Hall/Townhouse Apartments	28,700	Housing	40	350	0.15	0
26	Information Systems	38,200	Academic	40	325	0.22	0
27	Residential Community	**30,000**	Housing	40	350	0.15	0
28	WFDD Radio Station	**15,000**	Auxiliary	0	0	0.00	0
29	Museum of Anthropology	**30,000**	Academic	40	325	0.22	0
30	Piccolo Residence Hall	**15,000**	Housing	40	350	0.15	0
31	Palmer Residence Hall	**15,000**	Housing	40	350	0.15	0
32	Worrell Professional Center	178,100	Student Life	45	300	0.22	0
33	Faculty Appartments	**30,000**	Housing	40	350	0.15	0
34	Student Appartments	28,600	Housing	40	350	0.15	0
35	Scales Fine Arts Center	135,556	Academic	40	325	0.22	5,422
36	Starling Hall/Welcome Center	**15,000**	Student Life	45	300	0.22	0
37	Kenter Stadium	**30,000**	Athletics	45	375	0.25	0
38	Leighton Tennis Stadium	**15,000**	Athletics	45	375	0.25	0
39	Hooks Baseball Stadium	**15,000**	Athletics	45	375	0.25	0
40	Haddock Golf Center	**15,000**	Athletics	45	375	0.25	0
41	North Residence Hall	**15,000**	Housing	40	350	0.15	0
42	Spry Soccer Stadium	**15,000**	Athletics	45	375	0.25	0
43	Polo Residence Hall	45,000	Housing	40	350	0.15	0
44	North Chiller Plant	11,000	Miscellaneous	40	400	0.30	0
45	South Chiller Plant	8,000	Miscellaneous	40	400	0.30	0
46	West Chiller Plant	6,000	Miscellaneous	40	400	0.30	0
47	Greene Hall	80,000	Academic	40	325	0.22	3,200
49	Polo Road Gate	**250**	Miscellaneous	40	400	0.30	0
50	University Parkway Gatehouse	**250**	Miscellaneous	40	400	0.30	0
51	Reynolda Road Gatehouse	**250**	Miscellaneous	40	400	0.30	0
52	Miller Center	65,000	Student Life	45	300	0.22	2,925
-	UCC Campus	-	-	-	-	-	-
						Existing Load TotalsTotals	77,767
						Ex. Loads Diversified Total	58,325

Heating (PPH)			Cooling (Tons)				Domestic Water/Sewer (GPD)			
Phase 1	Phase 2	Phase 3	Existing	Phase 1	Phase 2	Phase 3	Existing	Phase 1	Phase 2	Phase 3
3,132	3,132	3,132	241	241	241	241	17,226	17,226	17,226	17,226
571	571	571	41	41	41	41	2,141	2,141	2,141	2,141
2,554	2,554	2,554	182	182	182	182	9,578	9,578	9,578	9,578
2,568	2,568	2,568	183	183	183	183	9,629	9,629	9,629	9,629
5,505	5,505	5,505	423	423	423	423	30,280	30,280	30,280	30,280
4,500	4,500	4,500	333	333	333	333	22,000	22,000	22,000	22,000
7,508	7,508	7,508	578	578	578	578	41,294	41,294	41,294	41,294
1,726	1,726	1,726	105	105	105	105	7,844	7,844	7,844	7,844
2,050	2,050	2,050	158	158	158	158	11,273	11,273	11,273	11,273
3,403	3,403	3,403	262	262	262	262	18,718	18,718	18,718	18,718
2,832	2,832	2,832	202	202	202	202	10,620	10,620	10,620	10,620
2,217	2,217	2,217	158	158	158	158	8,315	8,315	8,315	8,315
3,208	3,208	3,208	247	247	247	247	17,643	17,643	17,643	17,643
1,693	1,693	1,693	121	121	121	121	6,350	6,350	6,350	6,350
1,693	1,693	1,693	121	121	121	121	6,350	6,350	6,350	6,350
2,048	2,048	2,048	146	146	146	146	7,679	7,679	7,679	7,679
0	0	0	0	0	0	0	4,500	4,500	4,500	4,500
0	0	0	0	0	0	0	4,500	4,500	4,500	4,500
619	619	619	39	39	39	39	4,640	4,640	4,640	4,640
2,449	2,449	2,449	188	188	188	188	13,471	13,471	13,471	13,471
0	0	0	155	155	0	0	14,487	14,487	0	0
3,560	3,560	3,560	274	274	274	274	19,580	19,580	19,580	19,580
7,123	7,123	7,123	422	422	422	422	39,575	39,575	39,575	39,575
2,436	2,436	2,436	174	174	174	174	9,137	9,137	9,137	9,137
2,253	2,253	2,253	161	161	161	161	8,449	8,449	8,449	8,449
571	571	571	41	41	41	41	2,141	2,141	2,141	2,141
0	0	0	82	82	82	82	4,305	4,305	4,305	4,305
0	1,528	1,528	118	118	118	118	8,404	8,404	8,404	8,404
0	0	0	0	0	0	0	4,500	4,500	4,500	4,500
0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	6,600	6,600	0	0
0	0	0	0	0	0	0	2,250	2,250	0	0
0	0	0	0	0	0	0	2,250	2,250	0	0
0	8,015	8,015	594	594	594	594	39,182	39,182	39,182	39,182
0	0	1,200	0	0	0	0	4,500	4,500	4,500	4,500
0	0	1,144	82	82	82	82	4,290	4,290	4,290	4,290
5,422	5,422	5,422	417	417	417	417	29,822	29,822	29,822	29,822
0	0	0	0	0	0	0	3,300	3,300	3,300	3,300
0	0	0	0	0	0	0	7,500	7,500	7,500	7,500
0	0	0	0	0	0	0	3,750	3,750	0	0
0	0	0	0	0	0	0	3,750	3,750	3,750	3,750
0	0	0	0	0	0	0	3,750	3,750	3,750	3,750
0	0	0	0	0	0	0	2,250	2,250	2,250	2,250
0	0	0	0	0	0	0	3,750	3,750	3,750	3,750
0	0	0	129	129	129	129	6,750	6,750	6,750	6,750
0	0	0	28	28	28	28	3,300	3,300	3,300	3,300
0	0	0	20	20	20	20	2,400	2,400	2,400	2,400
0	0	0	15	15	15	15	1,800	1,800	1,800	1,800
3,200	3,200	3,200	246	246	246	246	17,600	17,600	17,600	17,600
0	0	0	0	0	0	0	75	75	75	75
0	0	0	0	0	0	0	75	75	75	75
0	0	0	0	0	0	0	75	75	75	75
2,925	2,925	2,925	217	217	217	217	14,300	14,300	14,300	14,300
-	-	-	-	-	-	-	-	-	-	-
77,767	87,310	89,654	6,901	6,901	6,746	6,746	527,947	527,947	498,610	498,610
58,325	65,482	67,240	5,176	5,176	5,060	5,060	448,755	448,755	423,819	423,819

Table A-2: New Building Load Analysis

Project Number	Bldg Name	GSF	Building Type	Estimated BTU/HR-SF	Estimated SF/Ton	Estimated GPD/SF	Existing
2	Admissions Building	46,800	Admissions	40	325	0.22	0
4	Salem Hall Expansion	50,140	Academic	40	325	0.22	0
5	New Science Building	36,000	Academic	40	325	0.22	0
6	Reynolds Library Expansion	84,640	Academic	40	325	0.22	0
7	New Academic Building (Davis Field)	36,300	Academic	40	325	0.22	0
9	New Academic Building (Davis Field)	32,370	Academic	40	325	0.22	0
10	Scales Fine Arts Center (Expansion)	24,254	Academic	40	325	0.22	0
11	Upper Class Residence Hall	27,990	Housing	40	350	0.15	0
12	Upper Class Residence Hall	81,975	Housing	40	350	0.15	0
14	Upper Class Residence Hall	37,800	Housing	40	350	0.15	0
15	Student Services Building	0	Housing	40	350	0.15	0
16	New Academic Building	69,960	Academic	40	325	0.22	0
18	New Academic Building	69,780	Academic	40	325	0.22	0
19	New Academic Building	105,630	Academic	40	325	0.22	0
20	North Plant Renovation	33,000	Miscellaneous	40	400	0.30	0
21	Worrell Professional Center	54,660	Academic	40	325	0.22	0
23	Campus Rec Center	256,800	Rec Center	45	350	0.22	0
25	Upper Class Residence Hall	38,925	Housing	40	350	0.15	0
26	Upper Class Residence Hall	38,925	Housing	40	350	0.15	0
27	New Academic Building	62,211	Academic	40	325	0.22	0
30	Carswell Hall Expansion	28,680	Housing	40	350	0.15	0
31	New Academic Building	60,840	Academic	40	325	0.22	0
32	Freshmen Residence Hall	33,150	Housing	40	350	0.15	0
33	Indoor Practice Facility	129,750	Rec Center	45	350	0.22	0
34	Freshmen Residence Hall	63,900	Housing	40	350	0.15	0
35	Freshmen Residence Hall	0	Housing	40	350	0.15	0
38	Golf Practice Facility	14,600	Rec Center	45	350	0.22	0
39	Freshman Residence Hall	26,160	Housing	40	350	0.15	0
40	Freshman Residence Hall	34,560	Housing	40	350	0.15	0
41	Freshman Residence Hall	24,180	Housing	40	350	0.15	0
						New Load Subtotal	0
						New Load Diversified Total	0
						Totals	77,767
						Diversified Total	58,325

Heating (PPH)			Cooling (Tons)				Domestic Water/Sewer (GPD)			
Phase 1	Phase 2	Phase 3	Existing	Phase 1	Phase 2	Phase 3	Existing	Phase 1	Phase 2	Phase 3
0	0	0	0	0	0	0	0	10,296	10,296	10,296
0	2,006	2,006	0	0	154	154	0	0	11,031	11,031
1,440	1,440	1,440	0	111	111	111	0	7,920	7,920	7,920
0	3,386	3,386	0	0	260	260	0	0	18,621	18,621
1,452	1,452	1,452	0	112	112	112	0	7,986	7,986	7,986
0	0	1,295	0	0	0	100	0	0	0	7,121
0	970	970	0	0	75	75	0	0	5,336	5,336
0	0	1,120	0	0	0	80	0	0	0	4,199
3,279	3,279	3,279	0	234	234	234	0	12,296	12,296	12,296
0	1,512	1,512	0	0	108	108	0	0	5,670	5,670
0	0	0	0	0	0	0	0	0	0	0
0	0	2,798	0	0	0	215	0	0	0	15,391
0	0	2,791	0	0	0	215	0	0	0	15,352
0	0	4,225	0	0	0	325	0	0	0	23,239
0	1,320	1,320	0	0	83	83	0	0	9,900	9,900
0	2,186	2,186	0	0	168	168	0	0	12,025	12,025
11,556	11,556	11,556	0	734	734	734	0	56,496	56,496	56,496
0	0	1,557	0	0	0	111	0	0	0	5,839
0	0	1,557	0	0	0	111	0	0	0	5,839
0	0	2,488	0	0	0	191	0	0	0	13,686
1,147	1,147	1,147	0	82	82	82	0	4,302	4,302	4,302
0	0	2,434	0	0	0	187	0	0	0	13,385
0	0	1,326	0	0	0	95	0	0	0	4,973
0	5,839	5,839	0	0	371	371	0	0	28,545	28,545
0	0	2,556	0	0	0	183	0	0	0	9,585
0	0	0	0	0	0	0	0	0	0	0
657	657	657	0	42	42	42	0	3,212	3,212	3,212
0	0	1,046	0	0	0	75	0	0	0	3,924
0	1,382	1,382	0	0	99	99	0	0	5,184	5,184
967	967	967	0	69	69	69	0	3,627	3,627	3,627
20,498	39,099	64,293	0	1,383	2,701	4,588	0	106,135	202,447	324,978
15,374	29,324	48,220	0	1,037	2,025	3,441	0	90,215	172,080	276,232
98,266	126,409	153,947	6,901	8,284	9,447	11,334	527,947	634,082	701,057	823,588
73,699	94,807	115,460	5,176	6,213	7,085	8,501	395,960	475,562	525,793	617,691

Acknowledgments

View of Wait Chapel from Taylor Residence Hall

Acknowledgments

During the course of the planning process, the design team traveled to campus eight times. On campus, the project team hosted five campus tours and about forty meetings with more than eighty individuals, including the members of two committees and three work groups. The University hosted six public forums and welcomed more than two hundred participants including students, staff, faculty, neighbors, and alumni. The University is grateful to every person who participated in the process, preserving traditions and outcomes that have long distinguished Wake Forest.

Steering Committee

The Steering Committee served as the principal working group for the Master Planning process.

Matthew S. Cullinan, Vice President for Administration, *Chair*
James E. Alty, Associate Vice President for Facilities and Campus Services
Jermyn M. Davis, Student Body President (2008-2009)
Carolyn E. Harbaugh, Student Trustee (2007-2008)
Lauren K. Hubbard, Student Trustee (2008-2009)
James J. Kuzmanovich, Professor of Mathematics
Robert E. Lamy, Associate Professor, Babcock Graduate School of Management
Whitney A. Marshall, Student Body President (2007-2008)
Mary E. Pugel, Senior Executive Assistant to the President
Kathleen B. Smith, Professor of Political Science
Nancy D. Suttenfield, Senior Vice President and Chief Financial Officer
Jill M. Tiefenthaler, Provost
Ronald D. Wellman, Director of Athletics
Kenneth A. Zick, Vice President for Student Life

Advisory Committee

The Advisory Committee captured the views, input, and feedback of a broad range of campus constituencies.

Matthew S. Cullinan, Vice President for Administration, *Chair*
Martha B. Allman, Director of Admissions
James E. Alty, Associate Vice President, Facilities and Campus Services
Deborah L. Best, Dean of the College (2007-2008)
Jermyn M. Davis, Student Body President (2008-2009)
Kelley L. Gaugler, Student Representative, Capital Planning Committee
Carolyn E. Harbaugh, Student Trustee (2007-2008)
Harold R. Holmes, Associate Vice President and Dean of Student Services
Lauren K. Hubbard, Student Trustee (2008-2009)
Charles H. Kennedy, Professor of Political Science
Michael S. Lawlor, Professor of Economics
Bill J. Leonard, Dean, Divinity School
Stephen T. Maciag, Student Representative, Capital Planning Committee (2007-2008)
Whitney A. Marshall, Student Body President (2007-2008)
Donna P. McGalliard, Director, Residence Life and Housing
Minta A. McNally, Associate Vice President, University Advancement
Ananda Mitra, Associate Professor of Communication
Lorna G. Moore, Dean, Graduate School of Arts and Sciences
Blake D. Morant, Dean, School of Law
Ajay Patel, Dean, Babcock Graduate School of Management (2007-2008)
Allison C. Perkins, Executive Director, Reynolda House
Steven S. Reinemund, Dean of Business (2008-2009)
Paul M. Ribisl, Interim Dean of the College (2008)
Gale Sigal, Professor of English
Lynn S. Sutton, Director, Z. Smith Reynolds Library
Ralph B. Tower, Professor, Calloway School of Business and Accountancy
Robert W. Ulery, Professor of Classical Languages
Mark E. Welker, Associate Provost for Faculty Affairs
Jack E. Wilkerson, Dean, Calloway School of Business and Accountancy (2007-2008)
David A. Wurtzbacher, Student Representative, Capital Planning Committee (2008-2009)

Academic Life Workgroup

Martha B. Allman, Director of Admissions
Deborah L. Best, Dean of the College of Arts and Sciences (2007-2008)
J. Kline Harrison, Associate Provost for International Affairs
Bill J. Leonard, Dean, Divinity School
George E. (Rick) Matthews, Associate Provost for Information Systems
Gordon E. McCray, Senior Associate Dean, Calloway School of Business and Accountancy
Lorna G. Moore, Dean, Graduate School of Arts and Sciences
Blake D. Morant, Dean, School of Law
Ajay Patel, Dean, Babcock Graduate School of Management (2007-2008)
Paul M. Ribisl, Interim Dean of the College of Arts and Sciences (2008)
Cecilia H. Solano, Associate Dean of the Graduate School of Arts and Sciences
Jill M. Tiefenthaler, Provost
Mark E. Welker, Associate Provost for Faculty Affairs
Jack E. Wilkerson, Dean, Calloway School of Business and Accountancy (2007-2008)

Student Life Work Group

Timothy L. Auman, Chaplain
Sylvia T. Bell, Associate Director, University Student Health Services
James R. Buckley, Director, Benson University Center
William C. Currin, Director, Career Services
J. Maxwell Floyd, Director, Campus Recreation
Mary T. Gerardy, Associate Vice President, Student Life
J. Kline Harrison, Associate Provost for International Affairs
Stephen R. Hirst, Director, Greek Life
Harold R. Holmes, Associate Vice President and Dean of Student Services
Regina G. Lawson, Chief, University Police
Donna P. McGalliard, Director, Residence Life and Housing
Donald J. (Buz) Moser, Executive Director, Business Services
Cecil D. Price, Director, University Student Health Services
Van D. Westervelt, Director, Learning Assistance Center
Kenneth A. Zick, Vice President, Student Life

Athletics and Recreation Workgroup

Steven D. Adams, Assistant Athletic Director, Internal Operations
George E. (Rick) Matthews, Associate Provost for Information Systems
J. Maxwell Floyd, Director, Campus Recreation
Barbara G. Walker, Senior Associate Athletic Director
Rebecca Ward, Associate Athletic Director, Special Projects
Ronald D. Wellman, Director of Athletics

Project Team

Wake Forest University

James E. Alty, Associate Vice President for Facilities and Campus Services
Connie L. Carson, Assistant Vice President for Campus Services & Planning (2007)
James B. Coffey, Director, Landscape Services
Matthew S. Cullinan, Vice President for Administration
Ryan F. Swanson, University Architect
Marybeth S. Wallace, Special Assistant to the President
Carolyn C. Winebarger, Assistant to the Vice President for Administration

Contact Information:
Facilities and Campus Services
1834 Wake Forest Road
Winston-Salem, NC 27106
T (336) 758-5679
F (336) 758-6060
http://wfu.edu/masterplan

Master Planning

Ayers Saint Gross
1040 Hull Street, Suite 100
Baltimore, MD 21230
T (410) 347-8500
F (410) 347-8519

Transportation Planning

Martin/Alexiou/Bryson, PLLC
4000 WestChase Boulevard, Suite 530
Raleigh, NC 27607
T (919) 829-0328
F (919) 829-0329

Ecological Assessment

Biohabitats
The Stables Building
2081 Clipper Park Road
Baltimore, MD 21211
T (410) 554-0156
F (410) 554-0168

Utilities Infrastructure

Affiliated Engineers, Inc.
1414 Raleigh Road, Suite 305
Chapel Hill, NC 27517
T (919) 419-9802
F (919) 419-9803

WAKE FOREST UNIVERSITY

1834 Wake Forest Road
Winston-Salem, NC 27106
P: 336-758-4623

AYERS SAINT GROSS

1040 Hull Street, Suite 100
Baltimore, MD 21230
P: 410.347.8500

Just for placement.
Printer will add actual logo.