WATER EFFICIENCY MEASURES AT EMORY UNIVERSITY

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INTRODUCTION

Higher education institutions are implementing environmentally friendly practices as never before. According to a 2009 survey undertaken by the Sustainable Endowments Institute, a nonprofit organization based in Cambridge, Massachusetts, more than 300 colleges and universities have become greener over the past few years despite tighter budgets and widely fluctuating energy costs. Three-quarters of these schools have adopted green building policies and about 44 percent have at least one LEED-certified building or are in the process of constructing one.

Emory University in suburban Druid Hills outside Atlanta, Georgia, is one of the more forward-looking of these institutions. In 2005, university president James Wagner began the greening of the 600-acre campus by forming a committee to develop an environmental agenda for guiding the institution's future. The following year, Emory opened an Office of Sustainability Initiatives to implement this policy.

The university's long-term goals include reducing campus energy use by 25 percent per square foot and food, materials, and electronic wastes by 65 percent per square foot—all by 2015. Already, the installation of water-saving fixtures and irrigation in accordance with drought restrictions helped to reduce water consumption by 12 percent between 2007 and 2009.

As part of its eco-friendly policy, Emory now requires all new structures on campus to earn a LEED silver rating from the U.S. Green Building Council. So far, the university has achieved LEED certification of 13 buildings on campus—5 gold, 5 silver, and 3 certified, including classroom, administrative, research, and healthcare facilities. In addition, six completed or nearly completed buildings are awaiting LEED certification.

Ayers Saint Gross Architects and Planners of Baltimore helped to boost the sustainability at Emory, beginning in 1998 with a master plan for the campus. The firm updated this strategy in 2005 just as the university began studying ways of becoming greener. Responding to this mandate, the plan called for native plantings and recycling receptacles on campus, and rerouting vehicular traffic away from the university core, among other environmentally sensitive measures.

Ayers Saint Gross has gone on to complete four, eco-friendly buildings at Emory. Each design conveys a distinctive architectural identity through varied types of metal panels and fenestration patterns. At the same time, the buildings' red-tiled roofs and exteriors of stucco and stone harmonize with the historic architecture originally designed by Beaux-Arts architect Henry Hornbostel at the heart of the campus.

These new structures include a mixed-use building housing the university's admissions office, a bookstore, and a café. A green roof is positioned over the parking garage connected to this building. Rainwater is collected in tanks below grade for irrigating the site.

More sophisticated are the rainwater harvesting and graywater recycling systems devised by Ayers Saint Gross for two of three freshman residence halls designed by the firm. These green measures are particularly well suited to residence halls as they capitalize on constant water usage in the buildings through toilets, sinks, showers, and laundry facilities. At the same time, they educate the students as to the merits of sustainable design by making visible the process of collecting and recycling water from inside and outside the residence halls.

KEYWORDS

rainwater harvesting, graywater, stormwater management, sustainability, student housing, residence hall design

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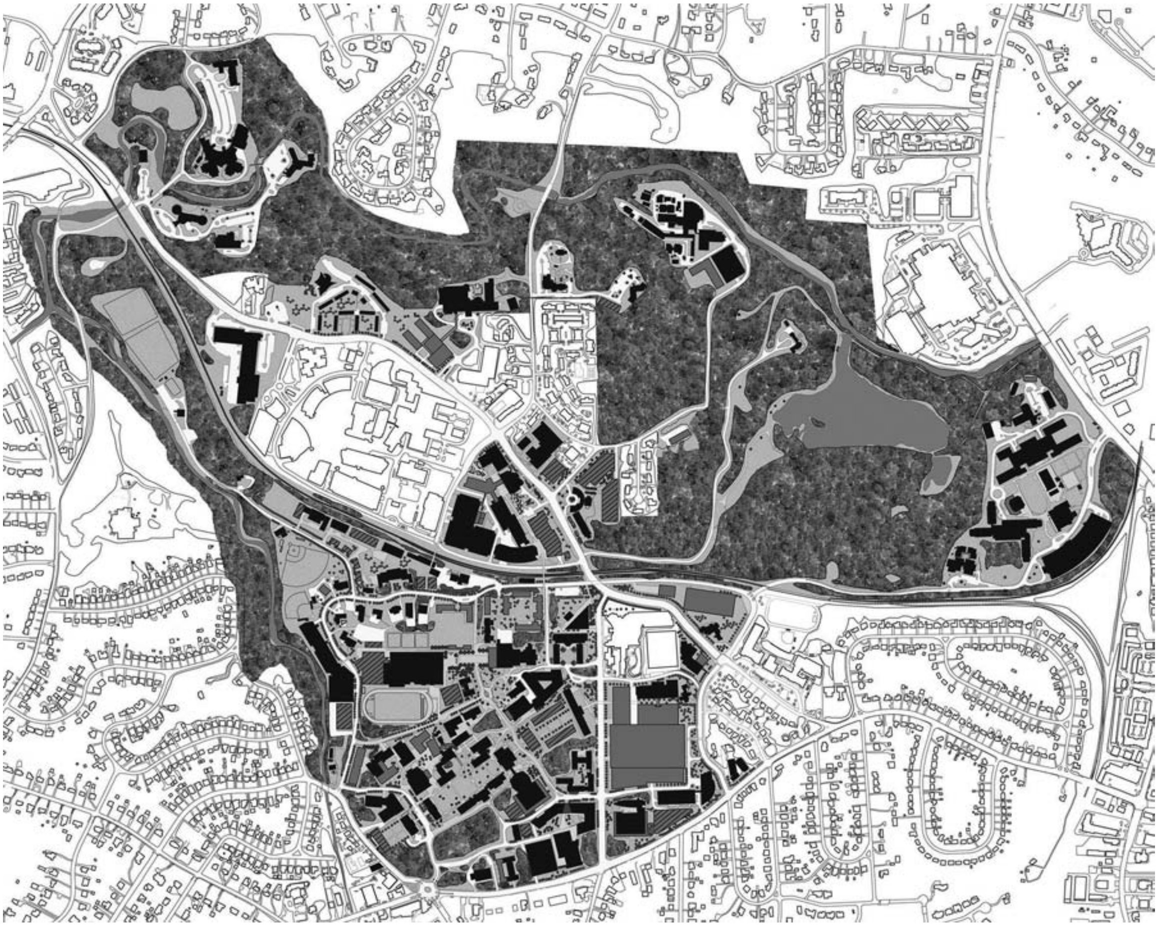
FIGURE 1. Emory University Campus Plan (credit Ayers/Saint/Gross).



FROM MASTER PLAN TO GREEN BUILDINGS

A portion of the 2005 master plan envisioned by Ayers Saint Gross called for building a cluster of freshman residence halls to replace the outdated, mid-20th-century dormitories scattered around the campus. The new buildings are grouped near the Dobbs University Center, a student union in the heart of the campus. The goal of this eight-building precinct, scheduled to be completed over the next decade, is to consolidate all the freshman halls in one place while enriching the First Year Experience program at Emory through a shared sense of community and purpose.

At the same time, the clustered buildings introduce a high level of sustainable design to the campus. The first of these green structures, Turman Hall, opened in 2007 on a former parking lot north of the DUC student center. This five-story building set a precedent for the university by introducing sustainable design features to a campus residence hall for the first time, including dual-flush toilets and an energy display monitor.

The dual-flush toilets, low-flow shower heads, and sinks with automatic shut-off valves allow the 44,000-square-foot structure to consume 30 percent less water than a typical building of comparable size. Floors covered in bamboo, a renewable plant,

FIGURE 2. Emory Freshman Housing Master Plan (credit Ayers/Saint/Gross).

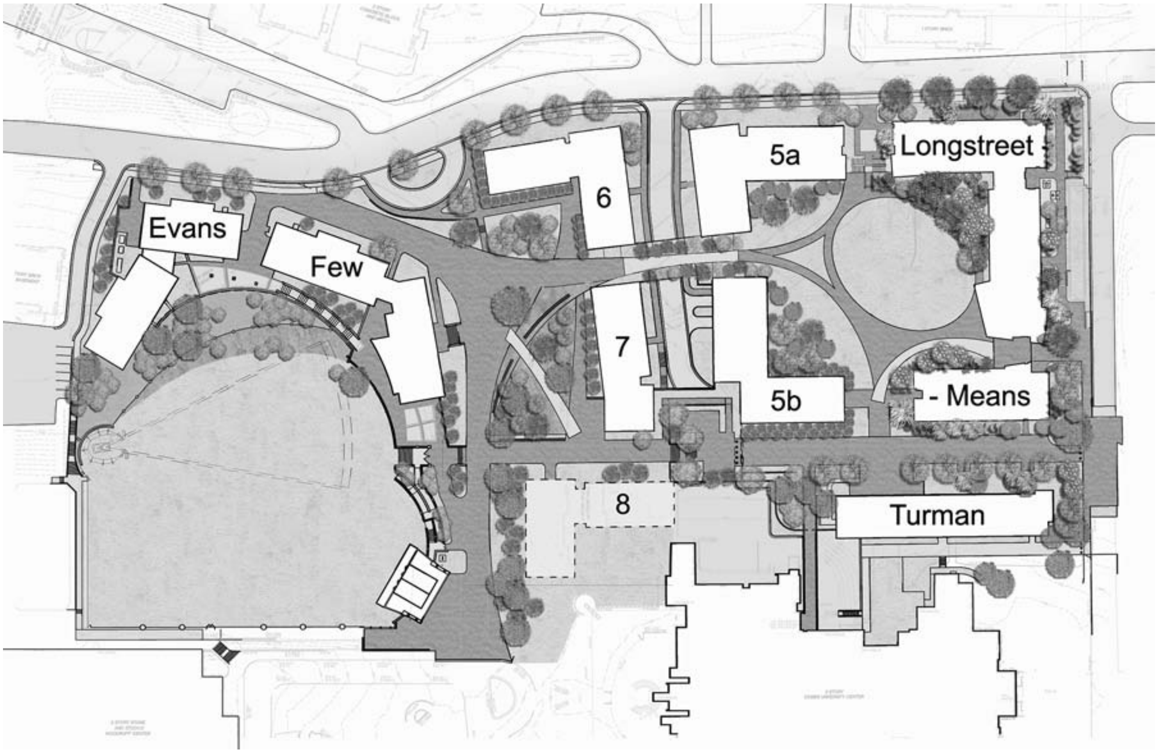


FIGURE 3. Turman Hall (credit W. Scott Chester Photography).

FIGURE 4. Energy Display Monitor (credit Emory Photography).

FIGURE 5. Few Hall (credit W. Scott Chester Photography).

and terrazzo made with recycled glass save material resources. Energy Star-rated appliances, individually controlled thermostats, and monitoring of energy consumption reduce utility costs. Large windows in the 130-bed residence hall's double and single rooms, two staff apartments, and common spaces provide abundant daylight to decrease the need for artificial lighting.

During construction, 78 percent of debris—the equivalent of 732 tons—was recycled to save even more energy and resources. This waste included 29 tons of metal, 65 tons of wood, 72 tons of gypsum board, and 566 tons of concrete sent to a recycling facility instead of a landfill.

Freshmen living in Turman are encouraged to monitor and participate in the building's eco-friendly systems through screens in the lobby displaying the energy consumption of the building. Students strive for the lowest usage levels as part of a friendly competition among residents on different floors. This interaction helps conserve energy as well as to raise student awareness of the broader sustainable strategies now being implemented on campus.

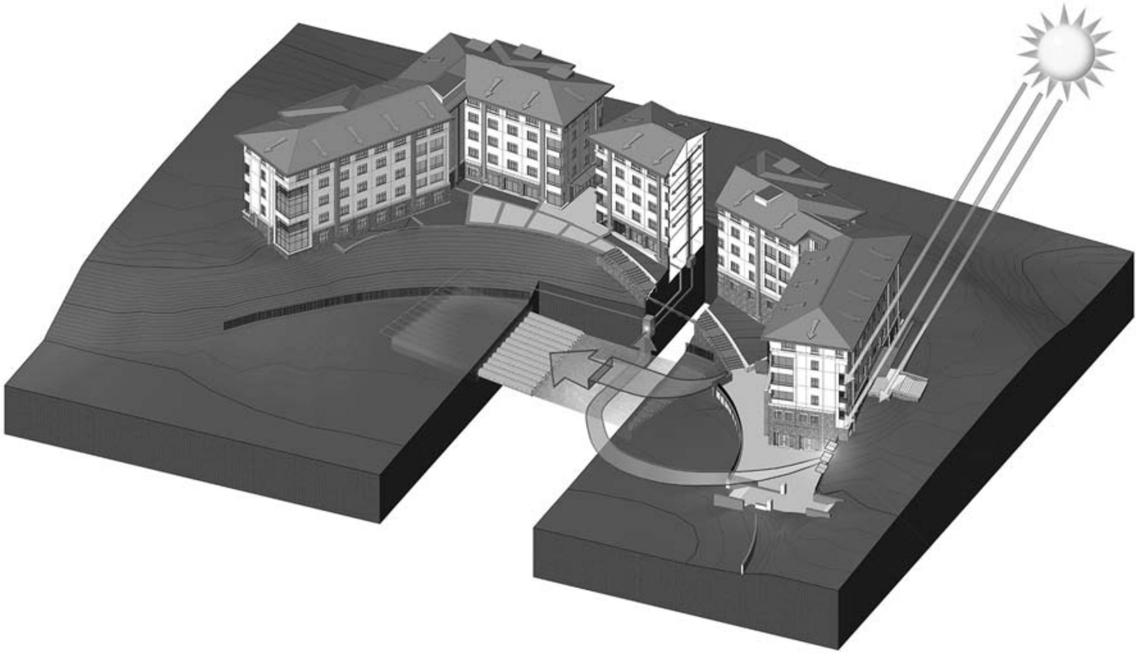
RAINWATER HARVESTING INTRODUCED AT RESIDENCE HALL

From Turman, Ayers Saint Gross moved on to design Ignatius Few Hall and Lettie Pate Whitehead Evans Hall, two freshman residences housing 293 beds. Few and Evans are located to the west of Turman at the top of a hill overlooking McDonough Field, which is used for recreational sports and special events. In addition to designing the 111,000-square-foot buildings, the architects replaced the existing McDonough Field Stage at the southeast corner of the athletic grounds. The new steel performance structure is fitted with granite piers, a metal roof, and rigging for lighting.

Designs for the Few and Evans residence halls were developed from 2006 to 2007 when a severe drought had overtaken Georgia and the Southeast. These conditions led the architects and university staff to consider reclaiming rainwater and condensation from air-conditioning equipment as part of a water conservation strategy for the buildings.

Rainwater harvesting, practiced since ancient times, is now enjoying a revival. States such as Arizona, California, New Mexico, and Texas offer tax incentives and environmentally friendly building

FIGURE 6. Few and Evans Halls Rainwater Harvesting Diagram (credit Ayers/Saint/Gross).



codes to encourage the collection of rainwater for irrigation and non-potable applications, especially in arid climates.

To determine the best way of implementing this green technology at Emory, the architects, engineers, and university staff held a sustainability workshop in 2006 at the beginning of the design process. During their discussions, participants set a goal of achieving a LEED gold rating for the combined residence halls through measures such as a storm water management program, Energy Star-equipped rooms and reliance on daylighting. These green features were seen as a potential educational tool for students and faculty in teaching lessons about environmental stewardship. Subsequent meetings with DeKalb County officials helped the team determine ways of implementing a rainwater harvesting system as well as potential strategies for recycling graywater in future buildings.

At Emory, the sloping site for Few and Evans halls offered a natural advantage for funneling rainwater and condensation waste into an underground cistern between the two buildings. Rain

FIGURE 7. Downspouts spill to brick runnels in the landscape (credit Ayers/Saint/Gross).

lands on the buildings' pitched, clay-tiled roofs, runs into sheet-metal gutters and collects in sheet-metal downspouts. At grade, the water spills into a series of brick and concrete runnels rather than conventional, below-grade piping, which would conduct the water directly to the municipal stormwater system. The runnels are incorporated into the landscape design so that the collected rainwater remains visible as it moves through the site. They converge on a stepped concrete channel running adjacent to a curved staircase stepping down the slope of the site. For the freshmen living in Few and Evans, which have been occupied since 2008, the noticeable collection system makes manifest the residence halls' theme of "Living Green: Sustainability in the 21st Century."

From the drainage system, the water spills over a stone weir to a bioswale at the bottom of the hill. This teardrop-shaped swale buffers the building site from the adjacent athletic field while allowing rainwater to percolate through the ground to storage tanks. The top layer of the swale is designed as a wetland of plants growing in four feet of specially blended topsoil. Under this garden is a layer of filter fabric placed over a minimum six-inch-depth of gravel, allowing the water to drain from the surface while keeping the topsoil in place. Below the gravel, a row of half-cylindrical plastic chambers (162 Stormtech SC-740 chambers) supply a storage capacity of 89,000 gallons—enough to provide 2,168 gallons of water per day—needed to flush all toilets in the buildings and accommodate run-off from severe storms.

Within this capacity, 16,000 gallons are used to meet the toilet flushing demand. This size was determined through a water-savings analysis performed by Nitsch Engineering of Boston, Massachusetts. The firm's model took into account historical rainfall data for the Atlanta region, expected demand from the dual-flush toilets in the paired residence halls, and 300,000 gallons of condensation collected annually from the air-conditioning equipment. Because most of the condensate water is collected during the summer months (May through September) when the rainfall is the lowest, the size of the cistern could be determined according to the amount of rainfall during the winter months (October through April) when rainfall levels are higher. However, no harvested rainwater system can be deemed 100 percent reliable in meeting a given demand unless it is super-sized. So Nitsch Engineering undertook a cost-benefit analysis to determine that the 16,000 gallons from the cistern would meet the average annual demand for toilet flushing during 89 percent of the year. This size struck a good balance between reliable capacity and construction costs, while estimating Emory would save 704,000 gallons of potable water per year.

FIGURE 8. Stone weir conducts stormwater into the bioswale (credit Ayers/Saint/Gross).

FIGURE 9. Stormtech chambers being placed below the swale during construction (credit Emory Photography).

FIGURE 10. Cistern Size/Water Savings Analysis (credit Nitsch Engineering).

Parameters
Tank = 16,000 gal
2006 Water Rate = $4.14 per 1,000 gal
Summer supply = rainfall + condensate average (2055 gpd)
Winter supply = rainfall only

PREVIOUS MODEL RUN - Assumes dual flush toilets; (2,168 gallons per day)

Regional Analysis - Buildings 2-3	Summer (May-Sept)				Winter (Oct-Apr)				Year Round			
Water Reuse Program	Demand (gpd)	Tank Reliability (%)	Water Saved (gal)	Savings	Demand (gpd)	Tank Reliability (%)	Water Saved (gal)	Savings	**Annual Water Required for Toilet Flushing (gal)**	**Water Saved From Rainwater Harvesting (gal)**	Water Saved (%)	Savings
Buildings 2-3 Only	2,168	100.0	329,717	$1,365	2,168	81.1	374,477	$1,550	**791,320**	**704,194**	89.0	$2,915

HARVESTING SYSTEM'S STORM-WATER MANAGEMENT CAPACITIES

In addition to harvesting run-off for use in the building, the swale provides storm-water management for the site. The high-strength plastic storage chambers rest on another bed of gravel poured over an impermeable, waterproof membrane of medium-density polyethylene at the bottom of the excavation. This assembly turns the entire volume of the swale into a large cistern. At the western end, a concrete outlet control structure incorporates pipe inlets positioned at a site-specific elevation to allow water overflow from the plastic chambers to discharge into the municipal system at a controlled rate during significant storm events. At the same time, the position of the pipes allows the 16,000 gallons needed to meet the toilet flushing demand to remain at the bottom of the tanks.

The control structure, combined with the filtering and absorption of water by the swale, reduces the quantity and rate of stormwater run-off from the site by 39 percent compared to pre-development site conditions. This reduction is important for improving the quality of the local watershed through decreased erosion and decreased quantity of pollutants in the stormwater run-off.

Rainwater collected in the lower portion of the cistern can be stored since it falls below the inlet elevation. This stored water at the lower elevation is collected by a type of manhole called a lifting station at the eastern end of the swale opposite from the outlet control structure. The lifting mechanism contains a submersible pump to transfer the harvested rainwater into the building on demand from a computerized control system. This pump is powered by six 170-watt solar panels (Sharp NE 170U1) mounted atop a granite retaining wall adjacent to a terrace outside Few Hall.

FIGURE 11. Solar Panels adjacent to a terrace power the pumps for the rainwater harvesting system (credit Ayers/Saint/Gross).

Once inside the basement mechanical room of the residence hall, the harvested rainwater passes through a filter bank to be cleansed. It is then chlorinated and dyed blue as required by DeKalb County to ensure residents know it is undrinkable. Once deposited into a holding tank, the non-potable water is pumped through the building for toilet flushing.

Several primary and backup features within the logic sequence of the control system ensure there is always water to flush the toilets (see Fig. 12):

- If water in the holding tank falls below a third full, a float sensor calls for more rainwater from the solar-powered pumps in the lifting station.
- A flow meter just beyond the basement filter bank monitors the movement of harvested rainwater through the system. If a low flow is detected, a maintenance alert is sent to the control system and a motorized valve is opened to supplement the system with potable water from the municipal source.
- A float sensor in the lifting station can also open the motorized potable water valve if it detects a low level of harvested rainwater in the cistern.
- If the harvested rainwater level or flow rate is low enough that all potable water is flowing through the system, the controls will automatically shut off the chlorine and dye injection stations. So, if students see clear water in the toilets, they will know that the system is not using harvested rainwater.
- A second potable water connection allows the entire rainwater harvesting system to be bypassed in the event of a significant maintenance procedure. This bypass is controlled by a manual valve.

GRAYWATER ADDED TO RECYCLING EFFORTS

From the rainwater harvesting system at Few and Evans, the architects moved on to combine this technology with recycled graywater at the five-story Longstreet-Means Hall. The 138,000 square-foot residence hall complex, opening in August 2010, replaces two outdated dormitories from the 1950s with four interconnected structures arranged into a U-shape around a courtyard. This landscaped open space acts as a green roof over a single-level, 52-space parking garage built under the courtyard.

Inside the 351-bed residence hall, a graywater system recycles waste water from all sinks, showers, bathtubs, and washing machines for use in flushing toilets. The drained water is diverted from the sanitary sewer system to a lint interceptor in the basement mechanical room that filters the graywater before storing it in a pair of 3,000-gallon holding tanks. Water within these chambers is circulated past an ultraviolet lamp to prevent the growth of bacteria. From the holding tanks, the graywater passes through two sets of filter banks before reaching the chlorine and dye injection stations required by the county as in the rainwater harvesting system in Few and Evans halls. Next, the water enters a third, 1,500-gallon holding tank before being pumped up through the building for toilet flushing.

As in the rainwater harvesting system for Few and Evans, the control system's logic sequence incorporates several primary and backup features to ensure water is always available to flush the toilets (see Fig. 15):

- If water in the final holding tank falls below half full, a float sensor calls for more graywater from the first two holding tanks.
- A flow meter just beyond the filter banks monitors the movement of graywater through the system. If a low flow is detected, a maintenance alert is sent to the control system and a motorized valve is opened to supplement the system with potable water from the municipal source.
- A float sensor in the first two tanks can also open the motorized potable water valve if it detects a low level of graywater.
- Another sensor in the overflow from the lint interceptor will also send a maintenance alert to the control system to check for clogs in the lint interceptor.
- If the graywater level in the first two tanks or the flow rate is low enough that all potable water is flowing through the system, the controls will automatically shut off the chlorine and dye injection station. So, if students see clear water in the toilets, they will know that graywater is not present in the system.
- Chlorine levels are also monitored to ensure that the 3ppm level required by the county is maintained.
- Because the building will typically generate more graywater than the demand for toilet flushing, the first two holding tanks are also equipped with overflow piping to the sanitary sewer system to carry off the excess volume of collected graywater before it is treated for use in the building.

FIGURE 12. Rainwater harvesting system schematic (credit Newcomb & Boyd).

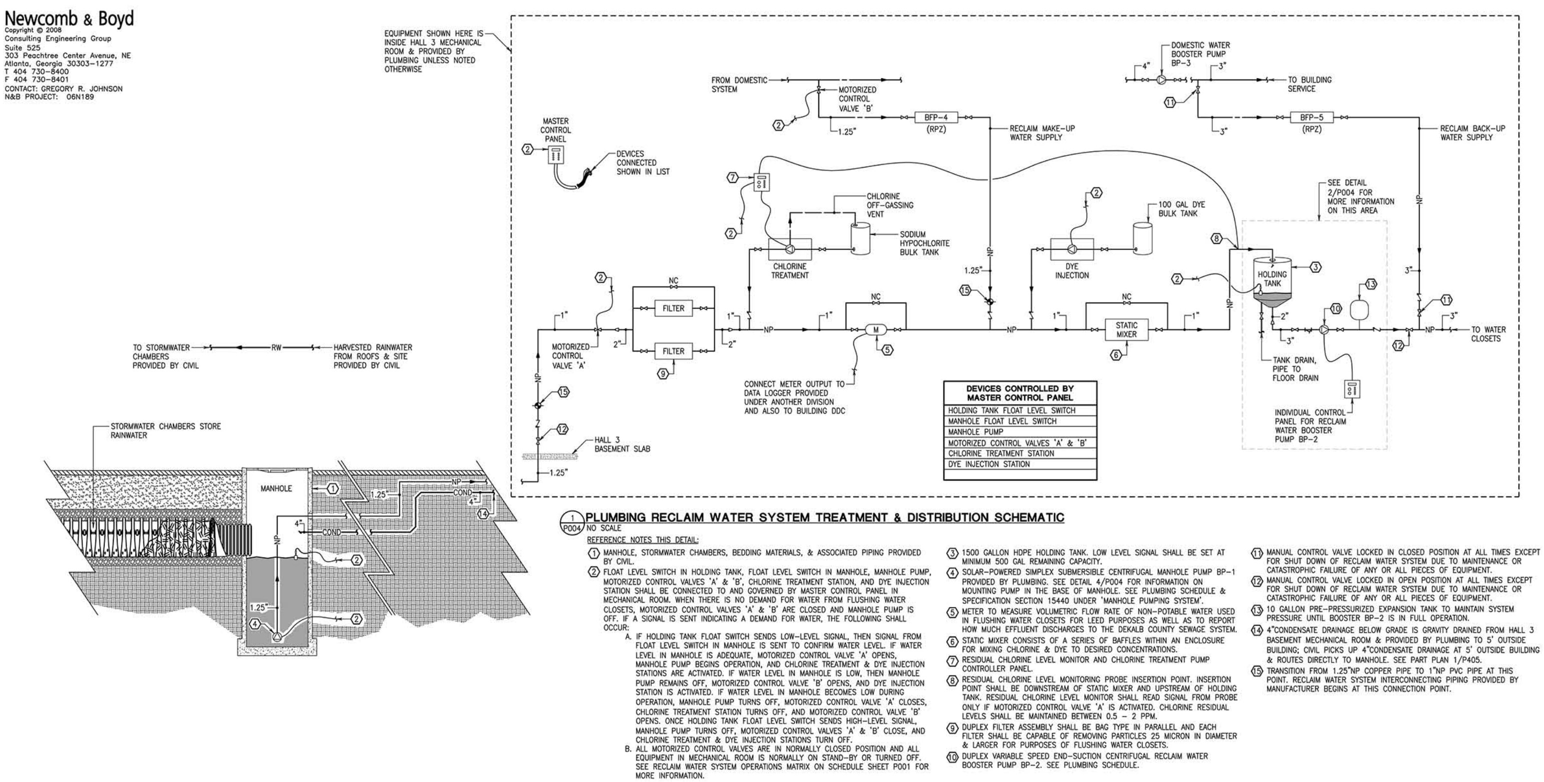


FIGURE 13. Longstreet-Means Hall rendering (credit Ayers/Saint/Gross).

FIGURE 14. Longstreet-Means Rainwater and Greywater Recycling Diagram (credit Ayers/ Saint/Gross).

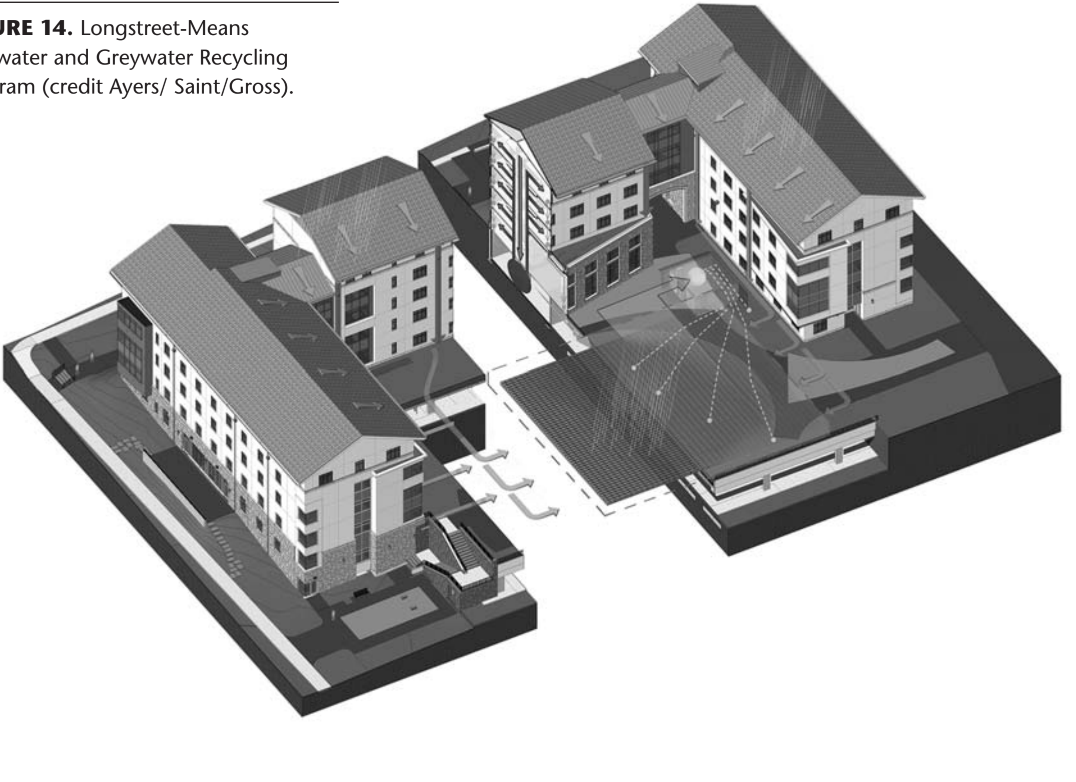
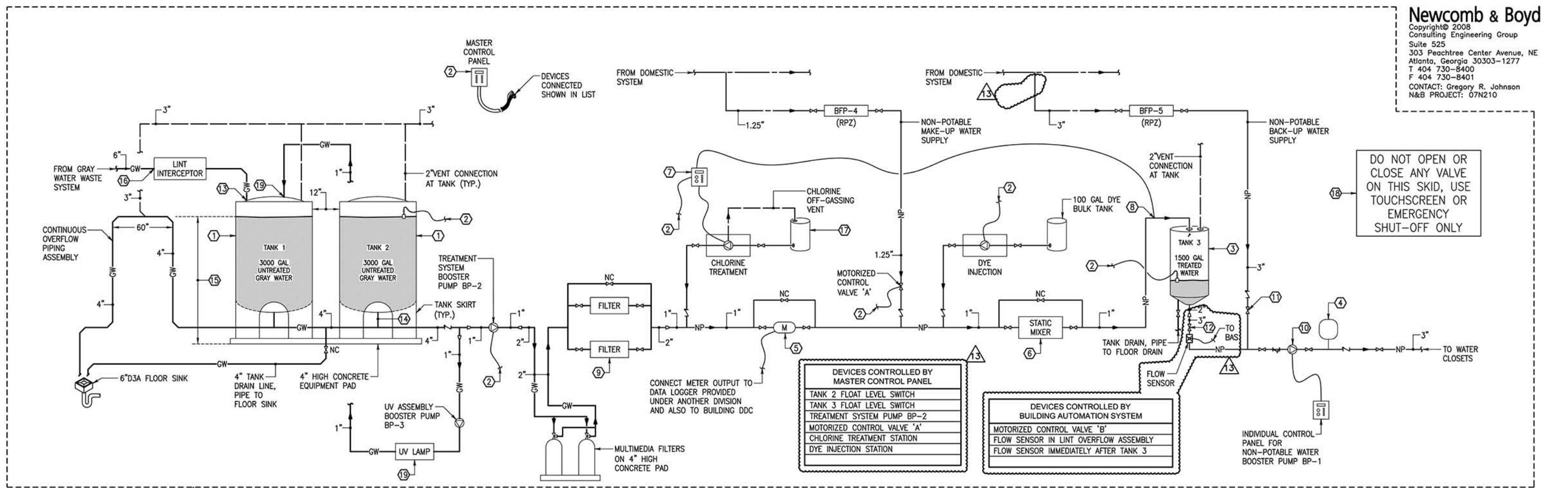


FIGURE 15. Greywater Recycling System Schematic (credit Newcomb & Boyd Consulting Engineers).



EQUIPMENT SHOWN HERE IS INSIDE HALL 4 GROUND FLOOR MECHANICAL ROOM & PROVIDED BY PLUMBING UNLESS NOTED OTHERWISE

(1/P703) PLUMBING GRAY WATER SYSTEM TREATMENT & DISTRIBUTION SCHEMATIC
NO SCALE

REFERENCE NOTES THIS DETAIL:

1. 3000 GAL UNTREATED GRAY WATER WASTE TANKS 1 & 2. TOTAL USABLE VOLUME OF TANKS SHALL BE A MINIMUM OF TWICE THE AMOUNT OF WATER REQUIRED TO MEET DAILY FLUSHING REQUIREMENTS OF ALL WATER CLOSETS. TANKS MUST BE INSTALLED BEFORE MECHANICAL ROOM IS COMPLETELY ENCLOSED. TANK DIMENSIONS REQUIRE THEIR INSTALLATION BEFORE THE WALLS ARE BUILT.
2. FLOAT LEVEL SWITCH IN TANK 2, FLOAT LEVEL SWITCH IN TANK 3, TREATMENT SYSTEM PUMP BP-2, MOTORIZED CONTROL VALVE 'A', CHLORINE TREATMENT STATION, AND DYE INJECTION STATION SHALL BE CONNECTED TO AND GOVERNED BY MASTER CONTROL PANEL IN THE BASEMENT MECHANICAL ROOM. WHEN THERE IS NO DEMAND FOR WATER FROM FLUSHING WATER CLOSETS, MOTORIZED CONTROL VALVE 'A' IS CLOSED AND TREATMENT SYSTEM PUMP IS OFF. IF A SIGNAL IS SENT INDICATING A DEMAND FOR WATER, THE FOLLOWING SHALL OCCUR:
   A. IF TANK 3 FLOAT SWITCH SENDS LOW-LEVEL SIGNAL, THEN SIGNAL FROM FLOAT LEVEL SWITCH IN TANK 2 IS SENT TO CONFIRM WATER LEVEL. IF WATER LEVEL IN TANK 2 IS ADEQUATE, TREATMENT SYSTEM PUMP BEGINS OPERATION, AND CHLORINE TREATMENT & DYE INJECTION STATIONS ARE ACTIVATED. IF WATER LEVEL IN TANK 2 IS LOW, THEN TREATMENT SYSTEM PUMP REMAINS OFF, MOTORIZED CONTROL VALVE 'A' OPENS, AND DYE INJECTION STATION IS ACTIVATED. IF WATER LEVEL IN TANK 2 BECOMES LOW DURING OPERATION, TREATMENT SYSTEM PUMP TURNS OFF, CHLORINE TREATMENT STATION TURNS OFF, AND MOTORIZED CONTROL VALVE 'A' OPENS. ONCE TANK 3 FLOAT LEVEL SWITCH SENDS HIGH-LEVEL SIGNAL, TREATMENT SYSTEM PUMP TURNS OFF, MOTORIZED CONTROL VALVE 'A' CLOSES, AND CHLORINE TREATMENT & DYE INJECTION STATIONS TURN OFF.
   B. ALL MOTORIZED CONTROL VALVES ARE IN NORMALLY CLOSED POSITION AND ALL EQUIPMENT IN MECHANICAL ROOM IS NORMALLY ON STAND-BY OR TURNED OFF. SEE GRAY WATER TREATMENT SYSTEM OPERATIONS MATRIX ON PLUMBING SCHEDULE SHEET FOR MORE INFORMATION.
3. 1500 GAL NON-POTABLE WATER HOLDING TANK 3. LOW LEVEL SIGNAL SHALL BE SET AT MINIMUM HALF-FULL LEVEL.
4. 10 GALLON PRE-PRESSURIZED EXPANSION TANK TO MAINTAIN SYSTEM PRESSURE UNTIL BOOSTER BP-1 IS IN FULL OPERATION.
5. METER TO MEASURE VOLUMETRIC FLOW RATE OF NON-POTABLE WATER USED IN FLUSHING WATER CLOSETS FOR LEED PURPOSES AS WELL AS TO REPORT HOW MUCH EFFLUENT DISCHARGES TO THE MUNICIPAL SEWAGE SYSTEM.
6. STATIC MIXER CONSISTS OF A SERIES OF BAFFLES WITHIN AN ENCLOSURE FOR MIXING CHLORINE & DYE TO DESIRED CONCENTRATIONS.
7. RESIDUAL CHLORINE LEVEL MONITOR AND CHLORINE TREATMENT PUMP CONTROLLER PANEL.
8. RESIDUAL CHLORINE LEVEL MONITORING PROBE INSERTION POINT. INSERTION POINT SHALL BE DOWNSTREAM OF STATIC MIXER AND UPSTREAM OF HOLDING TANK. RESIDUAL CHLORINE LEVEL MONITOR SHALL READ SIGNAL FROM PROBE ONLY IF TREATMENT SYSTEM PUMP BP-2 IS ACTIVATED. CHLORINE RESIDUAL LEVELS SHALL BE MAINTAINED AT 3 PPM.
9. DUPLEX FILTER ASSEMBLY SHALL BE BAG TYPE IN PARALLEL AND EACH FILTER SHALL BE CAPABLE OF REMOVING PARTICLES 5 MICRON IN DIAMETER & LARGER FOR PURPOSES OF FLUSHING WATER CLOSETS.
10. NON-POTABLE WATER BOOSTER PUMP BP-1. SEE PLUMBING SCHEDULE.
11. 3" MOTORIZED CONTROL VALVE 'B' OPENS WHEN 3" FLOW SWITCH AFTER TANK 3 DETECTS ZERO FLOW AND CLOSES AGAIN ONCE 3" FLOW SWITCH DETECTS A FLOW CONDITION; SEE GRAY WATER TREATMENT SYSTEM OPERATIONS MATRIX ON PLUMBING SCHEDULE.
12. MANUAL CONTROL VALVE (NORMALLY OPEN) SHALL BE CLOSED ONLY WHEN BOOSTER PUMP BP-1 IS OUT OF OPERATION OR DURING SYSTEM MAINTENANCE; SEE GRAY WATER TREATMENT SYSTEM OPERATIONS MATRIX ON PLUMBING SCHEDULE.
13. 6"GW INLET TO TANK 1 SHALL BE NO HIGHER THAN 9'-4" AFF.
14. 4"GW OUTLET CONNECTION AT TANK (TYP.)
15. HEIGHT OF CONTINUOUS OVERFLOW PIPING ASSEMBLY ABOVE FINISHED FLOOR SHALL BE DETERMINED BY HEIGHT OF WATER LEVEL AT ITS MAXIMUM CAPACITY IN EACH TANK.
16. 6"GW INLET TO LINT INTERCEPTOR @ IE = 945.84' OR 10'-10" AFF; SEE DETAIL 2/P703 & SHEET P300A.
17. 55 GALLON SODIUM HYPOCHLORITE BULK TANK. FIRST BULK TANK SHALL BE PROVIDED BY CONTRACTOR THROUGH OWNER'S MECHANICAL WATER TREATMENT SYSTEM VENDOR. ONE 55 GALLON DRUM SHALL BE SUFFICIENT FOR 6 MONTHS OF OPERATION.
18. AFFIX PVC PLASTIC SIGN WITH RED FACE, MIN. 3/8" HIGH WHITE LETTERING, AND 1/2" BORDER ALL AROUND TO SIDE OF MASTER CONTROLLER ENCLOSURE.
19. ULTRAVIOLET LAMP ASSEMBLY WITH BOOSTER PUMP BP-3 ON SKID. CONNECT 1"GW TO INLET & OUTLET OF UV LAMP AND CONNECT 1"GW OUTLET TO 2" BLIND FLANGE ON TOP OF TANK 1 THROUGH INCREASER/REDUCER.

- A second potable water connection allows the entire graywater system to be bypassed in the event of a significant maintenance procedure. This bypass is controlled by a manual valve.

The system generates 12,486 gallons of graywater per day to meet a total flushing demand of 2,793 gallons per day, saving more than 1 million gallons of potable water a year. Because the volume of graywater is so much higher than the demand for toilet flushing, the university plans to connect the system to future residence halls in the vicinity. This linkage will maximize the return on investment for the system's tanks, filtration systems, and controls.

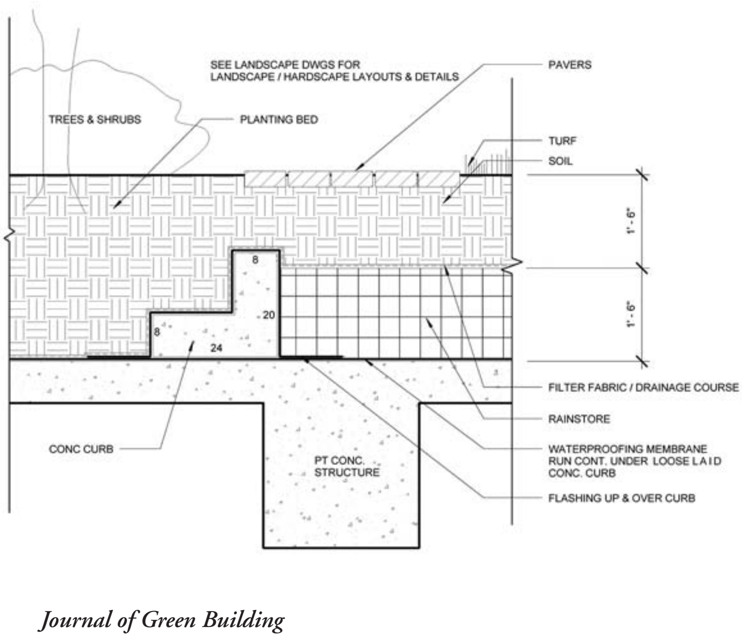
RAINWATER HARVESTING FOR IRRIGATION

Rainwater is also collected from the residence hall's metal gutters and downspouts to irrigate the site. The downspouts are piped directly into a cistern located below the green roof over the underground parking garage. The actual roof consists of a hot rubberized asphalt waterproofing membrane applied directly to the concrete slab over the parking deck. Placed on top of the membrane is a layer of drainage board. Above the board, a series of 18-inch-deep Raintank modules (from ACF Environmental) forms a cistern while structurally supporting 16–18 inches of soil and turf on top of the green roof. These modules, covering roughly 75 percent of the roof area, supply a storage capacity of approximately 150,000 gallons. The remaining 25 percent of the green roof contains layers of soil extending the full depth of the roof's cross-section to allow for the planting of larger shrubs and trees in these areas.

At the northern end of the roof, an outlet control structure incorporates pipe inlets at a site-specific elevation to allow overflowing water to discharge into the municipal system at a controlled rate during significant storm events. This structure, combined with the filtering and absorption of water by the green roof, reduces the quantity and rate of stormwater run-off from the site by 21 percent compared to pre-development conditions. This reduction is important for improving the quality of the local watershed through decreased erosion and decreased quantity of pollutants in stormwater run-off. The inlet elevation at the outlet control structure also allows for the storage of rainwater collected in the lower portion of the cistern that sits below the pipe inlet.

At the opposite end of the green roof, a sump pit collects the rainwater stored at the lower elevation and pipes it to an irrigation pump room housed in the parking deck below. From this room, the harvested water is pumped and distributed throughout the site to irrigate plants on the green roof and in areas around the residence hall.

FIGURE 16. Typical Section at Green Roof (credit Ayers/Saint/Gross).



Of the cistern's total capacity of 150,000 gallons, only 50,000 gallons are used to meet the site's irrigation demands. The remaining100,000 gallons of water are designated for county and LEED-required stormwater detention on the residence hall's 2.5-acre site. The 50,000 gallon size was calculated by determining the worst case month for irrigation demand. Working with Irrigation Consultant Services of Conyers, Georgia, as well as Ayers Saint Gross's landscape design studio, the architects and engineers determined that a weekly demand of 25,274 gallons per week in July was the highest use that needed to be met. This quantity was determined based on annual rainfall data for the area, the size of the site, and the project's plant palette, which balances the university's need for turf recreational space and drought-tolerant species. The team also considered the cistern's collection of condensate water at a rate of 6,375 gallons per week in July. These factors determined that a cistern sized for two weeks of the worst case irrigation demand would reliably meet the irrigation needs of the project.

LESSONS LEARNED FROM SYSTEM IMPLEMENTATION

Because rainwater harvesting and graywater recycling were new to Emory, it was important to involve all of the concerned parties in the design, implementation, and start-up of the systems. These stakeholders included the commissioning agent for the project, EMC Engineers of Atlanta, Georgia, as well as Emory's engineering services and maintenance staffs assigned to the buildings. Based on their thoughtful insights and "what-if" questions, the systems and control sequences were refined to provide a finished product that is easier to operate and maintain.

An example of their influence came during the start-up of the rainwater harvesting system at Few and Evans Halls when the system ran dry even as the float sensor showed ample water in the lifting station. While the original design included a flow meter positioned downstream from the filter banks to allow Emory to measure potable water savings, this meter was not programmed to open the potable water make-up valve in the event that the filters became clogged and rainwater flow was stopped. As a result, the flow meter was linked to the control system so the switch-over to potable water is now automatic and an alert is sent to the computer system to check the filter banks for clogging. This lesson was subsequently applied to the graywater system in Longstreet-Means Hall where a flow meter downstream from the filter banks is linked to the control system for the potable water make-up valve.

Graywater recycling and rainwater harvesting at its residence halls have led Emory to consider future applications of these systems in other locations on campus. In the near future, the university plans to connect the graywater system at Longstreet-Means to new freshman residence halls constructed in the vicinity and maximize its return on investment for the equipment. Emory's commitment to these pioneering systems bolsters their long-standing leadership on sustainability issues within the local community as well as among higher education institutions nationwide.

More significantly, the university has raised awareness of sustainable design by putting students in touch with conservation measures in the very places where they live. Whether watching rainwater rush down a runnel or checking their own energy consumption on the Web, inhabitants of the residence halls are consciously involved in the sustainable systems. They are developing green habits at Emory that may continue long after graduation.

Project Team for Few & Evans Halls

- Emory University: Andrea Trinklein (executive director of residence life and housing), Jen Fabrick (university architect), Glenn Kulasiewicz (project management and construction)
- Ayers/Saint/Gross Architects + Planners (architecture and landscape architecture): Eric Moss (principal in charge), Dennis Lynch (project manager), Hans Graf (project architect), Betsy Boykin (landscape architect), Chris Moore (landscape architect)
- Travis Pruitt & Associates (civil engineering): Eric Pilcher and Andrew Blakey (project managers)
- Nitsch Engineering (civil engineering, rainwater harvesting concept design and analysis): Steve Benz and Nicole Holmes (project engineers)
- Newcomb & Boyd (MEP/FP engineering): Greg Johnson (project manager), Scott King (plumbing engineer)

- EMC Engineering (commissioning agent): Mike Hardy and Trey Headrick (commissioning engineers)
- Turner Construction Company (construction manager): Reggie Askew (project manager)

Project Team for Longstreet-Means Hall

- Emory University: Andrea Trinklein (executive director of residence life and housing), Jen Fabrick (university architect), Glenn Kulasiewicz (project management and construction)
- Carter (program manager): David Nelson (project manager)
- Ayers/Saint/Gross Architects + Planners (architecture and landscape architecture): Eric Moss (principal in charge), Dennis Lynch (project manager), Hans Graf (project architect), Chris Moore (landscape architect), Jonathan Ceci (landscape architect)
- Travis Pruitt & Associates (civil engineering): Andrew Blakey (project manager)
- Landis, Inc. (soils consulting): Barrett Kays
- Newcomb & Boyd (MEP/FP engineering): Greg Johnson (project manager), Scott King (plumbing engineer)
- Irrigation Consultant Services (irrigation design): Carey June
- EMC Engineering (commissioning agent): Mike Hardy and Trey Headrick (commissioning engineers)
- New South Construction (construction manager): Fredrik Nilsson (senior project manager), Brian Dugan (project manager)