Appendix D

Cost Estimating Methodology

D.1 Cost Estimate/Cost Comparison for TEMF and Bde HQ HQ – ASHRAE 90.1-2007 vs. 189.1-2009/2011

D.1.1 ARCHITECTURAL METHODOLOGY (TEMF)

D.1.1.1

General architectural assumptions were made to ensure a comparable model was examined against the varied requirements of the ASHRAE documents. These assumptions included building orientation and building envelope construction. The building's north, south, east and west orientations assume that the building is ideally sited with the long axis of the building along the east-west axis and the main entrance to the facility facing due south. The building envelope for the TEMF Facility was assumed to be constructed of the following components for all climate zones. Please note, the insulation R-value requirement vary per climate zone:

- Roof Section: Metal Deck, extruded polystyrene rigid insulation (thickness varies with climate zones), self-adhering rubberized asphalt sheet membrane, Standing Seam Metal Roof (SSMR).
    - SSMR shall have an SRI of 29 minimum.
- Wall Section:
    - To 8’-0” above finished grade: 8” Concrete Masonry Unit (CMU) back-up wall, damp proofing, extruded polystyrene rigid insulation (thickness varies with climate zones), 1” airspace, 4” CMU veneer.
    - Above 8’-0”: Insulated metal panel (thickness varies with climate zones) with a minimum SRI of 29 over Pre-engineered Metal Buildings (PEMB) wall girt.
        - Insulated metal panel shall have an SRI of 29 minimum.
    - Entrance Vestibule: Full height 8” CMU back-up wall, damp proofing, extruded polystyrene rigid insulation (thickness varies with climate zones), 1” airspace, 4” CMU veneer.
- Floor Section: 8” concrete slab on grade, polystyrene rigid insulation (as required, thickness varies with climate zone) 24” surrounding foundation perimeter.
- Foundation Insulation: polystyrene rigid insulation (as required, thickness varies with climate zone) down interior face of Concrete stem walls.
- Hypothetical windows assumed for vertical glazing (metal framing for all entrance door and all other glazing frames), skylights (with curb, plastic 2.1%–5.0% of Roof) and opaque doors to meet exact U-values and SHGC assembly maximums indicated in the respective ASHRAE requirements.
    - Overhead coiling doors on East and West façade shall have an SRI of 29 minimum.
- Air Barrier Components: Self-adhering rubberized asphalt sheet membrane at roof wrapping over eaves to back side of insulated metal panels. Self-adhering rubberized asphalt sheet membrane adhered to back side of insulated metal panel wrapping to

face of extruded polystyrene insulation board (3/4" thick minimum) over 8" CMU back-up wall. Concrete slab on grade.

- Permanent Projections (exterior sunshades) shall be provided for all fenestration on the E, S, and W facades.

D.1.1.2

In addition, architectural compliance path assumptions were made regarding specific ASHRAE 189.1 sections. These additional compliance path assumptions are as follows:

- In order to comply with the requirements of Paragraph 5.3.2.2, the TEMF must pursue exception (1). The insulated metal wall panel and rolling overhead door colors shall be selected to have a minimum Solar Reflective Index (SRI) value of 29. Assuming the building will be optimally sited with the longer façade of the building facing due south, the area of insulated metal panel and rolling overhead door on the shorter façades accounts for 75% (E Façade) and 80% (W façade) of the overall façade area, therefore satisfying the requirements of the exception that, "…75% or more of the opaque wall surfaces on the east and west have a minimum SRI of 29".
- In order to comply with the requirements of Paragraph 5.3.2.3, the TEMF roof slope is assumed at a slope greater than 2:12. The roof color shall be selected to have a minimum SRI value of 29.
- Non-Smoking signs shall be posted within 10 ft of building entrance. Exterior smoking areas shall be located 25 ft from any building entrance, typically outside of the fenced hardstand area.
- All building entrances shall include an entrance mat system with a scraper surface, absorption surface and finishing surface. Width shall be the size of the entrance opening, and 4'–0" long minimum.
- All material selections are assumed to be selected in accordance with Section 8.4.2 Materials; however, the cost estimate does not necessarily identify these selections as this level of detail is not included in the estimate.
- All interior finishes are assumed to be selected in accordance with Section 9.4.1 Reduced Impact Materials; however, the cost estimate does not necessarily identify these selections as this level of detail is not included in the estimate.

D.1.2 ARCHITECTURAL METHODOLOGY (Bde HQ)

D.1.2.1

General architectural assumptions were made to ensure a comparable model was examined against the varied requirements of the ASHRAE documents. These assumptions included building orientation and building envelope construction. The building's north, south, east and west orientations assume that the building is ideally sited with the long axis of the building along the east-west axis and the main entrance to the facility facing due south. The building envelope for the Bde HQ Facility was assumed to be constructed of the following components for all climate zones. Please note, the insulation R-value requirement vary per climate:

- Roof Section: Metal Deck, extruded polystyrene rigid insulation (thickness varies with climate zones), self-adhering rubberized asphalt sheet membrane, Standing Seam Metal Roof (SSMR).
    - SSMR shall have an SRI of 29 minimum.

- Wall Section: 4” brick veneer, 1” airspace, sheet waterproofing, expanded polystyrene rigid insulation (as required, thickness varies with climate zone) drain board, 6” non-load bearing metal studs, fiberglass Kraft paper faced batt insulation (thickness varies with climate zone), gypsum wallboard.
- Floor Section: 8” concrete slab on grade, polystyrene rigid insulation (as required, thickness varies with climate zone) 24” surrounding foundation perimeter, vapor barrier.
- Foundation Insulation: polystyrene rigid insulation (as required, thickness varies with climate zone) down interior face of Concrete stem walls.
- Hypothetical windows assumed for vertical glazing (metal framing for all storefront, entrance door and all other glazing frames) and opaque doors to meet exact U-values and SHGC assembly maximums indicated in the respective ASHRAE requirements.
- Air Barrier Components: Self adhering rubberized asphalt sheet membrane at roof wrapping over eaves to polystyrene rigid insulation board (3/4” thick minimum). Concrete slab on grade.
- Permanent Projections (exterior sunshades) shall be provided for all fenestration on the E, S, and W facades.
- Vestibules are provided per the standard design at all main entrance doors.

D.1.2.2

In addition, architectural compliance path assumptions were made regarding specific ASHRAE 189.1 sections. These additional compliance path assumptions are as follows:

- In order to comply with the requirements of Paragraph 5.3.2.3, the Bde HQ HQ roof slope is assumed at a slope greater than 2:12. The roof color shall be selected to have a minimum SRI value of 29.
- Non-Smoking signs shall be posted within 10 ft of building entrance. Exterior smoking areas shall be located 25 ft. from any building entrance.
- All building entrances shall include an entrance mat system with a scraper surface, absorption surface and finishing surface. Width shall be the size of the entrance opening, and 4’-0” long minimum.
- All material selections are assumed to be selected in accordance with Section 8.4.2 Materials; however, the cost estimate does not necessarily identify these selections as this level of detail is not included in the estimate.
- All interior finishes are assumed to be selected in accordance with Section 9.4.1 Reduced Impact Materials; however, the cost estimate does not necessarily identify these selections as this level of detail is not included in the estimate.

D.2.1 CIVIL METHODOLOGY (TEMF)

D.2.1.1 GENERAL

The baseline site established for the TEMF is based on a project at Fort Campbell, KY. The project is the 1 BCT Transformation Complex TEMF, PN 64295, P2 156118, FY2011. The project site is 9.79 acres. Fort Campbell represents one of the climate zones in the study, climate zone 4A. Further, the average annual rainfall at Fort Campbell is 52”, and the average annual rainfall for the cities in the study are 53”, 9”, 55”, 44”, 40”, and 12” for Houston, El Paso, Memphis, Baltimore, Salem, and Boise, respectively.

D.2.1.2

Assumptions used in the baseline site included:

- Greyfield site, or according to ASHRAE 189.1, "a site of which more than 20% is already developed with impervious surfaces"
- Wetlands, floodplains, and other environmental issues would not impact the site
- Detention of storm water runoff would be required, and the Fort Campbell requirement of maintaining pre-development runoff for the 10-yr, 24-hour storm was used
- Organizational parking pavement type would be concrete

D.2.1.3 CHANGES FROM BASELINE TO 189.1-2009

Nine different ASHRAE standards were evaluated and these included:

- Site Selection (5.3.1)
- Mitigation of Heat Island Effect, Site Hardscape (5.3.2.1)
- Mitigation of Heat Island Effect, Walls (5.3.2.2)
- Invasive Plants (5.3.4)
- Pedestrian and Transit Connectivity (5.3.5)
- Effective Pervious Area (5.4.1.1)
- Site Water Use Reduction, Landscape Design (6.3.1.1)
- Site Water Use Reduction, Irrigation System Design (6.3.1.2)
- On-Site Renewable Energy Systems (7.3.2)

D.2.1.4

Generally, there were not significant changes from the baseline to ASHRAE 189.1-2009. Using the assumptions detailed above, the site selection standard was met. Given the type of facility, the large amount of concrete pavement allows the site to achieve the LEED credit for mitigation of heat island effect, non-roof, and also meet the ASHRAE standard for mitigation of heat island effect, site hardscape. Mitigation of heat island for walls is not required in LEED. For ASHRAE 189.1-2009, this might be difficult for a TEMF facility, depending on the building construction. For this study, the architect communicated the fact that the east and west walls would have a minimum SRI of 29 for 75% or more of the opaque wall surfaces, thereby meeting the ASHRAE standard.

Invasive plants and pedestrian and transit connectivity were not standards in ASHRAE 189.1-2009, therefore there was no change from the baseline.

Effective pervious area contained the largest change from baseline. There is not a direct LEED equivalent of this standard; however the Storm water Quality Control is close. Since LEED credits are voluntary, and many Army projects, especially greyfield sites, are limited on land area, it was assumed that a typical project would not be able to practically achieve this LEED credit. Effective pervious area is an ASHRAE standard which can be met by using a prescriptive or performance option. For this study the prescriptive option was chosen for simplicity and due to the fact that a preliminary analysis indicated that the prescriptive option would be the most cost effective method to meet the ASHRAE standard. Changes to the site to meet the standard included changing the POV lot from asphalt to pervious concrete, changing the gravel surrounding the security fence to porous gravel with under drain pipe, and changing a small portion of the Organization parking to permeable interlocking concrete pavers from concrete. As a result of making these changes, storage for runoff was created, eliminating the need for half of the detention system.

Another change from the baseline to ASHRAE 189.1-2009 was the inclusion of vegetated native plantings for 60% of the improved landscape, in lieu of turf grass. Obviously this has a first-cost

effect, captured in this study, but also a long-term maintenance cost will be associated with this change.

No change was observed for the irrigation system design standard, since irrigation systems are generally not used on Army projects, and would certainly not be warranted on a TEMF project.

D.2.1.5 CHANGES FROM 189.1-2009 TO 189.1-2011

The 2011 version of ASHRAE 189.1 only made insignificant changes to site requirements. Of note are the requirements to remove invasive plants from the site and the pedestrian and transit connectivity requirement. In most projects, these would have very little cost impact. The invasive plants would be expected to be demolished as part of the site development process. Some additional clearing and replanting might be necessary, depending on the particular site conditions. Pedestrian and transit connectivity would likewise already be included in the project design, or at the most consist of providing additional concrete sidewalk, pavement striping, and handicap ramps.

D.2.2 CIVIL METHODOLOGY (Bde HQ)

D.2.2.1 GENERAL

The baseline site established for the HQ Brigade is based on a project at Fort Campbell, KY. The project is the New Clarksville Base Consolidated Battalion Brigade Headquarters, PN 58511, P2 114432, FY11. The project site is 12.72 acres. Fort Campbell represents one of the climate zones in the study, climate zone 4A. Further, the average annual rainfall at Fort Campbell is 52”, and the average annual rainfall for the cities in the study are 53”, 9”, 55”, 44”, 40”, and 12” for Houston, El Paso, Memphis, Baltimore, Salem, and Boise, respectively. The site design was modified to reflect the requirements for a HQ Brigade building, instead of a consolidated battalion brigade headquarters building.

D.2.2.2

Assumptions used in the baseline site included:

- Greyfield site, or according to ASHRAE 189.1, "a site of which more than 20% is already developed with impervious surfaces"
- Wetlands, floodplains, and other environmental issues would not impact the site
- Detention of storm water runoff would be required, and the Fort Campbell requirement of maintaining pre-development runoff for the 10-yr, 24-hour storm was used

D.2.2.3 CHANGES FROM BASELINE TO 189.1-2009

Nine different ASHRAE standards were evaluated and these included:

- Site Selection (5.3.1)
- Mitigation of Heat Island Effect, Site Hardscape (5.3.2.1)
- Mitigation of Heat Island Effect, Walls (5.3.2.2)
- Invasive Plants (5.3.4)
- Pedestrian and Transit Connectivity (5.3.5)
- Effective Pervious Area (5.4.1.1)
- Site Water Use Reduction, Landscape Design (6.3.1.1)
- Site Water Use Reduction, Irrigation System Design (6.3.1.2)
- On-Site Renewable Energy Systems (7.3.2)

D.2.2.4

Generally, there were not significant changes from the baseline to ASHRAE 189.1-2009. Using the assumptions detailed above, the site selection standard was met. Given the type of facility, the site would typically use asphalt pavement for parking and not be able to achieve the LEED credit for mitigation of heat island effect, non-roof. To meet the ASHRAE standard for mitigation of heat island effect, site hardscape, approximately 15,000 square feet of asphalt pavement was changed to pervious concrete. The change to pervious concrete will aid in reducing the amount of storm water detention required. Mitigation of heat island for walls is not required in LEED. For ASHRAE 189.1-2009, it was assumed that trees required for the ASHRAE Landscape Design requirement would meet the shade requirement for the building walls.

Invasive plants and pedestrian and transit connectivity were not standards in ASHRAE 189.1-2009, therefore there was no change from the baseline.

Effective pervious area is an ASHRAE standard which can be met by using a prescriptive or performance option. For this study the prescriptive option was chosen for simplicity and due to the fact that a preliminary analysis indicated that the prescriptive option would be the most cost effective method to meet the ASHRAE standard. The ASHRAE Landscape Design requirement of providing vegetated native plantings for 60% of the improved landscape enabled the project to meet the effective pervious area requirement and not require any change from the baseline project conditions.

The major change from the baseline to ASHRAE 189.1-2009 was the inclusion of vegetated native plantings for 60% of the improved landscape, in lieu of turf grass. Obviously this has a first-cost effect, captured in this study, but also a long-term maintenance cost will be associated

with this change. Approximately 225,000 square feet of turf grass seeding was changed to plantings.

No change was observed for the irrigation system design standard, since irrigation systems are generally not used on Army projects.

D.2.2.5 CHANGES FROM 189.1-2009 TO 189.1-2011

The 2011 version of ASHRAE 189.1 only made insignificant changes to site requirements. Of note are the requirements to remove invasive plants from the site and the pedestrian and transit connectivity requirement. In most projects, these would have very little cost impact. The invasive plants would be expected to be demolished as part of the site development process. Some additional clearing and replanting might be necessary, depending on the particular site conditions. Pedestrian and transit connectivity would likewise already be included in the project design, or at the most consist of providing additional concrete sidewalk, pavement striping, and handicap ramps.

D.3.1 ELECTRICAL METHODOLOGY (TEMF)

D.3.1.1 General

The basis for this study was a Standard Design based design that was performed for the 7th Transportation Battalion at Fort Bragg, North Carolina. Assumed lighting illuminance levels and space type interpretations for the TEMF were taken from the "TEMF Standards Modeling Overview" developed by NREL and dated September 20, 1012. This design was used in the interest of schedule.

Also since no site electrical design was provided with the TEMF design, a related EISA study, "MILCON Energy Efficiency and Sustainability Study of Five Types of Army Buildings", provided as reference material, did not include site lighting analysis, and to meet schedule limitations, this study does not include exterior lighting analysis. This should have minimal effect on the study since parking lighting, which is the cost driver for exterior applications, can generally be met for all the ASHRAE standards being considered using conventional metal halide area lighting fixtures. The only possible challenge could be in Lighting Zones LZ0 and LZ1 for ASHRAE 189.1 2011. These requirements are applied to remote or rural areas, and state and federal parks which could apply to projects not on major bases and some reserve centers. The lighting power allowance for LZ1 in ASHRAE 189.1 2011 is .036 W/ft^2 and would probably require a higher efficiency and more expensive fixture type which could have a material cost four to six times conventional fixtures but may be offset somewhat by life cycle costs.

In general the electrical cost variances for the climate zones analyzed in this study across the various ASHRAE standards are driven by and included in HVAC analysis. Changes in electrical design would be captured in the costs of HVAC equipment for each climate zone. The climate zones therefore do not significantly affect the electrical cost estimate.

D.3.1.2 ON SITE RENEWABLE ENERGY SYSTEMS

Provisions were added to the cost estimate for conduit to support a photovoltaic array located on canopies over the parking areas. The distance was based on the design used in the civil portion of this study and the size was based and the roof square footage as required in the ASHRAE 189.1 standards. Direction was given not to include the costing of the photovoltaic array and support equipment in the estimate due to the exception to the requirement of the Army.

D.3.1.3 ENERGY CONSUMPTION MANAGEMENT

Provisions were added to the cost estimate for upgrades to panels to provide sub-metering and network connections for lighting, HVAC, and plug loads that exceed the KW threshold required in the ASHRAE 189.1 standards to require monitoring.

D.3.1.4 PRESCRIPTIVE OPTION

- Lighting Power Allowance: Lighting power allowance was addressed as described in the Methodology section of the electrical section of this report.

- Occupancy Sensor Controls (ASHRAE 189.1 2009 only): The baseline design chosen for the study includes occupancy sensor control and although ASHRAE 90.1 2007 allows for the use of automatic controls other than occupancy sensor control it is common practice to use occupancy sensor control to meet this requirement. This requirement was therefore not included as an additional cost to the study.

- Occupancy Sensor Controls with Multi-Level Switching or Dimming: This requirement does not apply to the TEMF spaces.

- Automatic Controls for Egress and Security Lighting: This requirement can be managed without adding cost to the project and was therefore not included in the study.

- Automatic Controls for Lighting of Daylight Zones (ASHRAE 189.1 2009 only): This cost was addressed in the study by the addition of daylight sensors, additional conduit and wiring, and dimming ballasts for lighting fixtures in areas where day lighting control would apply and with the addition of more expensive lighting control panels.

- Controls for Exterior Sign Lighting (ASHRAE 189.1 2011 only): There was no exterior signage included in the provided documentation of the baseline design however it is common practice to include exterior lighting control in projects and this requirement could be met by controller programming changes that would not add cost to the project. It was therefore not addressed in the cost study.

- “Manual ON” Occupancy Sensors: This requirement can be met by standard options on existing occupancy sensors and controls that are already included in the baseline design and therefore were not included as an additional cost in the study.

- Controls for Outdoor Lighting (ASHRAE 189.1 2009 only): Exterior lighting was not included in the provided documentation of the baseline design however it is common practice to include exterior lighting control in projects and this requirement could be met by controller programming changes that would not add cost to the project. It was therefore not addressed in the cost study.

- Other Equipment: ENERGY STAR and other efficiency requirements for motors are included in changes made to the baseline design included in the mechanical section of this study and therefore were not addressed in the electrical section.

D.3.2 ELECTRICAL METHODOLOGY (Bde HQ)

D.3.2.1 GENERAL

The basis for this study was the Brigade HQ Adapt-Build Standard Design

The primary electrical system affected by the ASHRAE 189.1 standards requirements is interior lighting. The methodology used for each of the building type was to take a standard design provided for the study as a baseline for room square footage, fixture types, and fixture count and measure it against the IESNA illuminance values and the various ASHRAE standard lighting power densities. The lumen method equations were used to compute the expected illuminance at the desired work planes based on coefficient of utilization values for the fixtures in the provided designs. This value was used to approximate the quality of illumination of the spaces and to provide an educated guess at the number of fixture necessary to meet engineering guidance. Once this was established the input wattage for the fixtures specified in the sample designs could be used to estimate the lighting power density. If the maximum power density for a given space was not achieved a more efficient fixture was chosen for selected spaces that would affect significant change to the power densities. The cost change for this change was then applied.

D.3.2.2 ON SITE RENEWABLE ENERGY SYSTEMS

Provisions were added to the cost estimate for conduit to support a photovoltaic array located on canopies over the parking areas. The distance was based on the design used in the civil portion of this study and the size was based and the roof square footage as required in the ASHRAE 189.1 standards. Direction was given not to include the costing of the photovoltaic array and support equipment in the estimate due to the exception to the requirement of the Army.

D.3.2.3 ENERGY CONSUMPTION MANAGEMENT

Provisions were added to the cost estimate for upgrades to panels to provide sub-metering and network connections for lighting, HVAC, and plug loads that exceed the KW threshold required in the ASHRAE 189.1 standards to require monitoring.

D.3.2.4 PRESCRIPTIVE OPTION

- Lighting Power Allowance: Lighting power allowance was addressed as described in the Methodology section of the electrical section of this report.

- Occupancy Sensor Controls (ASHRAE 189.1 2009 only): The baseline design chosen for the study includes occupancy sensor control and although ASHRAE 90.1 2007 allows for the use of automatic controls other than occupancy sensor control it is common practice to use occupancy sensor control to meet this requirement. This requirement was therefore not included as an additional cost to the study.

- Occupancy Sensor Controls with Multi-Level Switching or Dimming: This requirement does not apply to the Bde HQ HQ spaces.

- Automatic Controls for Egress and Security Lighting: This requirement can be managed without adding cost to the project and was therefore not included in the study.

- Automatic Controls for Lighting of Daylight Zones (ASHRAE 189.1 2009 only): This cost was addressed in the study by the addition of daylight sensors, additional conduit and wiring, and dimming ballasts for lighting fixtures in areas where day lighting control would apply and with the addition of more expensive lighting control panels.

- Controls for Exterior Sign Lighting (ASHRAE 189.1 2011 only): There was no exterior signage included in the provided documentation of the baseline design however it is common practice to include exterior lighting control in projects and this requirement could be met by controller programming changes that would not add cost to the project. It was therefore not addressed in the cost study.

- "Manual ON" Occupancy Sensors: This requirement can be met by standard options on existing occupancy sensors and controls that are already included in the baseline design and therefore were not included as an additional cost in the study.

- Controls for Outdoor Lighting (ASHRAE 189.1 2009 only): Exterior lighting was not included in the provided documentation of the baseline design however it is common practice to include exterior lighting control in projects and this requirement could be met by controller programming changes that would not add cost to the project. It was therefore not addressed in the cost study.

- Other Equipment: ENERGY STAR and other efficiency requirements for motors are included in changes made to the baseline design included in the mechanical section of this study and therefore were not addressed in the electrical section.

D.4.1 MECHANICAL METHODOLOGY (TEMF)

D.4.1.1 GENERAL

The ASHRAE guidelines referenced were the 90.1-2007 (Baseline), 189.1-2009 and 189.1-2011. The equipment which was affected by the different ASHRAE guidelines and climate zones is presented and discussed in the section below. These elements included ductwork insulation thicknesses, air handling unit economizers, domestic and hydronic piping insulation, and plumbing fixtures. The split system air handling unit(s), boiler(s), large exhaust fan(s) and heating ventilating unit(s) capacities and sizes were taken from the National Renewable Energy Laboratory (NREL) energy study of a medium sized TEMF at Fort Bragg, North Carolina. All the mechanical and plumbing equipment for the TEMF facility was reviewed with the estimating department to ensure all equipment was accounted for in the estimate.

D.4.1.2

The referenced design criteria and assumptions used during this study for each combination above are listed below.

D.4.1.2.1 ASHRAE 90.1-2007 (BASELINE) CRITERIA:

a. Electric motors comply with EPAct1992 as shown in Table 10.8. *90.1*
b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the Energy Policy Act (EPAct) and ASHRAE 90.1.
c. Ductwork seal class B. *UFC 4-214-02-2010*
   - Conditioned space return-seal class C *90.1*
   - Conditioned space supply≤2inwg-seal class C *90.1*
   - Conditioned space exhaust-seal class B *90.1*
d. Ductwork insulation R6 (1.5inch mineral fiber wrap). *UFC4-214-02-2010*

- Indirectly conditioned spaces-none per Table 6.8.2. *90.1*
- 1.5inch mineral fiber wrap R6 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation. *90.1*

e. Air handler economizers used in climate zones 3B, 4C and 5B for capacities ≥65MBH per Table 6.5.1. *90.1*

f. Heating hot water piping insulation thickness 0.5inch for ≤1inch pipe, and 1inch for ≥1.5inch piping per Table 7B. *90.1*

g. Outdoor air heat recovery unit required for >5000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness. Exception for spaces which are not mechanically cooled and heated below 60DegF. *90.1*

h. Domestic hot water piping insulation thickness 0.5inch for <1.5inch pipe, and 1inch for ≥1.5inch piping per Table 6.8.3. *90.1*

i. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*

j. Hydronic boiler efficiency is 80% E_t per Table 6.8.1F. *90.1*

k. Domestic boiler efficiency is 80% E_t per Table 7.8. *90.1*

l. Plumbing fixture water use efficiencies used as a baseline were taken from LEED 2009 v.3.0 WEc3 or EPAct1992.

D.4.1.2.2 ASHRAE 189.1-2009/90.1-2007 CRITERIA:

a. Electric motor efficiencies comply with Table C-13. *189.1*

b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the National Appliance Energy Conservation Act (NAECA), Energy Policy Act (EPAct), and the Energy Independence and Security Act (EISA) per 7.4.3.1a and with Appendix C. *189.1*

c. Ductwork insulation R8 (1.5inch mineral fiber wrap). *189.1*

- Indirectly conditioned spaces-none per Table C-x. *189.1*
- 1.5inch mineral fiber wrap R8 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation.

d. Air handler economizers used in climate zones 3A, 3B, 4A, 4C and 5B for capacities ≥33MBH. *189.1*

e. Domestic hot water piping insulation thickness 1inch for <1.5inch pipe, and 1.5inch for ≥1.5inch piping per Table C11. *189.1*

f. Hydronic hot water piping insulation thickness 1.5inch for <4inch piping per Table C11. *189.1*

g. Outdoor air heat recovery unit required for > 5000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness. Exception for spaces which are not mechanically cooled and heated below 60DegF. *90.1*

i. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*

j. Hydronic boiler efficiency is 80%E_t per Table 6.8.1.F. *90.1*
k. Domestic boiler efficiency is 80%E_t per Table C12. *189.1*
l. Plumbing fixture water use efficiencies per Table 6.3.2.1. *189.1*
m. Total outdoor airflow measuring station included per 8.3.1.2. *189.1*
n. MERV 8 filters provided on all air handling equipment per 8.3.1.3. *189.1*
o. Condensate from air conditioning equipment with capacities larger than 65MBtuh per 6.3.2.3.c will be collected and made available at a 1000gallon above ground cistern for gravity watering. *189.1*

D.4.1.2.3 ASHRAE 189.1-2011/90.1-2010 CRITERIA:

a. Electric motor efficiencies comply with Table C-12. *189.1*
b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the National Appliance Energy Conservation Act (NAECA), Energy Policy Act (EPAct), and the Energy Independence and Security Act (EISA) per 7.4.3.1a and with Appendix C. *189.1*
c. Ductwork insulation R8 (1.5inch mineral fiber wrap). *189.1*
   - Indirectly conditioned spaces-none per Table C-x. *189.1*
   - 1.5inch mineral fiber wrap R8 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation.
d. Air handler economizers used in climate zones 2A, 3A, 3B, 4A, 4C and 5B for capacities ≥33MBH. *189.1*
e. Domestic hot water piping insulation thickness 1inch for ≤1inch pipe, and 1.5inch for ≥1.5inch piping per Table 6.8.3A. *90.1*
f. Hydronic hot water piping insulation thickness 1.5inch for ≤1.5inch pipe, and 2inch for ≥1.5inch piping per Table 6.8.3A. *90.1*
g. Outdoor air heat recovery unit required for > 5000cfm outside air and ≥70% outside air of total supply air with minimum 60% enthalpy recovery effectiveness for climate zones 3B, 4C and 5B. Exception for spaces which are not mechanically cooled and heated below 60DegF. *90.1*
h. Outdoor air heat recovery unit required for > 1000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness for climate zone 4A. Exception for spaces which are not mechanically cooled and heated below 60DegF. *90.1*
i. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*
j. Domestic water heating efficiency 90%; not used for study. *UFC 4-214-02-2010*
k. Hydronic boiler efficiency is 80%E_t per Table 6.8.1.F. *90.1*
l. Domestic boiler efficiency is 80%E_t per Table C11. *189.1*
m. Plumbing fixture water use efficiencies per Table 6.3.2.1. *189.1*
n. Total outdoor airflow measuring station included per 8.3.1.2. *189.1*

o. MERV 8 filters provided on all air handling equipment per 8.3.1.3. *189.1*
p. Condensate from air conditioning equipment with capacities larger than 65MBtuh per 6.3.2.3.c will be collected and made available at a 1000gallon above ground cistern for gravity watering. *189.1*

D.4.1.3 GENERAL NOTES AND ASSUMPTIONS

a. HVAC system types used for the TEMF building were taken from NREL study data.
b. HVAC system cooling and heating capacities for all climate zones used for the TEMF building were taken from NREL study data.
c. All interior back of house split system air conditioning equipment capacities remained constant across the climate zones and energy levels.
d. All general nominal horsepower exhaust fan equipment and capacities remained constant across the climate zones and energy levels.
e. Initial domestic hot water heating equipment required capacity was taken from the NREL study TEMF building design drawings. This required capacity was set equal to the flow requirements for the plumbing fixtures per the baseline above.
f. Reduced domestic hot water flow requirements per the water efficiency requirements (EPAct 1992 to 189.1) were translated to the domestic hot water heating equipment sizes.
g. No outdoor air heat recovery used for the TEMF building in any climate zone based on exceptions above.
h. Ductwork seal classes were not accounted for in this analysis.
i. Filtration efficiencies were not accounted for in this analysis.
j. Air filtration elements considered to remain constant across energy standards and climate zones.
k. Air handling unit fan motors used for this study were taken from manufacturers catalog data for air handling unit based on cooling capacity and the corresponding volumetric flow rate per ton of cooling.
l. Total hydronic boiler capacity was divided into two boilers per UFC3-410-01FA.5-3.

D.4.2 MECHANICAL METHODOLOGY (Bde HQ)

D.4.2.1 GENERAL

The ASHRAE guidelines referenced for this study were the 90.1-2007, 189.1-2009 and 189.1-2011. The packaged four pipe air handling units, boilers, chillers, hydronic pump and domestic hot water boiler capacities and sizes were taken from the Pacific Northwest National Laboratory (PNNL) energy study of a large sized Brigade Headquarters facility. Other mechanical and plumbing elements which were modified in accordance with the different ASHRAE guidelines are listed in the section below. This information was transferred to the estimating department for costing.

D.4.2.2

The referenced design criteria and assumptions used during this study for each combination above are listed below.

D.4.2.2.1 ASHRAE 90.1-2007 (BASELINE) CRITERIA:

a. Electric motors comply with EPAct1992 as shown in Table 10.8. *90.1*

b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the Energy Policy Act (EPAct) and ASHRAE 90.1.

c. Ductwork seal class:
- Conditioned space return-seal class C *90.1*
- Conditioned space supply≤2inwg-seal class C *90.1*
- Conditioned space exhaust-seal class B *90.1*

d. Ductwork insulation:
- Indirectly conditioned spaces-none per Table 6.8.2. *90.1*
- 1.5inch mineral fiber wrap R6 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation.

e. Air handler economizers used in climate zones 3B, 4C and 5B for capacities ≥65MBH per Table 6.5.1. *90.1*

f. Heating hot water piping insulation thickness 0.5inch for ≤1inch pipe, and 1inch for ≥1.5inch piping per Table 7B. *90.1*

g. Outdoor air heat recovery unit required for > 5000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness; not required. *90.1*

h. Domestic hot water piping insulation thickness 0.5inch for <1.5inch pipe, and 1inch for ≥1.5inch piping per Table 6.8.3. *90.1*

i. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*

j. Air cooled chiller COP=2.8 and IPLV=3.05 per Table 6.8.1C. *90.1*

k. Hydronic boiler efficiency is 80%E_t per Table 6.8.1F. *90.1*

l. Domestic boiler efficiency is 80%E_t per Table 7.8. *90.1*

m. Plumbing fixture water use efficiencies used as a baseline were taken from LEED 2009 v.3.0 WEc3 or EPAct1992.

D.4.2.2.2 ASHRAE 189.1-2009/90.1-2007 CRITERIA:

a. Electric motor efficiencies comply with Table C-13. *189.1*

b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the National Appliance Energy Conservation Act (NAECA), Energy Policy Act (EPAct), and the Energy Independence and Security Act (EISA) per 7.4.3.1a and with Appendix C. *189.1*

c. Ductwork insulation R8 (1.5inch mineral fiber wrap). 1*89.1*
- Indirectly conditioned spaces-none per Table C-x. *189.1*
- 1.5inch mineral fiber wrap R8 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation.

d. Air handler economizers used in climate zones 3A, 3B, 4A, 4C and 5B for capacities ≥33MBH. 1*89.1*

e. Domestic hot water piping insulation thickness 1inch for <1.5inch pipe, and 1.5inch for ≥1.5inch piping per Table C11. *189.1*

f. Hydronic hot water piping insulation thickness 1.5inch for <4inch piping per Table C11. *189.1*

g. Outdoor air heat recovery unit required for > 5000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness; not required. *90.1*

h. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*

i. Air cooled chiller COP=3.22 and IPLV=4.02 per Table C3. *189.1*

j. Hydronic boiler efficiency is 80%E_t per Table 6.8.1.F. *90.1*

k. Domestic boiler efficiency is 80%E_t per Table C12. *189.1*

l. Plumbing fixture water use efficiencies per Table 6.3.2.1. *189.1*

m. Total outdoor airflow measuring station included per 8.3.1.2. *189.1*

n. MERV 8 filters provided on all air handling equipment per 8.3.1.3. *189.1*

o. Condensate from air conditioning equipment with capacities larger than 65MBtuh per 6.3.2.3.c will be collected and made available at a 1000gallon above ground cistern for gravity watering. *189.1*

D.4.2.2.3 ASHRAE 189.1-2011/90.1-2010 CRITERIA:

a. Electric motor efficiencies comply with Table C-12. *189.1*

b. HVAC air conditioning and plumbing equipment minimum efficiencies comply with the National Appliance Energy Conservation Act (NAECA), Energy Policy Act (EPAct), and the Energy Independence and Security Act (EISA) per 7.4.3.1a and with Appendix C. *189.1*

c. Ductwork insulation R8 (1.5inch mineral fiber wrap). *189.1*

- Indirectly conditioned spaces-none per Table C-x. *189.1*
- 1.5inch mineral fiber wrap R8 used on all mechanical room, bay supply, and above ceiling ducts for condensing moisture resistance and energy conservation.

d. Air handler economizers used in climate zones 2A, 3A, 3B, 4A, 4C and 5B for capacities ≥33MBH. *189.1*

e. Domestic hot water piping insulation thickness 1inch for ≤1inch pipe, and 1.5inch for ≥1.5inch piping per Table 6.8.3A. *90.1*

f. Hydronic hot water piping insulation thickness 1.5inch for ≤1.5inch pipe, and 2inch for ≥1.5inch piping per Table 6.8.3A. *90.1*

g. Outdoor air heat recovery unit required for > 5000cfm outside air and ≥70% outside air of total supply air with minimum 60% enthalpy recovery effectiveness for climate zones 3B, 4C and 5B; not required. *90.1*

h. Outdoor air heat recovery unit required for > 1000cfm outside air and ≥70% outside air of total supply air with minimum 50% enthalpy recovery effectiveness for climate zone 4A; not required. *90.1*

i. Hydronic pumps >10Hp employ variable flow control; none on project. *90.1*

j. Air cooled chiller COP=3.22 and IPLV=4.02 per Table C3. *189.1*

k.	Domestic water heating efficiency 90%; not used for study.	*UFC 4-214-02-2010*
l.	Hydronic boiler efficiency is 80%E_t per Table 6.8.1.F.	*90.1*
m.	Domestic boiler efficiency is 80%E_t per Table C11.	*189.1*
n.	Plumbing fixture water use efficiencies per Table 6.3.2.1.	*189.1*
o.	Total outdoor airflow measuring station included per 8.3.1.2.	*189.1*
p.	MERV 8 filters provided on all air handling equipment per 8.3.1.3.	*189.1*
q.	Condensate from air conditioning equipment with capacities larger than 65MBtuh per 6.3.2.3.c will be collected and made available at a 1000 gallon above ground cistern for gravity watering.	1*89.1*

D.4.2.3 GENERAL NOTES AND ASSUMPTIONS

a. HVAC system types used for the Bde HQ HQ building were taken from PNNL energy study data.
b. HVAC system cooling and heating capacities for all climate zones used for the Bde HQ HQ building were taken from PNNL study data.
c. All computer room and interior back of house split system air conditioning equipment capacities remained constant across the climate zones and energy levels.
d. All general nominal horsepower exhaust fan equipment and capacities remained constant across the climate zones and energy levels.
e. Initial domestic hot water heating equipment required capacity was taken from energy PNNL energy study data. This required capacity was set equal to the flow requirements for the plumbing fixtures per the baseline above.
f. Reduced domestic hot water flow requirements per the water efficiency requirements (EPAct 1992 to 189.1) were translated to the domestic hot water heating equipment sizes.
g. No outdoor air heat recovery used for the Bde HQ HQ building in any climate zone based on required volumetric airflow and percentages above.
h. Ductwork seal classes were not accounted for in this analysis.
i. Filtration efficiencies were not accounted for in this analysis.
j. Air filtration elements considered to remain constant across energy standards and climate zones.
k. Air handling unit fan motors used for this study were taken from manufacturers catalog data for air handling unit based on cooling capacity and the corresponding volumetric flow rate per ton of cooling.
m. The difference in required efficiencies for the air cooled chiller per the ASHRAE 90.1-2007 and the ASHRAE 189.1 standards was assumed to be negligible and was not accounted for in this study.

D.5.1 ESTIMATING METHODOLOGY (TEMF & Bde HQ)

D.5.1.1 GENERAL

Once designers had identified the requirements of compliance with each standard, the building was estimated in detail using Micro-Computer Aided Cost Estimating Software (MCACES) V4.1. A “donor” estimate from a previous 2011 EISA study was used as a basic skeleton for the estimate. This skeleton was then modified per the requirements for each building and climate

zone to establish a construction cost. The use of an estimate skeleton with modifications allows a simple "delta" approach to establish cost impact of complying with the newer standards over the previous versions.

D.5.1.2

The detailed estimate was tailored specific to each standard and location. The material Area Cost Factor (ACF) from the approved dataset for Parametric Cost Engineering System (PACES) 1.0 software was used to address local material cost fluctuations, and the appropriate local Davis-Bacon wage decision was used to reflect the local labor market. State designations for contractors per the locale were made to appropriately capture payroll tax and insurance effects for each trade. Contractors were assigned as appropriate to task items with specific markups, rather than using a general Prime/Sub relationship. The R.S. Means 2010 unit price book was used in conjunction with vendor pricing on major mechanical equipment. An additional material adjustment factor of 10% was applied to material costs only to address historical cost inflation according to Engineering News Record data from the period of JAN 2010 to OCT 2012, thus making material costs current. No escalation was applied since the study is theoretical and no construction schedule is known. Design costs were not included in the cost estimates.

D.5.1.3

Vendor pricing for major mechanical equipment was obtained where possible. Since the differences in the standards include many small incremental changes in equipment size, efficiency, etc, it is not practical to obtain vendor pricing for every possible combination in the study. Instead, a manufacturer's line of equipment was identified and vendor pricing was obtained for equipment lying at the extremes of the size/efficiency range and several points in between. A simple regression was then used to establish costs for components that fell between provided cost data.

D.5.2 ESTIMATING RESULTS TABLES (TEMF)

TEMF Construction Cost		ASHRAE 90.1 (2007) Compliant	ASHRAE 189.1 (2009) Compliant	ASHRAE 189.1 (2011) Compliant
Houston, TX 2A	Primary	$5,694,751	$5,884,439	$5,863,027
	Support	$4,976,748	$4,909,840	$4,915,255
Memphis, TN 3A	Primary	$6,037,809	$6,238,276	$6,211,747
	Support	$5,161,874	$5,108,677	$5,114,196
El Paso, TX 3B	Primary	$5,112,766	$5,298,270	$5,276,930
	Support	$4,728,740	$4,738,875	$4,743,555
Baltimore, MD 4A	Primary	$6,850,712	$7,118,830	$7,097,023
	Support	$5,802,975	$5,726,160	$5,733,285
Salem, OR 4C	Primary	$7,117,050	$7,412,271	$7,390,550
	Support	$6,027,471	$6,022,431	$6,030,384
Boise, ID 5B	Primary	$6,637,212	$6,898,933	$6,876,305
	Support	$5,553,065	$5,511,273	$5,517,688

Table 1: TEMF Primary and Supporting Facilities Construction Costs

TEMF Houston, TX CZ 2A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,146,782	$1,195,782	4.3%	$1,195,782	4.3%
	HVAC	$863,650	$866,982	2.0%	$866,982	2.0%
	Electrical	$766,685	$890,442	16.1%	$869,031	13.3%
Water	CRS[1]	$0	$13,598	∞	$13,598	∞
Site	Paving	$2,510,769	$2,525,607	0.6%	$2,531,023	0.8%
	Storm	$876,857	$568,850	-35.1%	$568,850	-35.1%
	Plantings	$27,753	$53,236	91.8%	$53,236	91.8%

Table 2: TEMF Breakdown by System Climate Zone 2A

TEMF Memphis, TN CZ 3A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,227,277	$1,275,168	3.9%	$1,275,168	3.9%
	HVAC	$905,075	$915,149	2.7%	$910,221	2.2%
	Electrical	$789,955	$917,873	16.2%	$896,271	13.5%
Water	CRS[1]	$0	$14,584	∞	$14,584	∞
Site	Paving	$2,624,580	$2,650,946	1.0%	$2,656,465	1.2%
	Storm	$909,092	$591,095	-35.0%	$591,095	-35.0%
	Plantings	$29,443	$58,408	98.4%	$58,408	98.4%

Table 3: TEMF Breakdown by System Climate Zone 3A

TEMF El Paso, TX CZ 3B[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,030,177	$1,074,927	4.3%	$1,074,927	4.3%
	HVAC	$698,095	$709,508	3.1%	$709,508	3.1%
	Electrical	$707,447	$826,895	16.9%	$805,555	13.9%
Water	CRS[1]	$0	$9,894	∞	$9,894	∞
Site	Paving	$2,452,558	$2,452,558	0.0%	$2,457,237	0.2%
	Storm	$839,952	$839,952	0.0%	$839,952	0.0%
	Plantings	$18,317	$28,452	55.3%	$28,452	55.3%

Table 4: TEMF Breakdown by System Climate Zone 3B

TEMF Baltimore, MD CZ 4A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,418,288	$1,526,092	7.6%	$1,526,092	7.6%
	HVAC	$977,224	$986,122	2.5%	$986,122	2.5%
	Electrical	$933,917	$1,069,322	14.5%	$1,047,515	12.2%
Water	CRS[1]	$0	$16,011	∞	$16,011	∞
Site	Paving	$2,777,732	$2,814,348	1.3%	$2,821,474	1.6%
	Storm	$1,021,030	$680,054	-33.4%	$680,054	-33.4%
	Plantings	$34,301	$63,362	84.7%	$63,362	84.7%

Table 5: TEMF Breakdown by System Climate Zone 4A

TEMF Salem, OR CZ 4C[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,556,366	$1,679,892	7.9%	$1,679,892	7.9%
	HVAC	$983,655	$1,001,283	3.6%	$1,001,283	3.6%
	Electrical	$919,945	$1,056,546	14.8%	$1,034,825	12.5%
Water	CRS[1]	$0	$17,465	∞	$17,465	∞
Site	Paving	$2,805,022	$2,867,109	2.2%	$2,875,062	2.5%
	Storm	$1,071,440	$741,840	-30.8%	$741,840	-30.8%
	Plantings	$39,037	$68,465	75.4%	$68,465	75.4%

Table 6: TEMF Breakdown by System Climate Zone 4C

TEMF Boise, ID CZ 5B[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,414,268	$1,519,266	7.4%	$1,519,266	7.4%
	HVAC	$918,519	$922,127	2.0%	$921,415	1.9%
	Electrical	$851,583	$990,321	16.3%	$968,406	13.7%
Water	CRS[1]	$0	$14,375	∞	$14,375	∞
Site	Paving	$2,813,227	$2,868,982	2.0%	$2,875,396	2.2%
	Storm	$977,843	$635,201	-35.0%	$635,201	-35.0%
	Plantings	$25,098	$43,586	73.7%	$43,586	73.7%

Table 7: TEMF Breakdown by System Climate Zone 5B

D.5.3 ESTIMATING RESULTS TABLES (Bde HQ)

Bde HQ Construction Cost		ASHRAE 90.1 (2007) Compliant	ASHRAE 189.1 (2009) Compliant	ASHRAE 189.1 (2011) Compliant
Houston, TX 2A	Primary	$7,963,589	$8,156,896	$8,176,124
	Support	$2,391,495	$2,504,481	$2,504,481
Memphis, TN 3A	Primary	$8,446,421	$8,641,962	$8,633,022
	Support	$2,588,650	$2,720,506	$2,720,506
El Paso, TX 3B	Primary	$7,429,442	$7,614,767	$7,611,417
	Support	$2,225,108	$2,271,537	$2,271,537
Baltimore, MD 4A	Primary	$9,327,901	$9,557,863	$9,554,059
	Support	$2,811,536	$2,941,990	$2,941,990
Salem, OR 4C	Primary	$9,646,806	$9,869,347	$9,859,946
	Support	$3,121,864	$3,244,213	$3,244,213
Boise, ID 5B	Primary	$9,032,469	$9,242,668	$9,234,390
	Support	$2,711,233	$2,799,737	$2,799,737

Table 8: Bde HQ Primary and Supporting Facilities Construction Costs

Brigade Headquarters Houston, TX CZ 2A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,059,435	$1,213,840	14.6%	$1,213,840	14.6%
	Plumbing	$282,247	$276,231	-2.1%	$276,231	-2.1%
	HVAC	$2,244,300	$2,227,949	-0.7%	$2,252,298	0.4%
	Electrical	$1,077,371	$1,131,951	5.1%	$1,126,829	4.6%
Water	CRS[1]	$0	$6,689	∞	$6,689	∞
Site	Paving	$1,135,983	$1,142,594	0.6%	$1,142,594	0.6%
	Plantings	$140,526	$391,056	178.3%	$391,056	178.3%

Table 9: Bde HQ Breakdown by System Climate Zone 2A

Brigade Headquarters Memphis, TN CZ 3A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,171,916	$1,316,567	12.3%	$1,316,567	12.3%
	Plumbing	$295,805	$289,662	-2.1%	$289,662	-2.1%
	HVAC	$2,402,728	$2,400,863	-0.1%	$2,397,302	-0.2%
	Electrical	$1,125,911	$1,171,442	4.0%	$1,166,064	3.6%
Water	CRS[1]	$0	$7,283	∞	$7,283	∞
Site	Paving	$1,217,932	$1,225,906	0.7%	$1,225,906	0.7%
	Plantings	$80,341	$204,229	154.2%	$204,229	154.2%

Table 10: Bde HQ Breakdown by System Climate Zone 3A

Brigade Headquarters El Paso, TX CZ 3B[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$988,892	$1,120,751	13.3%	$1,120,751	13.3%
	Plumbing	$260,059	$254,601	-2.1%	$254,601	-2.1%
	HVAC	$2,254,205	$2,261,972	0.3%	$2,261,972	0.3%
	Electrical	$995,314	$1,041,155	4.6%	$1,037,805	4.3%
Water	CRS[1]	$0	$5,317	∞	$5,317	∞
Site	Paving	$1,079,892	$1,085,817	0.5%	$1,085,817	0.5%
	Plantings	$115,588	$317,291	174.5%	$317,291	174.5%

Table 11: Bde HQ Breakdown by System Climate Zone 3B

Brigade Headquarters Baltimore, MD CZ 4A[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,347,344	$1,505,583	11.7%	$1,505,583	11.7%
	Plumbing	$306,715	$300,264	-2.1%	$300,264	-2.1%
	HVAC	$2,430,906	$2,457,076	1.1%	$2,457,076	1.1%
	Electrical	$1,311,000	$1,355,413	3.4%	$1,351,607	3.1%
Water	CRS[1]	$0	$7,591	∞	$7,591	∞
Site	Paving	$1,322,305	$1,331,884	0.7%	$1,331,884	0.7%
	Plantings	$118,706	$317,503	167.5%	$317,503	167.5%

Table 12: Bde HQ Breakdown by System Climate Zone 4A

Brigade Headquarters Salem, OR CZ 4C[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,485,765	$1,643,129	10.6%	$1,643,131	10.6%
	Plumbing	$315,012	$308,315	-2.1%	$308,315	-2.1%
	HVAC	$2,431,211	$2,433,439	0.1%	$2,429,579	-0.1%
	Electrical	$1,320,909	$1,382,152	4.6%	$1,376,610	4.2%
Water	CRS[1]	$0	$8,401	∞	$8,401	∞
Site	Paving	$1,459,512	$1,477,661	1.2%	$1,477,661	1.2%
	Plantings	$195,615	$546,868	179.6%	$546,868	179.6%

Table 13: Bde HQ Breakdown by System Climate Zone 4C

Brigade Headquarters Boise, ID CZ 5B[2]						
Category	System	90.1 (2007)	189.1 (2009)	Delta %[3]	189.1 (2011)	Delta %[3]
Energy	Envelope	$1,329,354	$1,495,462	12.5%	$1,495,462	12.5%
	Plumbing	$300,258	$293,726	-2.2%	$293,726	-2.2%
	HVAC	$2,477,209	$2,466,858	-0.4%	$2,462,490	-0.6%
	Electrical	$1,226,869	$1,281,087	4.4%	$1,277,178	4.1%
Water	CRS[1]	$0	$6,754	∞	$6,754	∞
Site	Paving	$1,294,662	$1,301,971	0.6%	$1,301,971	0.6%
	Plantings	$132,877	$363,367	173.5%	$363,367	173.5%

Table 14: Bde HQ Breakdown by System Climate Zone 5B

Notes:
1. Condensate Recovery System
2. Tables represent Contract Costs.
3. Baseline standard is ASHRAE 90.1 compliant construction.