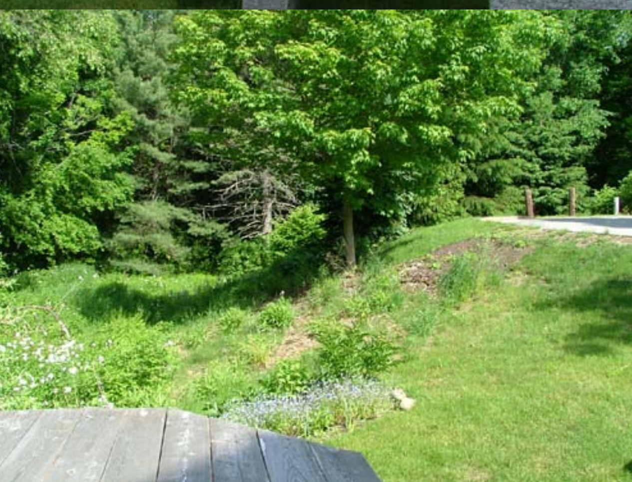

# Building Performance Evaluation and Sustainability Assessment

## Rye Public Library

Rye, New Hampshire

June 2009

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# Acronyms and Abbreviations

| | |
|---|---|
| ADA | American Disabilities Act |
| ANSI | American National Standards Institute |
| ASHRAE | American Society of Heating, Refrigeration, and Air-Conditioning Engineers |
| AT/FP | Antiterrorism / Force Protection |
| cf | Cubic Feet |
| CFM | Cubic Feet per Minute |
| CIP | Cast-In-Place |
| CMU | Concrete Masonry Unit |
| DoE | United States Department of Energy |
| EB | Existing Building |
| EPA | United States Environmental Protection Agency |
| GWP | Global Warming Potential |
| IBC | International Building Codes |
| IBCC | International Building Code Council |
| IEBC | International Existing Building Code |
| IECC | International Energy Conservation Code |
| IESNA | Illuminating Engineering Society of America |
| IR | Infra-Red |
| LEED | Leadership in Energy and Environmental Design |
| LPG | Liquefied Propane Gas |
| M&V | Measurement and Verification |
| MASB | Minimum Antiterrorism Standards for Buildings |
| MERV | Minimum Efficiency Rating Value |
| NC | New Construction |

| | |
|---|---|
| NEC | National Electrical Code |
| NFPA | National Fire Protection Association |
| NG | Natural Gas |
| ODP | Ozone Depletion Potential |
| PESA | Performance Evaluation and Sustainability Assessment |
| psi | Pounds per Square Inch |
| sf | Square Feet |
| UFC | Unified Facilities Criteria |
| USGBC | United States Green Building Council |
| UST | Underground Storage Tank |
| VRFZ | Variable Refrigerant Flow Zone |
| VAV | Variable Air Volume |
| WBDG | Whole Building Design Guide |

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# 1.0 INTRODUCTION

## Forward

Buildings constructed prior to 2003 likely do not comply with current energy efficiency standards for new buildings. In 2003, the *International Energy Conservation Code* (IECC) was developed and adopted by most state and municipal building regulators. The IECC was revised in 2009 which defines new standards including more efficient mechanical equipment and thermal performance of building envelopes.

Through diligent evaluation and enhancement of existing buildings and systems, overall building performance and sustainability can be improved substantially. Enhancements to the building will result in reduced consumption of non-renewable energy resources, improved occupant comfort, and reduced impacts to land, water, and air resources.

## Purpose

Under an existing contract with the Town of Rye for Comprehensive Energy Audits, anix completed a building Performance Evaluation and Sustainability Assessment (PESA) of the Town Library.

The primary objectives of this task are: 1) to evaluate the overall building performance as defined by energy consumption and building integrity; 2) to assess the overall sustainability of the building components and infrastructure; and, 3) provide recommendations that improve building performance and occupant comfort. Consistent with these objectives, the following general scope of this PESA includes: reviewing historical records and existing building drawings provided by the Town of Rye; visual inspection of the building components and systems and photographic documentation (Exhibit A); a thermal imaging survey of the building envelope (Exhibit B); indoor air quality measurements (Exhibits C-F); and, evaluation and assessment of the building components and systems within the context of current building codes and industry standards.

Between June 2nd and 5th, 2009 anix completed a comprehensive inspection of the library facility. Results of this inspection and all information obtained are presented herein. This report also presents pertinent information gathered from a historical records review. Based upon the evaluation, recommendations are provided for consideration. A red flag ( ) symbol included the text body denotes a recommended action; these actions are tabulated in Section 6.0.

## Relevant Codes and Standards

The following current building codes and industry standards are applicable to building performance and sustainability. Although determining compliance with each code and standard is beyond the scope of this PESA, these serve as general guidelines for this building evaluation and assessment.

Table 1.1 – Relevant Codes and Standards

| Current Code / Standard | Issuing Agency | Applicability |
|---|---|---|
| International Building Codes (IBC), 2006 | International Building Code Council (IBCC) | Standards for building construction practices |
| International Energy Conservation Code (IECC), 2006 | International Building Code Council (IBCC) | DoE recognized standard energy code |
| NFPA Standard 70, National Electrical Code (NES), 2008 | National Fire Protection Association (NFPA) | Standards for electrical and life safety practices |
| NFPA Standard 101, Life Safety Code, 2009 | National Fire Protection Association (NFPA) | Industry standard for life safety codes |
| NFPA Standard 5000, Building Construction and Safety Code, 2009 | National Fire Protection Association (NFPA) | Industry standard for fire prevention requirements for new construction |
| American Disabilities Act (ADA), Title III (CFR 28 Part 36), 1994 | U.S. Department of Justice (DoJ) | Building code requirements to accommodate disabled persons |
| ANSI/ASHRAE/IESNA Standard 90.1, 2007 | American Society of Heating, Refrigerating and Air-Conditioning Engineers | DoE and USGBC recognized standard for mechanical and electrical systems |
| ANSI/ASHRAE Standard 62.1, 2007 | American Society of Heating, Refrigerating and Air-Conditioning Engineers | DoE and USGBC recognized standard for ventilation systems |
| Energy Code for New Federal, Commercial and Multi-Family High-Rise Residential Buildings, 10CFR434.401, 2002 | U.S. Department of Energy (DoE) | Older energy code for federal buildings (*currently under revision consistent with other referenced standards*) |
| ENERGY STAR® Guidelines for Energy Management, Buildings and Plants | U.S. Environmental Protection Agency (EPA) | Energy management program that defines processes to increase energy efficiency of commercial buildings |
| LEED® Reference Standard for New Construction and Major Renovation, v. 2.2, 2007 | U.S. Green Building Council (USGBC) | Defines energy performance and sustainability standards required for LEED® certification of commercial buildings |

## Records Review

As part of the library evaluation, available historical documents were reviewed to gain a better understanding of the building systems and components. Documents provided by Town of Rye personnel and reviewed as part of this evaluation include drawing plans from the addition construction project completed in 1998:

- Ground Level HVAC Plan (M1), Tennant/Wallace Architects, 1997
- Upper Level HVAC Plan (M2), Tennant/Wallace Architects, 1997
- HVAC Schedules (M3), Tennant/Wallace Architects, 1997
- Lower Level Floor Plan (A1), Tennant/Wallace Architects, 1997
- Upper Level Floor Plan (A2), Tennant/Wallace Architects, 1997

## Building Description and History

The Town of Rye Public Library is located at 581 Washington Street in the center of Rye within the defined historic district. It is composed of two joined buildings including the original historic structure (c. 1911) and a more recent building addition (c. 1998). The building and associated infrastructure, including parking, are sited on Town owned land within the historic section of the Town center. Abutting the library to the north is the Rye Historical Society and Museum Building. This building shares common access and parking with the library.

The Public Library building is orientated approximately forty degrees counter-clockwise from the north-south axis with the building front facing due southeast. The original building is a two-story Cape Cod style structure with a hip roof and single window dormers projecting from the northeast and southwest roofs and two chimneys located on the rear/northwest wall of the original structure. The addition projects from northwest wall of the original building with a lower level, of which the northwest and southwest walls are exposed, and an upper level which meets the original first floor elevation of the original Library structure.

Although there are few historical records of the original Public Library building, some anecdotal information is provided in a historical account of the Town of Rye written in 1903 by Langdon B. Parsons. This account predates the library construction in 1911 but it identifies Rye as the only town, of thirty-seven, in Rockingham County that does not have a Public Library. He further discusses the Sleeper Legacy in which Oliver Sleeper of Newton, MA, a former resident of Rye, bequeaths $8,000 to the town following his death in 1883 to fund the construction of Rye's first Public Library. A proviso of the bequest stated that in the event that the Town does accept the money for a library then it would be donated in equal portions to the Rye Congregational Church and the Christian Church. On August 1$^{st}$, 1883 an emergency town meeting was called to vote on the library but only a handful of Rye's three-hundred residents attended the meeting and twenty-six votes were cast, the majority of which voted against the library –"then came something very much like a storm".

Hearing of the vote result, the townspeople erupted in angst accusing a group of church members of voting in their own self-interest. A re-vote was held in which the town unanimously approved accepting the bequest for the library. A legal battle ensued between the churches and Town each claiming right to the bequest and ten years later the courts ruled in favor of the churches – after all legal fees each church received the sum of $1,500. From that time to 1903 Langdon states that a Town article has been inserted each year asking "Is it expedient to establish a Town library?" and each year the voters overwhelmingly respond "No". Perhaps the most interesting fact of the Sleeper Legacy is that the library could have been constructed for the cost of legal fees spent as a result of the church and town dispute. The relevance of this historic account is that sometime between 1903 and when the library was constructed in 1911, there was a revelation by the Town of Rye residents that establishing a Public Library was an expedient action.


Rye Public Library, 1911

On March 8$^{th}$, 1910, the Library Trustees issued a report to the Town of Rye documenting the construction of the Rye Public Library. By means of a land donation (current library site) and a financial contribution in the sum of $7,500 made by Mrs. Mary Tucker Rand, the Town finally approved construction of the library. Although the relationship to Mary Rand could not be confirmed, it is of notable interest that Mr. Charles Rand was the successful bidder for construction of the library at the sum of $6,993. This cost was considerably less that the highest bidder at $9,450 and interestingly, left just enough money to cover the cost for the architect design fee by Howard C. Walker of Boston, MA. Presumably, the Rand family worked closely with the Library Trustees to ensure that it was fully funded as to assure approval by the Town of Rye voters – apparently, their definition of "expedient" was consistent with "no taxpayer funding".

## Space Configuration and Use

The net conditioned area of the building is approximately 11,097 square feet including storage and mechanical spaces located on the first floor. This area does not account for the attic space above the original building –prior to the addition construction, this was usable second-story space within the conditioned envelope. The addition represents approximately 90% of the total building area.

Designated use spaces within the library include entry vestibules, common spaces utilized to house the book collection and for reading areas, computer stations, meeting rooms, media rooms, private office spaces, lavatories, storage, and mechanical spaces. Table 1.2 presents the estimated area based on the designated use for the library. Figures 1 and 2 present a building floor plan and use designation map of the library for the lower and upper floors respectively.

Table 1.2 – Gross Floor Area by Use

| Use Designation | Net Conditioned Area (sf) | % Gross Area |
|---|---|---|
| Assembly | 7,865 | 70.9 |
| Dining / Food Prep | 66 | 0.6 |
| Equipment | 37 | 0.3 |
| Lavatory | 167 | 1.5 |
| Mechanical / Utility | 710 | 6.4 |
| Office | 595 | 5.4 |
| Passage | 712 | 6.4 |
| Storage / Warehouse | 615 | 5.5 |
| Utility | 21 | 0.2 |
| Vestibule / Entry | 309 | 2.8 |
| TOTAL: | 11,097 | 100% |

The current building configuration and space use appears to support the needs of the library users. Future planning of town facilities to meet public use needs may consider expanding the library to provide additional capacity for current uses, and/or, adding space to accommodate new use designations such as common meeting space for public use and private study rooms for students. Because the site is constrained, any additions to the building would have to be a vertical expansion by adding a third floor to the existing building.

# 2.0 BUILDING SYSTEMS PERFORMANCE EVALUATION

## Envelope Integrity and Performance

The building envelope and performance of the library buildings were evaluated based on a visual inspection and thermal imaging survey of all building systems and components. Representative photographs are presented in Exhibit A and the thermal survey report is presented as Exhibit B.

### Foundation

The original building has a full basement and is supported by a stone and mortar foundation along the south, east, and west walls with the north wall supported entirely by brick. Foundation walls extend from the cellar floor to grade along the front of the building with increasing exposed faces as the site grade descends from south to north. As part of the addition construction project, a 4-inch thick false concrete masonry unit (CMU) wall was erected to cover the southeast face of the stone foundation wall –no insulation was added to the cavity (Photograph 249). The foundation system for the newer addition consists of a poured concrete spread-footing and walls. It is presumed that the timber framed walls connect to a sill plate that is anchored to the foundation wall.

Exterior and interior visual inspection of the foundation system did not reveal any notable deficiencies such as cracking, spalling, or weakened materials. All mortar, stone, and brick were observed to be in satisfactory condition. Inspection of the foundation and interior walls did not indicate any notable differential settlement. Backfilled soils against the foundation walls appeared stable and well vegetated – no indication of erosion, sloughing, or soil movement were observed.

Some penetrations were noted in the old foundation system and it is recommended that they be sealed using an epoxy-based mortar to mitigate pathways for moisture and insect intrusion (Photographs 213 and 220). Additional noted deficiencies include the old window opening on the west side of the mechanical room where air-conditioning and heating oil piping enters the mechanical room (Photographs 215 and 271). The former window has been replaced with plywood and expanded polyurethane foam to seal the pipe penetrations. The plywood and the expanded foam are deteriorating – it is recommended that they be replaced with more durable and secure materials such as brick and mortar or concrete.

Evidence of water leakage at the southeast corner of the mechanical room on the southwest wall was noted during inspections and confirmed by library personnel (Photograph 245). Water appears to seep through the foundation wall during wet periods flooding a portion of the mechanical room. Inspection of the exterior conditions revealed that the current site grades at the southeast corner of the original building cause runoff to pool and infiltrate along the foundation wall likely creating hydraulic pressure resulting in the wall seepage (Photograph 161). It recommended that this area be filled and stabilized with vegetation to direct the runoff toward the west and away from the foundation.

### Floors

The basement concrete slab-on-grade (SOG) floor was visually inspected in the south mechanical and staff rooms and no indications of settlement or other defects were observed. The remainder of the floor is covered with carpeting –visual inspection did not reveal any indications of floor deficiencies. Floors for the second or upper floor areas are supported by a timber framed joist system which appears to be in satisfactory condition. Intermediate steel columns support the joist floor spans.

## Walls

The perimeter interior walls vary between the original structure and the addition. Walls in the original building consist of a 4-inch thick brick exterior bearing wall, a 10-inch timber framed wall, plaster and lathe, a 4-inch timber framed wall, and plaster and lathe (interior wall covering). Based on the architectural drawing plans (wall sections not available), walls in the newer addition consist of brick veneer, 1-inch of polystyrene rigid insulation board, 6-inch timber framed wall, fiberglass batt insulation (R-19), and two layers of 5/8-inch gypsum wall board. Table 1.3 presents the perimeter interior wall sections based on observations and presumptions.

Table 1.3 – Perimeter Wall Sections

| Location | Wall Section | Cavity Insulation |
|---|---|---|
| Original Structure | Brick & mortar, 2"x4" timber stud wall, plaster & lathe, 4-inch timber stud wall, plaster and lathe. | None |
| Addition | Brick veneer, 1" EPS, 2"x6" timber stud wall, FGB, 2 layers of 5/8" GWB. | FGB (R-19) |

Legend: GWB = Gypsum Wall Board, EPS = Extruded Polystyrene, FGB = Fiberglass Batt

The brick and mortar wall on the original structure is a bearing wall supported by the stone foundation wall. No structural deficiencies were noted and all walls appeared to be plumb and sound. Recommendations for the walls include insulating the walls in the original building and improving insulation in the addition walls particularly at window and outlet box penetrations.

## Ceilings

Ceilings in the original library building are composed of lathe and plaster. Suspended acoustical ceilings are located in the remainder of the building with the exception of the mechanical and storage areas where gypsum wallboard is used for fire-resistance.

All ceilings are in satisfactory condition with the exception of three areas where water staining is evident. A limited area of staining was evident at the addition inner vestibule at the northeast edge of the ceiling (Photographs 125 and 126). Although the source of the water leakage could not be verified, it is assumed to be a result of ice dam formation along the roof eave. This may have resulted due to a lack of insulation at the eave thereby creating a warm roof resulting in a freeze-thaw action and eventual ice dam (evidence of this was provided by the thermal camera imaging which revealed significant heat loss in this location). It is recommended that the roof eave be inspected and insulation be repaired. The second stained area is located at the southeast intersection of the original building and addition (Photographs 48 and 215). This leakage is presumed to emanate from the fresh-air ducts on the rooftop where the caulking has separated from the duct (Photographs 192 to 197, and 200). It is recommended that the rooftop duct penetrations be re-caulked with roofing sealant. The third location of water damage is in the common office area along the northeast wall beneath the attic window dormer. The dormer flashing or window frame is suspected to be the cause of leakage (Photographs 7, 40, and 127). It is recommended that the dormer and window be inspected and repaired as needed.

## Attic

An attic space exists above the original structure which formerly served as a second floor space prior to the newer addition –limited attic space also exists above the addition area beneath the gable roof. Inspection of the attic spaces revealed several issues including accumulated combustible debris (wood and paper), improperly installed ceiling insulation, and poor heating and cooling supply duct connections (Photographs 1-18).

A substantial amount of combustible debris including timber, wooden doors, wooden shelving, and paper is located within the attic space above the original structure. In addition to providing a combustible fuel source in the event of fire, this debris creates a general housekeeping concern by limiting access for workers and encouraging rodent infestation. It is recommended that all debris be removed from the attic space.

The ceiling is considered an integral part of the building envelope since the attic is designated as unconditioned space and there is no insulation within the roof rafters. As part of the addition construction, the second floor space in the original structure was converted to unconditioned attic space. This included insulating the attic floor to perform as the thermal barrier from the conditioned space below. To achieve this, R-30 fiberglass batts were laid directly on top of the attic floor and were not adhered or secured in any manner (Photographs 6, 12, 13, and 16). The batts have become disturbed and compressed from worker access and traffic. Additionally, the batts were improperly placed around existing debris items and do not entirely cover the floor area. As a result, the thermal value of the insulation has been greatly reduced and the effective value of the ceiling insulation is estimated at R-20. Recommendations for the attic space include removing the batt insulation and replacing it with sprayed-foam insulation – this will also reduce the air exchange between the lower conditioned space and the attic space.

Other issues noted within the attic include insufficient ventilation and thermal loss through the ducting and connections (discussed in following sections). Significant thermal transfer through the roof was evident during inspection with the infra-red (IR) thermal imaging camera.

## Roof

The roofing system for the original structure and the addition are composed of plywood decking and asphalt shingles. It is presumed that the entire roof was installed as part of the building addition in 1998. In general, the roof appears to be in satisfactory condition with some minor recommended repairs. Repairs include re-sealing all roof penetrations including the air supply ducts (2) where the deteriorated caulking is assumed to be the cause of leaks into the building interior (southwest duct) (Photographs 192 to 195). Additionally, cracked shingles were noted on the short ridgeline near the southwest chimney most likely the result of traffic by workers accessing the roof area (Photograph 196). It is recommended that this ridgeline section be covered with new shingles to prevent leakage.

## Windows and Glazing

Inspection of the existing window units included visual inspection and a survey with an infra-red (IR) camera. The windows in the historic structure are the original double-hung units with intact sash cord and weights. These windows are low-efficiency single-pane units but are considered to be historically significant to the structure. The window sashes, glazing, and grilles are in good condition. As an alternative to replacing the units with high-efficiency windows, these historic windows can be preserved and retrofitted to improve thermal performance. Retrofitting of the units includes removing the original sash cord and weights and filling the weight cavities with expanding insulation such as polyurethane foam. It is also recommended that the windows be permanently sealed to minimize air infiltration by caulking the interior and exterior frame using polyurethane caulking. Although this will prevent operation of the window units, the newer operating units in the addition can be used to provide fresh-air ventilation during transitional seasons (spring and fall).

Windows in the addition include wood-framed operating double-hung units and aluminum-framed fixed units. All units consist of double-pane glass with a ½-inch air-break and metal spacer. The window units (c. 1998) were found to be in good condition but are considered sub-standard compared to today's high-efficiency units based on UV and thermal integrity. Noted deficiencies included gaps between the sash and frame due to improper installation. Several of the double-hung units were found to have inadequate seals allowing air infiltration (Photographs 56 and 58). It is recommended that the seals be repaired or replaced. Some of the caulking at the exterior frame is failing and should be removed and replaced (Photographs 141 and143). Table 1.4 presents a window schedule for the library.

The roof overhang provides some shading of the upper fixed light units on the addition. Deciduous trees to the northwest and southwest provide shading thereby reducing solar heat loading during cooling periods. Interior horizontal shades are located on the original double-hung windows in the older building helping to reduce solar heat gain during cooling periods.

Table 1.4 – Window Schedule

| Unit No. | Location | Window Type | Operable/ Fixed | Window Construction | Notes |
|---|---|---|---|---|---|
| 1 | Addition | Double-hung | O | Wood and vinyl framed, double-pane glazing with ½" air-break and metal spacer. | Low-efficiency units. Several units have gaps between sash and frame due to poor installation. |
| 2 | Original Structure | Double-hung, true divided lights | O | Wood frame, sash, and grilles. Single-pane glass. Sash cord and weight operation. | Very low-efficiency units. Original historic windows in operable condition. |
| 3 | Addition | Undivided lights and storefront assemblies | F | Aluminum frame, double-pane glazing with ½" air-break and metal spacer. | Low-efficiency units. Some caulking is separating from glazing. |

## Doors

Similar to the windows, inspection of the existing entry doors units included checking door operation, visual inspection of door integrity, and a survey with an IR camera. There are a total of five entry doors for the library including the main entry which includes a storefront system consisting of four glass door units on the outer vestibule and four glass doors on the inner vestibule.

Doors on the northwest and southwest faces provide emergency egress from the northwest stairwell and the multi-purpose media room, respectively. A solid wood door is located on the southeast face and served as the main entry to original structure. This door now functions as an emergency egress and was observed to be in satisfactory condition with the exception of gaps along the frame and threshold. Frame and threshold seals on all entry doors should be adjusted or replaced to reduce air infiltration. Caulking around the front entry aluminum door frames has deteriorated (Photographs 181, 184, 185. Removal of the existing caulking and placement of polyurethane caulking is recommended.

The mechanical room door consists of an older wooden unit with top glazing and a lower louver panel. This door is very inefficient and unsecure as entry can be easily gained through the door and into the building. Replacement of this door with a hollow metal insulated door unit is recommended. Table 1.5 presents a schedule of all entry doors for the library.

Table 1.5 – Entry Door Schedule

| Perimeter Wall | Location | Door Type | Glazing | Notes |
|---|---|---|---|---|
| Northeast | Storefront Entry | Full glazed units, double-pane glass w/ ½" air-break. | Full | Air gaps on units. Frame and threshold seals require replacement. |
| Northwest | Northwest Corner | Metal insulated door with top glazing | Upper | Adjust seals to reduce air infiltration. |
| Southwest | Multi-purpose Room | Metal insulated door with top glazing | Upper | Adjust seals to reduce air infiltration. |
| | Mechanical Room | Solid wood door with ventilation louvers and top glazing. | Upper | Very inefficient door. Louvers are covered with cardboard to reduce air infiltration. Replacement recommended. |
| Southeast | Original Front Entry | Solid wood door | None | Air gaps on frame and threshold. Requires new seals. |

### Exterior Trim

Observations of the exterior trim include peeling paint and weathering of wood, it is most notable on the southwest side of the building which is mostly shaded (Photographs 138, 140, 145, 146). It is recommended that all wood trim including fascia, eave-boards, roof edge molding, and window molding be scraped, sanded, primed, and repainted using a high quality exterior grade paint.

Some of the mortar for the stonework including the granite watermark on the original building has deteriorated (Photograph 160, 161, 173, 175). It is recommended that the mortar be repaired.

## Mechanical Systems

### Heating

Heating is provided to the library from a series of oil-fueled furnace units. Furnace units include two single units and two double units twinned in parallel. The furnaces supply four zones including two on the lower floor and two on the upper floor – published specifications (Tennant/Wallace) are presented in Table 1.6.

Table 1.6 – Furnace Unit Rated Specifications(1)

| Unit No. | No. Furnaces | CFM | AFUE (%) | Output (BTUH) | Notes |
|---|---|---|---|---|---|
| FU-1 | 1 | 2,000 | 81.5 | 151,200 | Inoperable. |
| FU-2 | 1 | 1,000 | 82.1 | 95,200 | Improper filter seal on air supply. |
| FU-3 | 2 | 2,000 | 81.5 | 151,200 | Improper filter seal on air supply. Evidence of water leakage inside furnace. |
| FU-4 | 2 | 2,000 | 81.5 | 151,200 | Improper filter seal on air supply. Evidence of water leakage inside furnace. |

(1) All specifications obtained from design schedule by Tennant/Wallace Architects, dated 1997.

Issues noted during inspection of the furnace units include evidence of water leakage from the air supply plenum (Photograph 112), unsealed supply filters (Photographs 115 and 117), and frequent repair of the units. Furnace FU-1 supplies the lower children's library area (northwest area) and is currently inoperable. According to library personnel the unit stopped working during the past heating season. Personnel also indicated that the furnace units require frequent repair. Considering the low-efficiency of the oil-fueled furnace units, poor controllability, repair history, and high air emissions, replacement of the entire heating system should be evaluated (refer to Section 4.0 of this report).

Recorded temperatures in the conditioned areas of the library ranged from 73°F to 77°F with an average reading of 75°F. It is noted that the temperatures are elevated due increased thermostat settings on the previous night to provide a better assessment of the system operation and envelope performance. The deviation in temperature suggests that heating distribution throughout the conditioned spaces is not balanced. This is partly a result of the inoperable furnace unit supplying the lower northwest wing.

Hot air from the furnaces is distributed via ductwork and ceiling mounted diffusers. Ductwork for the lower level is routed from the smaller mechanical room in the addition (southwest area) through the suspended ceiling. Ductwork for the upper level is routed vertically to the attic space where it connects to horizontal ducting. Connection from main supply ducts to the air diffusers is made with round solid and flexible ducting. All ductwork is insulated with wrapped fiberglass having a rated thermal value of R-5. As evidenced by the thermal imaging camera, issues with the ductwork include poorly insulated duct connections and damaged insulation (IR Report pp. 37-48). The effective insulation rating on the attic ductwork is estimated to be R-3. Recommendations for the supply ductwork include improving insulation on connections and installing additional insulation to reduce thermal transfer from the ducting into the unconditioned attic space.

The thermal imaging camera provided further evidence of the heat loss into the attic space based on survey of the exterior roof and eaves where a substantial amount of heat loss was detected (IR Report pp. 1-3, 5, 6, 8, 14, 18, 19, 20, 26, 32, 35). Based on observations, the estimated heat loss from the attic space to the atmosphere is 15% to 25% of the total generated heat by the furnace systems.

## Cooling

Cooling is supplied to the library building from a series of DX condensing units located on an exterior mechanical pad at the southwest side of the building. Table 1.7 presents a schedule of the air-conditioner condensing units.

Table 1.7 – Air-Conditioner Condensing Unit Rated Specifications(1)

| Unit No. | Refrigerant | Sensible (BTU/hr) | SEER Rating | Notes |
|---|---|---|---|---|
| CU-1 | R-22 | 41,760 | 10 | Condenser piping insulation is low quality material and incomplete. |
| CU-2 | R-22 | 24,700 | 11 | Condenser piping insulation is low quality material and incomplete. |
| CU-3A | R-22 | 41,760 | 10 | Condenser piping insulation is low quality material and incomplete. |
| CU-3B | R-22 | 41,760 | 10 | Condenser piping insulation is low quality material and incomplete. |
| CU-4A | R-22 | 41,760 | 10 | Condenser piping insulation is low quality material and incomplete. |
| CU-4B | R-22 | 41,760 | 10 | Condenser piping insulation is low quality material and incomplete. |

(1) All specifications obtained from design schedule by Tennant/Wallace Architects, dated 1997.

The condenser units are low-efficiency units compared to available technology. For example, high-efficiency condenser units can achieve SEER ratings in excess of 15. Therefore, a SEER 15 unit provides an equivalent amount of cooling capacity while using 33% less energy than the existing SEER 10 units. The existing condensing units contain R-22 refrigerant which has a relatively high ozone depletion potential (ODP) and global warming potential (GWP) compared to other available refrigerants.

Minimum recommendations for the existing cooling system include re-insulating the existing condenser piping with high thermal rated insulation. The units should also be covered during the winter months to prevent accumulation of debris and protect the condensers. Similar to the heating system, improving the duct insulation in the attic will improve the efficiency of the cooling system by reducing the cooling loss into the attic space. Ideally, the existing cooling system would be replaced concurrent with the heating system (refer to Section 4.0).

## Humidity Control

Measured relative humidity (RH) levels in the library indicate that humidity is within the recommended range per ASHRAE (25% to 60%). Recorded levels in the conditioned spaces of the library varied from 40% to 44% with an average level of 42% (Figure 4 and Exhibit E). It should be noted that the humidity measurements represent a single-point in time and that humidity will change based on meteorological conditions, building loading, and HVAC system operation. RH levels should be routinely measured and following any HVAC system modifications or improvements, ideally during peak heating and cooling periods. Proper humidity control is critical in libraries where historical documents may be stored and to ensure occupant comfort.

There are humidification units attached to each furnace unit. Operation of the units could not be verified but it is recommended that they be routinely cleaned and tested as part of the annual heating system inspection and maintenance. Manual controls for the humidifiers are located next to each thermostat. A new humidification system should be integrated into the design of a new heating and cooling system.

Humidity levels in the basement area are high due to moisture infiltration along the southwest wall in the mechanical room. This has created an uncomfortable environment for library staff and a portable dehumidifier and several air filtration units have been placed in the basement areas. Raising the perimeter grades along the exterior southwest perimeter will reduce water infiltration and design of a new HVAC system should consider humidity control for the basement areas.

### Ventilation

Return air is conveyed from within the building through a return plenum to the furnace units. Make-up outdoor air is provided to the furnace units supplying the upper floor via rooftop mounted ducting. The two ducts supplying the main mechanical room (FU-3 and FU-4) are rated at 130 CFM each and have manual volume dampers located in the mechanical room – these dampers should remain fully open to ensure adequate outdoor air supply. As part of a new HVAC system design, heat recovery units are recommended to improve outdoor air volume and to condition/heat the outdoor air prior to entering the furnace. Fresh-air is also supplied to the building through the operating double-hung windows and doors. During inspection several windows were observed to be open for passive air ventilation.

Based on the measured carbon dioxide ($CO^2$) concentrations in the library, the existing ventilation is inadequate for the building. The EPA recommended threshold for $CO^2$ is 1,000 parts per million (ppm) and of thirteen measurements throughout the lower and upper level occupied areas the concentration ranged from 1,137 ppm to 1,510 ppm with an average concentration of 1,296 ppm (Exhibits C and D). Based on these results, design of a new ventilation system is recommended – this should be considered as part of a new HVAC system design.

Combustion air is supplied via fixed door louvers in the main mechanical room and from mechanical wall vents in the secondary mechanical room. A piece of cardboard was blocking the door louvers to prevent air infiltration (Photograph 107). Installation of a new damper controlled vent is recommended as replacement to the passive louvers. The mechanical vents were noted to be in the open position when the HVAC system was off –it is recommended that the vents be inspected as part of the routine annual furnace maintenance to ensure proper operation.

Exhaust ventilation is provided by four fans located in the three lavatories and in the attic. The attic fan is rated at 220 CFM and is controlled by an automatic high limit thermostat. The fan was not operating during the inspection, operation of the fan should be tested and verified to ensure adequate building ventilation during cooling periods. It is also recommended that all exhaust fans be connected to the light switches to ensure operation during occupancy – this includes the exhaust in the utility room where cleaners and chemicals are typically used. Some of the exhaust fans are partially clogged and should be cleaned to ensure proper air flow (Photograph 43). Passive vents were also noted on the roof/attic.

## Electrical Systems

### Supply and Distribution

As part of the renovation and building addition a new 600-amp service was installed in the library mechanical room on the southeast wall. This service supplies two 225-amp, 120/208v, 3-phase circuit panels (Photographs 93-95, 97-98). The circuit panels are labeled and all electrical workmanship appears satisfactory. All wiring and outlets in the original building appear to have been replaced during the renovation.

It is noted that the electrical outlets in the basement are not GFCI protected. Because the basement has a history of flooding, it is recommended that all outlets in the mechanical room be changed to GFCI protected outlets .

## Lighting

Lighting fixtures in the library consist primarily of 4-foot fluorescent units. Other fixtures include recessed fixtures (lavatories), pendant fixtures (upper level northwest area), 4-inch diameter recessed fixtures (multi-purpose room), and 4-inch diameter track lights.

The fluorescent lighting ballasts and bulbs were recently replaced with low-wattage units by the local electrical utility company (PSNH). This conversion is expected to provide a noticeable reduction in electrical consumption as lighting is the primary electrical energy usage for the library. Other recommended measures include replacing all incandescent bulbs with compact fluorescent bulbs. Some of the lighting fixtures are controlled by motion sensitive switches such as the lavatories –it is recommended that motion sensitive switches be installed in all secondary spaces including offices, meeting rooms, and reading rooms .

## Appliances

The kitchenette area on the lower floor contains several small appliances including a compact refrigerator, microwave oven, and coffee makers. Future replacement of these appliances should consider EnergyStar rated units.

Several air-filtration units and a dehumidifier are located in the basement area and staff work room to reduce humidity levels (Photographs 84, 89, and 96). The air-cleaner units consume large amounts of electricity and will not reduce humidity levels. It is recommended that the air-filtration units be replaced with one or two additional EnergyStar rated portable dehumidifiers placed in the mechanical room where the source of the moisture infiltration is evident . Design of a new HVAC system should include humidity control in the basement so that local humidifier units are no longer needed.

## Mechanical Equipment

Major electrically controlled mechanical equipment includes the furnace fan units and the domestic hot water heater. By consolidating the six furnace fan units to fewer central units, or, installing a remote zone fan system such as variable air volume (VAV) units, the electrical consumption would be substantially reduced from the current configuration. Other recommendations include replacing the 40-gallon domestic hot water tank with propane or electric tankless unit(s) .

## Electronics

Notable electronic equipment for the library includes computers for staff and public access, a photocopier machine, a large screen television (multi-purpose room), and chargers for battery operated equipment. Often referred to "phantom loads" these electronics can be a significant source of electrical consumption. As evidenced by the thermal camera images (IR Report pp. 86, 87, 96, 101, and 106), these electronics also contribute to heat load within the building during cooling periods.

Recommendations to help reduce phantom loads include powering off all office equipment at the end of each day (computers, photocopier, and printers) and removing chargers from outlets when not in use. By plugging all equipment into a surge protected multi-outlet, multiple equipment can be powered on and off using a single switch.

## Plumbing Systems

### Water Supply and Distribution

Water for the library is supplied from a public distribution system managed by the Town of Rye. Based on visual inspection, it appears that all of the water distribution system was replaced as part of the renovation and addition project in 1998. No distribution system issues were noted and supply pressures are adequate for the current uses.

Recommendations for the water supply piping include reviewing Town records to verify that the main water supply pipe was replaced in 1998. If the original pipe and connection exists, complete replacement is recommended to mitigate a potential failure.

### Domestic Hot Water

Domestic hot water is provided by a forty-gallon electric hot water tank located in the main mechanical room (Photographs 104 and 105). The unit is relatively new but is not a high-efficiency unit compared to current standards. As evidenced by the IR thermal imaging (IR Report p. 107), thermal insulation of the unit and piping is insufficient.

Instant-on tankless units would reduce the electrical energy usage compared to the current system that continually heats water for the building. Because there are no high-volume demands for domestic hot water (e.g., showers), a single high-efficiency electric or propane tankless unit could replace the existing tank unit. Another option is to install multiple local units to the lavatories and kitchenette –this option is more costly but would reduce water consumption and associated costs as heated water would be immediately available and the user would not have to run gallons of water waiting for hot water.

### Fixtures

Plumbing fixtures in the library building include sinks, wash sinks, urinals, and toilets. Table 2.1 presents a summary of the interior fixtures and estimated maximum flow rates.

The lavatory sinks are controlled by motion-sensitive actuators (Photograph 46). Toilets have an air-pressure assisted flush. No leaking fixtures were observed and all fixtures appear to be operating as designed.

Table 2.1 –Interior Plumbing Fixtures

| Room and Description | Photograph No.(s) | Fixture Type | Qty. | Est. Max. Flow Rate (gpm/gpf) |
|---|---|---|---|---|
| Kitchenette | 74 | Kitchen Sink Faucet | 1 | 2.0 |
| Utility Sink | 75 | Sink Faucet | 1 | 3.0 |
| Women's Lavatory | 69-72 | Sink Faucets | 2 | 1.5 |
| | | Toilets | 2 | 1.6 |
| Men's Lavatory | 68 | Sink Faucet | 1 | 1.5 |
| | | Toilets | 1 | 1.6 |
| Staff Lavatory | 45-46 | Sink Faucet | 1 | 3.0 |
| | | Toilet | 1 | 2.0 |

### Sanitary Systems

All sanitary wastes drain to an on-site septic system. Plans and design information for the system were not available. Annual or bi-annual cleaning and inspection of the system is recommended to ensure proper operation.

## Hazardous Building Materials

Completion of a detailed building materials hazardous survey is beyond the scope of this evaluation, however, the following information is provided based on the building age and observations noted during the inspection. This is not intended to be a comprehensive listing and is provided as anecdotal information only.

### Asbestos Containing Materials

Some common asbestos containing materials (ACMs) used in building construction prior to the mid-1970s include:

- Pipe insulation
- Refractory masonry.
- Asphaltic roofing.
- Flooring tiles.
- Mastics and adhesives.
- Window glazing compound.
- Siding (transite).
- Piping (transite).

The addition was constructed in 1998 and does not contain any potential asbestos containing materials (ACMs). Potential ACMs in the original building include the brick and stone mortar, window glazing compound, piping insulation hidden in the existing walls, exterior buried piping insulation (heating oil supply), and exterior buried drainage piping (transite). Based on observed conditions, none of these suspect materials appear to pose a current hazard. However, it is recommended that these building components be tested for ACM prior to disturbing or removing/demolishing.

### Lead Paint

Based on the age of Building 100, it should be assumed that all original painted surfaces are covered with lead-based paints and/or primers. Suspect items include equipment, piping, walls, doors and moldings, windows moldings, and all exterior trim. Peeling and subsequent air suspension of lead containing particles presents the greatest hazard to building occupants (inhalation hazard). Peeling of painted interior surfaces was not apparent during the inspection, however, some peeling was observed on the exterior trim. Other activities that could create a hazard include sanding, grinding, and welding of lead painted surfaces. It is recommended that primed and painted surfaces in the original building be tested for lead prior to disturbing or disposing of such. Considering the addition age, it is not expected to contain lead paint.

### Mercury

Mercury containing devices in the library building are limited to fluorescent light bulbs. Old bulbs should be segregated for proper disposal/recycling. Several old 8-foot disconnected fluorescent light fixtures and bulbs are located in the attic space above the original building (Photograph 20). It is recommended that these bulbs be removed and properly disposed of.

### PCBs

Many older fluorescent lighting ballasts were manufactured with PCB containing capacitors. The old fixtures in the attic (Photograph 20) are suspected to contain PCB capacitors. Removal of the fixture housing will reveal the capacitors and unless they are clearly marked “DOES NOT CONTAIN PCBs”, then it should be assumed that the capacitors do contain PCBs.

# 3.0 BUILDING CODE COMPLIANCE

Although establishing compliance with current building code and regulatory requirements including the *International Building Code* (IBC) standards and the *American Disabilities Act* (ADA) is not the objective of this evaluation, following are some observations that may warrant further evaluation as part of planned building maintenance and alterations. Planned building renovations should also consider compliance with current and applicable building code standards, particularly the *International Existing Building Code* (IEBC, 2009) and the *International Energy Conservation Code* (IECC, 2006).

## Building Systems

### Insulation

The current building envelope insulation does not comply with current *International Energy and Conservation Code*, *2009* (IECC, 2009) standards. Potential improvements to the thermal envelope are discussed further in Section 2.0.

### Mechanical

No mechanical code compliance issues were noted during the inspection. It is recommended that operation of the duct smoke alarms be routinely tested for proper operation (see following Life Safety section).

### Electrical

The existing electrical distribution was evaluated based on current *National Electrical Cod*e (NEC, 2008) standards. Specific items noted during inspection that warrant further evaluation include:

- No GFCI protection on outlets in mechanical room where flooding occurs.

It is also recommended that all abandoned, de-energized wiring in the attic be completely removed (Photograph 18).

### Plumbing

No plumbing code compliance issues were noted during the inspection.

### Sanitary

The on-site septic discharge system (i.e., tanks and distribution field) was not inspected as part of this evaluation. It is recommended that the system be cleaned and inspected annually. Indications of a failed leaching/distribution field were not observed during the site inspection.

### Life Safety

As discussed in Section 2.0, a considerable amount of combustible debris is located in the abandoned attic space above the original building. This debris presents a fire hazard and should be removed.

A sprinkler system provides protection for all occupied areas and most of the unoccupied spaces including the mechanical room and attic space (Photographs 1, 91, and 92). An annual inspection of the system was recently completed and no issues were noted. The lower storage area used for staff activities does not contain a sprinkler system. Because the space contains electronic equipment and combustible materials, adding sprinkler protection to this area should be considered.

Testing of the fire detection and notification systems should be completed on a routine basis to ensure proper operation. Detection and notification apparatus includes duct smoke detectors in all furnace plenums, heat detectors in attic space, smoke/heat detectors in occupied spaces, audible and visual notification devices, and emergency egress lighting. This should be coordinated and completed by the Town of Rye Fire Department.

Emergency egress was inspected and appears to function as required. That is, egress points were clearly marked, emergency lighting was present, and access to the egress points was clear.

## ADA Compliance

### Parking

Handicap accessible parking spaces are provided and clearly marked in the main library parking area.

### Access and Egress

The main northeast vestibule entry is an at-grade entrance with two double doors. This outer vestibule connects to the inner vestibule where an elevator is located. Emergency egress from the lower area is provided by the northwest stairwell door. There is no at-grade emergency access from the upper floor in the event of that the elevator is inoperable –this would require wheelchair access either down the stairs to the main vestibule or down the stairs of the original entry on the southeast face. It is recommended that the library develop a contingency plan with the Rye Fire Department for assisting handicapped occupants in such event. ADA compliance should also consider installing automatic door openers and switches on the main vestibule entry doors.

### Lavatory Facilities

The public lavatory facilities appear to comply with ADA requirements.

### Kitchen Facilities

As currently configured, the kitchenette does not comply with ADA standards including countertop and sink access.

### Alarms

In addition to audible alarms, ADA requires that visual alarms are also present in occupied areas. Although present in the lavatories, visual alarms were not observed in the general assembly areas of the library.

# 4.0 SUSTAINABILITY ASSESSMENT

Although based largely upon the building performance evaluation, the following sustainability assessment provides a more holistic approach to evaluating the site and building and assessing overall sustainability, which by implication, also measures building performance. Because much of the information provided in the Performance Evaluation narrative, the reader should review that section to establish a competent understanding of the site, building, and all components.

This assessment is consistent with current industry sustainability initiatives and more specifically the intent of the U.S. Green Building Council (USGBC), *Leadership in Energy and Environmental Design* (LEED) program. The following sections provide a qualitative assessment of the Town of Rye Public Library and a general description of recommended performance and sustainability enhancements.

## Site

The Public Library site is considered to include the driveway, parking areas, and all landscaped areas adjacent to the building. Storm water generally flows east to west eventually draining to a wet area located due west of the site. Runoff controls are limited to some small catch basins and piping located on the northeast and southwest perimeters of the building to prevent water from pooling against the building. Landscaped areas are covered with native grasses, groundcover, trees, and shrubs. Mature deciduous trees on the southeast provide adequate shading for the building during summer months.

Presently a portion of the storm runoff flows offsite directly into the west wetland area. Methods to increase on-site infiltration include constructing a rain garden consisting of a small detention area planted with native water-loving plants. This would help improve storm water quality by reducing the potential for soils erosion and sediment transportation and will help treat runoff before entering the wetland.

Existing vegetation was in good condition and with the exception of an area located on the driveway turn-around (Photograph 135), all soils are well stabilized. Recommendations to repair the eroded section of slope include placing topsoil and native groundcover. The area should be maintained until the groundcover is established and soils are stabilized.

Although the site is very well planted with a rich variety of native shrubs and trees, recommendations include planting additional native deciduous shade trees on the northeast side of the building to help shade the storefront entry which creates a significant solar heat gain during cooling periods. Other potential site enhancements for the library site include reducing turf areas and replacing with low-maintenance, native drought-tolerant groundcover and shrubs. Recommended plants include native shrubs and spreading groundcover to improve soils stabilization on the slope and reduce mowing and maintenance requirements.

Other potential site sustainability initiatives include encouraging reduced air emissions and fuel conservation and by providing preferred parking for low-emissions and fuel-conserving/alternative energy vehicles.

## Water

Because there are no industrial or irrigation systems for the library, water usage is limited to the plumbing fixtures in the lavatory and kitchen areas. Most of the sink faucets and toilets are relatively new (c. 1998) and are low-usage fixtures. Sinks have motion-sensitive actuators and toilets have air-pressure assisted flush –both of the measures help to conserve water usage.

## Energy and Atmosphere

### Mechanical Systems

As presented in Section 2.0, the existing heating and cooling system consists of a split-system with oil-fired furnaces and DX condensing units. This equipment is low-efficiency and requires frequent maintenance and repair. The furnaces have a low-efficiency combustion resulting in increased particulate and gas emissions to the atmosphere (carbon dioxide, nitrogen oxides, and sulfur dioxide). There are no heat-recovery units and combustion heat is directly exhausted resulting in atmospheric warming. Leakage in the attic space ductwork is a source of thermal transfer resulting in substantial heat and cooling loss. The current configuration consisting of multiple furnace units and air-conditioning condenser units results in reduced operating efficiency (increased fuel usage and electricity for fan operation) and higher maintenance and repair costs. Furthermore, occupant comfort could be significantly improved by increasing heating and cooling zones and occupant control. Based on the system assessment and the current configuration, the existing heating and cooling system is recommended for replacement.

Replacement of the heating system should consider consolidating the units from six furnaces to a single high-efficiency oil-fired unit, a gas-fired unit, or an electric heat-pump system. Compared to conventional heating oil, domestically derived natural gas and propane gas have higher combustion efficiencies, lower stack emissions, and gas burning units require less maintenance than oil burning units. Although natural gas is a superior fuel compared to propane, regional availability may be limited in Rye. Alternative systems include high-efficiency electric heat pump systems with local VAV units – these provide the most efficient operation and are particularly efficient where simultaneous heating and cooling is required and can supply multiple zones from a single unit. It is also recommended that high efficiency filters having a Minimum Efficiency Reporting Value (MERV) of 13 or better be installed on the air distribution system(s) to improve indoor air quality.

Alternative humidification systems should also be considered including direct-injection (isothermic), electrode, and electric element humidification units. Multiple local systems would improve system controllability and efficiency.

In summary, design of a new HVAC system should consider:

- Single packaged high-efficiency heat-pump system with multiple zones (15-20).
- Programmable thermostat management with setbacks and pre and post-occupancy ventilation.
- Heat-recovery system.
- Carbon dioxide sensors and automatic exhaust fan controls.
- Humidity system including sensors and automatic controls.
- Humidity control for the basement area.
- High efficiency filtration system with MERV of 13 or better.

- Improving and reusing existing ductwork, or, installing new ductwork with minimum insulation rating of R-10.

## Domestic Hot Water

The 40-gallon electric domestic hot water heating tank unit servicing the library is an inefficient unit requiring substantial electrical consumption. Replacement with a single high-efficiency electric tankless unit or multiple local units would substantially reduce electrical consumption. Multiple local units would also reduce water consumption. A solar-powered unit might also be evaluated and costs should consider available state and federal tax credits in addition to reduced energy costs.

## Thermal Envelope

The existing thermal envelope for the original library structure does not comply with current energy code standards (IECC, 2009). Perimeter walls have assembly R-values 5.3 and 21 for the original building and addition, respectively. Based on results of the IR thermal imaging which revealed several gaps in the addition wall and ceiling insulation (vaulted section), the assembly value efficiencies were prorated accordingly. Roofing/ceiling R-values vary from 20 to 26 for the drop-ceiling section and the vaulted ceiling section in the northwest area. Assembly descriptions and associated R-values for the floors, walls, and roofs are summarized in Table 4.1.

Recommendations include insulating the three walls of the original building. The most economical and least intrusive approach is to improve the walls from the interior by filling the frame cavities with a loose-fill insulation product –depending on wall construction this would be applied from the wall top plate or through small holes in the wall plaster. Improving the insulation in the addition walls and vaulted ceiling could be achieved by identifying insulation gaps with an IR thermal imaging camera and then filling them with sprayed-foam insulation from the interior. The fiberglass batts ceiling insulation in the attic space should be replaced with by either removing the subfloor and insulting the ceiling joist cavities, or applying a sprayed-foam product directly on the subfloor.

Table 4.1 – Thermal Envelope R-Values

| Building Component | Assembly Description | Effective Assembly R-Value(1) |
|---|---|---|
| Floors – Carpet | 6" Concrete w/ carpet | 2.4 |
| Floors – Tile | 6" Concrete w/ tile | 1.4 |
| Floors – Concrete | 6" Concrete | 1.2 |
| Perimeter Walls – Original | 4" Brick & mortar, 8" timber stud wall, plaster & lathe, 4" timber stud wall, plaster & lathe. | 5.3 |
| Perimeter Walls – Addition | 1" Brick veneer, 1" EPS, 6" timber stud wall (16" OC), FGB, 2 layers of 5/8" GWB (low quality) | 21 |
| Roof/Ceiling | Acoustical ceiling panels, R-30 FGB (low quality) | 20 |
| Roof/Ceiling – Vaulted Section | GWB, R-30 FGB (low quality) | 26 |

(1) Assembly values include interior air films (0.68 for walls and 0.61 for ceilings) and exterior air films (0.17).

If the original windows are to be preserved, then it is recommended that the sash cord and weights be removed and the cavity filled with insulating foam. The windows should be sealed and the sash should be caulked to the frame using a polyethylene caulking. The newer operable double-hung windows in the addition should be inspected and all gaps should be repaired by either repairing the existing seal or installing a new seal.

## Renewable Energy Considerations

To explore potential renewable energy applications we have completed a preliminary evaluation of potential technologies that might be practically implemented for the library considering site constraints and building function. Table 4.2 presents the potential technologies and provides a preliminary assessment of economic considerations and feasibility for the Library.

Table 4.2 – Potential Renewable Energy Applications

| Energy Application | Economic Considerations | Feasibility Assessment |
|---|---|---|
| Photovoltaic Systems | PV systems are relatively expensive and without significant State financial incentives, the ROI period is long. | A relatively large area would be required to justify the installation expense. The building does not have a roof plane oriented within 20° of due south. The southwest plane is shaded by mature deciduous trees. |
| Solar Domestic Hot Water | Systems are relatively expensive due to installation of piping network and they have a substantial ROI period. | A smaller area is required for the solar panel and could be sited on the ground. Considering that the domestic hot water demand is very low for the library, the payback would be significant. |
| Combined Heat and Power Systems | CHP or cogeneration systems are proven technology in the industrial sector. Systems are typically developed for large power demand industry and commercial facilities. | Because the unit is powered by a combustion engine, noise and exhaust emissions are a concern considering the small site and proximity to residential areas. A large fuel storage tank would be necessary on an already constrained site. |
| Geothermal Heating/Cooling | Geothermal heating/cooling systems can be very cost-effective systems depending on site constraints. ROI in the New England area varies from 5-20 years for the wells and piping system (not including equipment). | Because the site is constrained in area, the wells and piping network would have to be installed beneath the parking lot. Very simple and proven technology. Because the building is relatively small, the payback period will be substantial (>15 years). |
| Wind Power | Small-scale wind power systems are very costly compared to the energy savings. Systems are proving to be less efficient than expected in New England. | Wind towers would require a State permit and a Town zoning variance based on the height. Erecting a tower in the historic district of Town would likely create public concern. |
| Biomass Heating | Biomass systems can be cost effective assuming an endless supply of inexpensive biofuel. | Technology for small-scale applications is relatively new. Biomass fuel is a commodity with limited availability –pricing will increase with demand. |
| Green Grid Power | Regulated power supply from private energy companies provided at a higher rate. No capital investment in technology that can become obsolescent. Can terminate agreement at anytime. | Energy is developed by alternative Green technologies including wind farms, hydroelectric, and PV farms. |

All of the proposed renewable energy applications would improve the sustainability of the Rye Public Library. With the exception of Green Grid Power, each technology poses unique risks with respect to function, operating costs, and future costs of nonrenewable energies including coal, gas, and oil. The one consistent consideration among all of the renewable technologies is that the larger scale the application, the more economically feasible it becomes. Therefore, the Town might consider large-scale renewable energy applications that could support multiple buildings and facilities.

## Materials and Resources

The Public Library currently operates a recycling program in conjunction with the Town DPW. Other sustainable initiatives may include using only non-toxic cleaners. Building materials are more than ten years old and were installed prior to the availability of Green building materials that reduce the use of natural resources and toxins. For example, the existing carpeting and wall paint contain a high level of volatile organic compounds (VOCs) that are released to the indoor air over time. Replacement of these materials should consider using Green products.

## Indoor Environmental Quality

### Heating and Cooling Venting

As discussed in Section 2.0, indoor air quality measurements suggest that ventilation should be improved. Carbon dioxide concentrations exceeded EPAs recommended threshold for indoor air quality of 1,000 ppm. This is best achieved by designing a new HVAC system that includes air quality monitoring, increased outdoor air supply, and heat recovery units.

### Humidity Control

Measured relative humidity levels in the library were within the recommended range of 25% to 60%. As discussed in the preceding Mechanical Systems section, replacement of the existing humidification system should be considered as part of a new HVAC systems design.

### Lighting

As mentioned in Section 2.0, new lighting ballasts and bulbs were recently installed in the fluorescent fixtures. Other recommendations include changing all incandescent light bulbs to compact fluorescent bulbs and installing motion sensitive controls on light switches.

### Daylighting

Daylighting within the library is provided by the storefront and window units on the lower and upper floors. Table 4.3 presents a summary of the window areas for each wall on Building 100.

Table 4.3 – Daylighting Areas

| Wall Orientation | Wall Area (sf) | Window Area (sf) | % Total |
|---|---|---|---|
| Northeast | 2,016 | 517 | 25.6% |
| Northwest | 1,200 | 625 | 52.1% |
| Southeast | 700 | 258 | 36.9% |
| Southwest | 2,268 | 240 | 10.6% |
| TOTAL: | 6,184 | 1,640 | 26.5% |

Minimum daylighting standards as defined by LEED, are a minimum glazing factor of 2% in at least 75% of regularly occupied spaces. The library far exceeds the recommended standards with a net window area of 27% of the total wall area.

### Radon Gas

Radon gas is a naturally occurring radioactive gas that is regionally present within the New England region. Radon gas can enter buildings through small cracks in the foundation walls and floors and accumulate in the indoor atmosphere. The library does not contain a radon mitigation system –to ensure that radon concentrations are below the EPA threshold; annual radon testing in the lower levels of the building is recommended.

# 5.0 ENERGY MODELING

## Method and Purpose

Using the eQUEST energy simulation program (v. 3.63), a more quantitative assessment of the library energy consumption was completed. This simulation program is recognized and accepted by the U.S. Department of Energy (DoE), Energy Efficiency and Renewable Energy (EERE) program and the USGBC LEED program. Independent models were completed to provide a more accurate evaluation of energy performance based on the building configurations and the designated use. Local public utility rates for electric (Public Services of New Hampshire) were used in all simulations. Heating oil pricing of $2.80 per gallon ($2.01/therm) based on current, averaged local market pricing. Natural gas rates are $1.65/therm based on current Keyspan commercial rates. Net electric costs are estimated at $0.14/kWh based on current PSNH small commercial rates.

Four separate building energy simulations were completed for the library: 1) baseline model of the existing building; 2) improved building envelope with added insulation; 3) new high-efficiency heat-pump heating and cooling system; and, 4) new high-efficiency propane split system with DX cooling.

The simulations consider the current operating schedule of the library and that thermostat management is implemented. That is, it assumes that the HVAC system operates one hour before opening and one hour after closing for each scheduled day. Non-occupied setback temperatures are assumed to be 67°F during heating periods and 80°F for cooling periods. Occupied set temperatures are 69°F and 72°F for heating and cooling periods respectively.

Simulation reports for each simulation scenario are presented in Exhibit G and include:

- Detailed monthly and annual energy consumption by use category;
- Estimated monthly and annual energy costs;
- Monthly peak consumption by use category; and,
- Summary monthly and annual consumption by energy type (electric and gas/oil).

Because there are many variables affecting actual consumption and associated costs including building use and occupancy, actual efficiencies of existing equipment and systems, controls, actual utility costs, and limitations inherent to the energy simulation software, the presented values should be considered within a -15% to +10% range.

## Simulation Results

Table 5.1 presents the results of the three simulated HVAC systems – model output is presented in Exhibit G. The first simulation is the baseline model representative of the existing building envelope and HVAC systems. The second and third include improved building envelope and new high-efficiency HVAC system.

Table 5.1 –HVAC System Simulation Comparisons

| HVAC Systems | | | | | Est. Annual Energy Consumption | | Est. Annual Energy Cost[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| Heating | Fuel | AFUE (%) | Cooling | Distribution | Oil / NG (therms) | Electric (kWh) | Oil / NG | Electric | Total |
| Natural draft furnaces (existing) | Oil | 78 | Multiple split DX condensers (existing) | Four ducted fan systems (existing) | 2,502 | 6,249 | $5,029 | $875 | $5,904 |
| HE heat-pump w/ inverter compressor w/ heat recovery | Electric | 93 | Single packaged variable DX condenser | Multiple VRFZ cassettes | 0 | 16,440 | $0 | $2,301 | $2,301 |
| Single HE furnace w/ heat recovery | NG | 90 | Multiple split DX condensers | Single air-handler unit | 2,421 | 6,249 | $3,994 | $875 | $4,869 |

(1) Estimated costs are based on current (June 2009) utility and heating-oil rates for the southern NH region.

The predicted total annual energy savings for a new high-efficiency heat-pump HVAC system are presented in Table 5.2. These energy costs represent fuel/energy for the heating and cooling unit and energy for distribution.

Table 5.2 – New HVAC Annual Energy Cost Savings

| HVAC System Description | Predicted Savings | % Savings |
|---|---|---|
| HE Heat-Pump w/ VRFZ and heat recovery | $3,603 | 61% |
| Single HE Propane Furnace with Split DX and heat recovery | $1,035 | 18% |

Table 5.3 presents the estimated energy consumption reductions and associated cost savings for the proposed improved insulation EEM enhancement. EEM item 1 and the associated cost savings are not included in the new HVAC models presented in Table 5.1. However, the predicted cost savings in Table 5.3 are modeled with the new heat pump HVAC system.

Table 5.3 – Energy Efficiency Management Savings

| Potential Building Enhancements | | Est. Annual Energy Reduction | | Est. Annual Energy Savings[1] |
|---|---|---|---|---|
| No. | EEM Description | Oil / NG (therms) | Electric (kWh) | |
| 1 | Improve Building Envelope (insulate original building walls, re-insulate attic floor/ceiling, seal penetrations, seal windows and doors) | 0 | 2,849 | $399 |

(1) Estimated costs are based on current (June 2009) public utility and heating-oil rates for the southern NH region.

# 6.0 SUMMARY RECOMMENDATIONS

The following summary recommendations are provided with the intent of improving the overall performance and sustainability of the library facility. Determining which recommendations are appropriate for the building depend on the planned use designation and lifecycle, Town of Rye initiatives, and budgetary means. The red flag ( ) symbol included the text body denotes recommendations and are included as a one of the three tier categories. The three tier categories are based on life safety concerns, implementation costs, potential energy reduction and cost savings, operation and maintenance costs, and occupant comfort.

1. **Tier I Recommendations**: Tier I recommendations include maintenance related items that are relatively simple and low-cost to implement. They also include critical items associated with life-safety concerns and items that if left unattended to could result in damage to building components. Tier I recommendations are presented in Table 6.1.
2. **Tier II Recommendations**: Tier II recommendations are those that should be considered in current budgetary planning for building improvements – they can be major or minor improvements. They generally will provide substantial energy savings and/or improved occupant comfort. Tier II recommendations are presented in Table 6.2.
3. **Tier III Recommendations**: Tier III recommendations are major improvements affecting one or more building components. These are generally longer-term capital improvements that may be more economical to complete as part of a larger improvement project. Tier III recommendations are presented in Table 6.3.

Included in the tables are budgetary costs to implement the associated initiative. These costs are provided for planning purposes only.

Table 6.1 – Tier I Recommendations

| No. | Noted Item | Recommended Action | Budgetary Cost |
|---|---|---|---|
| 1 | Unsealed penetrations in the mechanical room foundation walls. | Seal the walls using an epoxy or polyurethane based sealant. | $300 |
| 2 | Inadequately sealed basement window in the southeast mechanical room used for pipe chase. | Seal the former window opening using brick and mortar or concrete. | $300 |
| 3 | Seepage through the foundation wall and floor at the southeast mechanical room. | Raise the exterior grade along the southwest building foundation wall to promote runoff drainage away from building. | $300 |
| 4 | Water staining on the southeast ceiling/wall of the main entry inner vestibule. | Inspect ceiling insulation and repair to prevent heat from reaching underside of roof resulting in ice dams. | $200 |
| 5 | Water staining on the ceiling near the southwest intersection of the original building and the addition (Mystery rack area). | Suspected leakage is through the rooftop mounted fresh-air intake duct. Re-caulk the duct penetration. | $300 |
| 6 | Fire safety concern. Substantial amount of combustible debris in the attic area above the original building. | Remove all debris from the attic space. | $400 |
| 7 | Cracked roofing shingles on ridge extending to southwest chimney. | Cover ridge with new shingles. | $200 |
| 8 | Some gaps in the seals on newer double-hung windows in addition. | Adjust the existing seals or replace with new seals. | $300 |
| 9 | Exterior caulking on newer windows deteriorated. | Remove caulking and replace with polyurethane caulking. | $500 |
| 10 | Exterior caulking on entry doors at northeast storefront is deteriorated. | Remove caulking and replace with polyurethane caulking. | $500 |
| 11 | Doors do not completely seal at the frame and threshold. | Inspect all doors and add new seals. | $500 |
| 12 | Louvered entry door in the mechanical room is insecure and inefficient. | Replace door with a solid steel or fiberglass insulated unit. | $800 |

| | | | |
|---|---|---|---|
| 13 | Exterior A/C condenser piping insulation in poor condition. | Replace insulation with high R-value insulation. *NOTE: Do not complete if new HVAC system is planned.* | $500 |
| 14 | A/C condenser units filled with debris and unprotected from winter weather. | Cover/protect units during heating periods. *NOTE: Do not complete if new HVAC system is planned.* | $500 |
| 15 | The existing humidification systems may not function as designed. | Measure relative humidity levels during peak heating and cooling seasons and adjust as needed. *NOTE: Do not complete if new HVAC system is planned.* | $500/year |
| 16 | Passive door louvers in mechanical room are inefficient method to provide combustion air to furnaces. | Replace door (I-10) and install pressure actuated mechanical damper in main mechanical room for combustion air supply. *NOTE: Do not complete if new HVAC system is planned.* | $800 |
| 17 | Mechanical air damper in secondary mechanical room appeared inoperative (in open position). | Inspect and repair damper as needed. *NOTE: Do not complete if new HVAC system is planned.* | $300 |
| 18 | Manual dampers on the furnace plenum may limit outdoor air supply. | Open all outdoor air dampers 100% to ensure maximum outdoor air supply. | $0 |
| 19 | Attic exhaust fan did not appear to be working during inspection. | Inspect fan and adjust thermostat control or replace fan unit with higher capacity fan (>300 CFM). | $700 |
| 20 | Lavatory and utility closet exhaust fans are operated by independent switch. | Wire the fans with the light switch to ensure activation. | $400 |
| 21 | Lavatory exhaust fans are partially clogged. | Clean all exhaust fan grilles and ducts. | $200 |
| 22 | Electrical outlets in basement mechanical room where flooding is evident are not GFCI protected. | Install GFCI protected outlets in mechanical room. | $200 |
| 23 | Lighting switches in secondary areas are manual toggle switches. | Replace toggle switches with motion-sensitive controllers. | $800 |
| 24 | Multiple air filtration units in basement area using high amounts of electricity. | Air filter units will not reduce humidity levels or prevent mold development – replace filter units with additional humidifiers and place inside mechanical room where water leakage is evident. | $400 |
| 25 | Misc. electronic equipment including computers, printers, photocopiers, chargers increase electrical consumption and internal heat load. | Plug electronics into surge protection units where multiple items can be powered off with a single switch. Turn-off all electronics when not in use. | $200 |
| 26 | Septic system should be maintained to prevent environmental release and ensure proper operation. | Clean and inspect septic system annually. | $700/year |
| 27 | Building materials in original building may contain asbestos. | Test suspect materials prior to disturbing or removing and manage appropriately. | $800 |
| 28 | Painted surfaces in original building may contain lead-based paint and primer. | Assume painted surfaces prior to 1975 contain lead paint and manage appropriately. | $0 |
| 29 | Fluorescent light bulbs contain mercury. | Dispose of light bulb appropriately. | $0 |
| 30 | Old fluorescent lighting ballasts may contain PCBs. | Assume old ballasts contain PCBs unless it is clearly noted otherwise and dispose of appropriately. | $0 |
| 31 | Old abandoned electrical wiring and switches remain in the attic. | Remove all abandoned electrical wiring and switches. | $500 |
| 32 | Fire detection and notification systems should be routinely tested. | Coordinate routine inspections with the Town of Rye Fire Department. | $0 |
| 33 | In the event of fire and inoperable elevator system, wheelchairs must access stairways. | Develop a contingency evacuation plan with the Rye Fire Department in the event of such. | $0 |

| | | | |
|---|---|---|---|
| 34 | Visual fire alarm notification for hearing impaired is limited to the lavatory areas. | In coordination with the Rye Fire Department, identify areas where additional visual alarms may be needed and install such. | $2,500 |
| 35 | Radon gas infiltration is a significant occupant hazard in New England. | Complete annual radon testing in basement spaces. | $200/year |

Table 6.2 – Tier II Recommendations

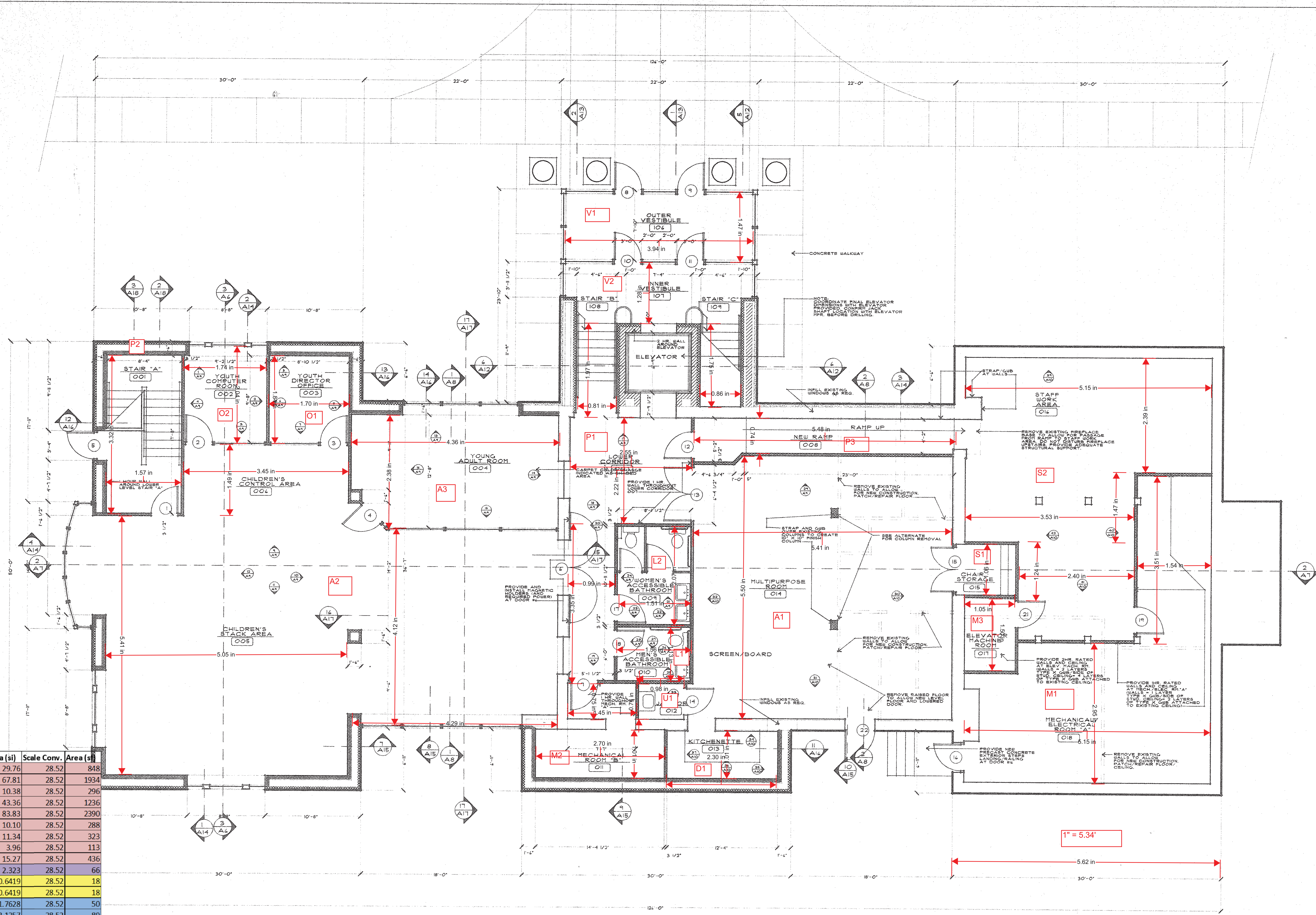
| No. | Noted Item | Recommended Action | Budgetary Cost |
|---|---|---|---|
| 1 | Walls in the original library building contain little or no insulation. | Add loose-fill insulation to the wall cavities. | $7,000 |
| 2 | Walls and ceilings in the addition area have several insulation gaps. | Add spray-foam insulation to the gap locations. | $3,000 |
| 3 | Ceiling insulation placed on attic floor is in poor condition. | Remove fiberglass batts and either insulate ceiling joists or apply sprayed-foam insulation to attic subfloor. | $3,000 |
| 4 | Historic windows in original building are a source of significant thermal transfer (heat loss and heat gain). | Retrofit the historic windows by removing sash cord and weights, filling the cavity with foam insulation, and sealing the windows with caulking to improve thermal performance. | $2,500 |
| 5 | Peeling paint on exterior wood trim including eaves, soffit, and windows. | Scrap, sand, prime, and repaint all exterior wood trim. | $3,000 |
| 6 | Substantial thermal transfer from the existing ductwork in the attic to unconditioned space. | Improve duct connections and insulation on attic ductwork. *NOTE: Do not complete if new HVAC system and ductwork are to be installed.* | $4,500 |
| 7 | Existing 40-gallon domestic hot water tank is inefficient. | Replace tank with a single tankless unit or multiple local units. | $2,000 |
| 8 | There are no automatically controlled doors for handicap access. | Install automatic door openers and switches on the northeast vestibule. | $2,500 |
| 9 | Soils erosion is evident at the driveway turn-around embankment. | Plant native bank groundcover to stabilize the eroded area. | $800 |

Table 6.3 – Tier III Recommendations

| No. | Noted Item | Recommended Action | Budgetary Cost |
|---|---|---|---|
| 1 | The existing HVAC system is very inefficient and requires high maintenance. Limited zones do not provide adequate distribution and ventilation. Substantial thermal loss through attic ducting. | Replace the existing HVAC system with a high-efficiency heat-pump system having multiple VRFZs. System should include heat-recovery, increased outdoor air supply, humidity control for all zones including basement, and air quality sensing and control. | $100,000 |
| 2 | The staff room / storage room located in the original basement area does not have fire suppression. | Consider adding fire sprinklers to the area to protect valuable items. | $3,500 |
| 3 | Much of the storm water runoff flows off site to the adjacent wetland area. | Construct a rain garden to detain and increase the volume of runoff that is infiltrated on site. | $3,000 |
| 4 | The northeast glazed storefront provides a significant heat load to the building. | Plant deciduous shade trees along the northeast perimeter to shade the storefront during cooling periods. | $2,000 |
| 5 | There is no preferred parking for low-emissions and alternative energy vehicles. | Add preferred parking to encourage the use of such. | $1,000 |

FIGURE 1

Building Use Designation Plan – Lower Level




| Room(s) | Floor | UD | Area (si) | Scale Conv. | Area (sf) |
|---|---|---|---|---|---|
| A1 | 1 | A | 29.76 | 28.52 | 848 |
| A2 | 1 | A | 67.81 | 28.52 | 1934 |
| A3 | 1 | A | 10.38 | 28.52 | 296 |
| A4 | 2 | A | 43.36 | 28.52 | 1236 |
| A5 | 2 | A | 83.83 | 28.52 | 2390 |
| A6 | 2 | A | 10.10 | 28.52 | 288 |
| A7 | 2 | A | 11.34 | 28.52 | 323 |
| A8 | 2 | A | 3.96 | 28.52 | 113 |
| A9 | 2 | A | 15.27 | 28.52 | 436 |
| D1 | 1 | D | 2.323 | 28.52 | 66 |
| E1 | 2 | E | 0.6419 | 28.52 | 18 |
| E2 | 2 | E | 0.6419 | 28.52 | 18 |
| L1 | 1 | L | 1.7628 | 28.52 | 50 |
| L2 | 1 | L | 3.1257 | 28.52 | 89 |
| L3 | 2 | L | 0.962 | 28.52 | 27 |
| M1 | 1 | M | 20.5979 | 28.52 | 587 |
| M2 | 1 | M | 2.727 | 28.52 | 78 |
| M3 | 1 | M | 1.575 | 28.52 | 45 |
| O1 | 1 | O | 3.128 | 28.52 | 89 |
| O2 | 1 | O | 3.5496 | 28.52 | 101 |
| O3 | 2 | O | 6.0836 | 28.52 | 173 |
| O4 | 2 | O | 8.1081 | 28.52 | 231 |
| P1 | 1 | P | 14.2707 | 28.52 | 407 |
| P2 | 1/2 | P | 5.2124 | 28.52 | 149 |
| P3 | 1/2 | P | 4.0552 | 28.52 | 116 |
| P4 | 2 | P | 1.4304 | 28.52 | 41 |
| S1 | 1 | S | 1.113 | 28.52 | 32 |
| S2 | 1 | S | 20.47 | 28.52 | 584 |
| U1 | 1 | U | 0.7252 | 28.52 | 21 |
| V1 | 1 | V | 5.7918 | 28.52 | 165 |
| V2 | 1 | V | 5.0432 | 28.52 | 144 |

A=ASSEMBLY
D=DINING/FOOD PREP
E=EQUIPMENT
L=LAVATORY
M=MECHANICAL
O=OFFICE
P=PASSAGE/CORRIDOR
S=STORAGE/WAREHOUSE
U=UTILITY
V=VESTIBULE/ENTRY

1 A1 LOWER LEVEL PLAN

REFERENCE NORTH

PRINTED AT 3/16" = 1'-0" SCALE (CONFIRM W/GRAPHIC SCALE)


TENNANT/WALLACE ARCHITECTS AIA·PA
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ADDITION/RENOVATION AT THE RYE PUBLIC LIBRARY

LOWER LEVEL FLOOR PLAN

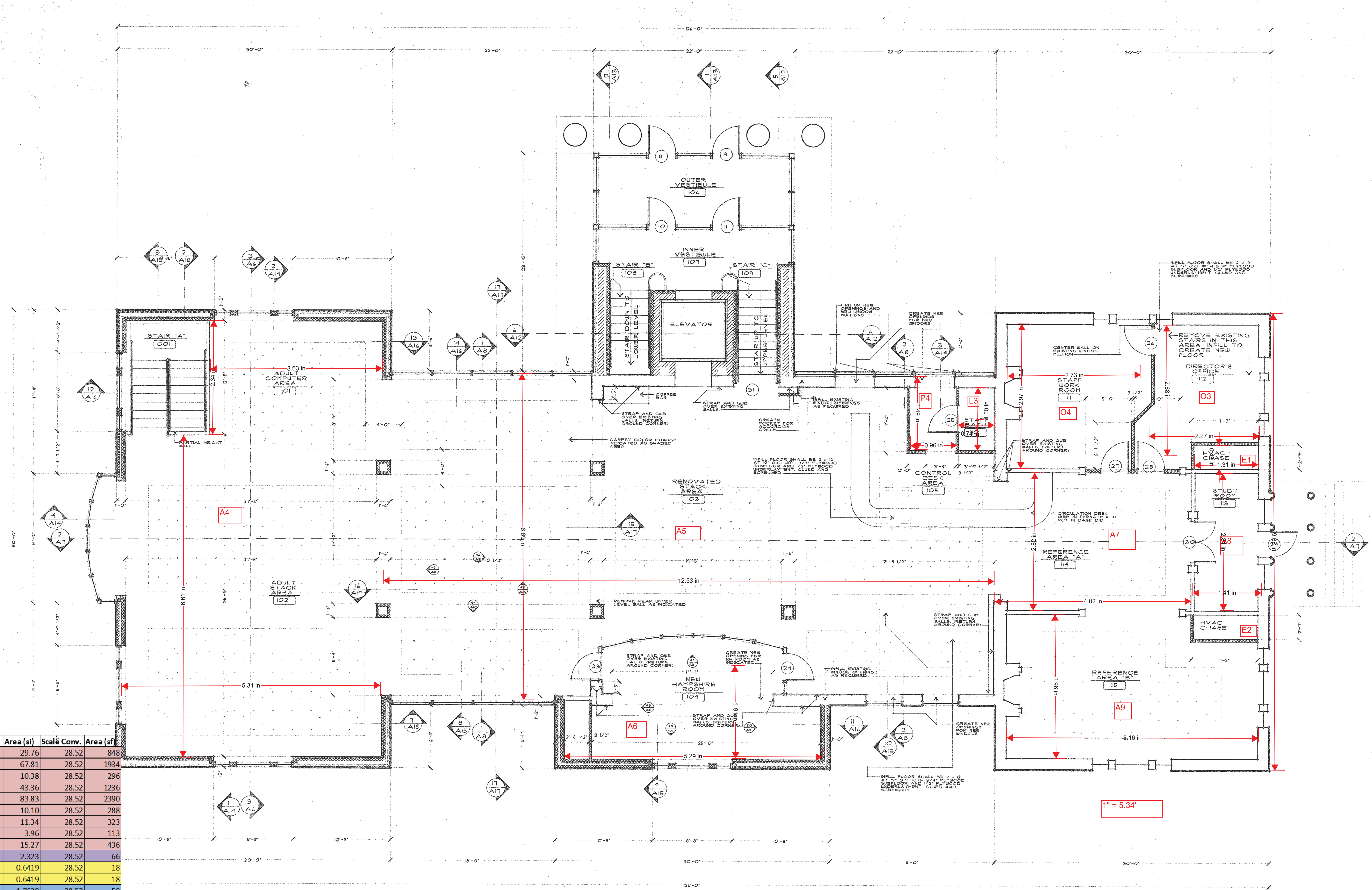
AUGUST 29, 1997

A1

SET #

FIGURE 2

Building Use Designation Plan – Upper Level

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| A9 | 2 | A | 15.27 | 28.52 | 436 |
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| O4 | 2 | O | 8.1081 | 28.52 | 231 |
| P1 | 1 | P | 14.2707 | 28.52 | 407 |
| P2 | 1/2 | P | 5.2124 | 28.52 | 149 |
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| P4 | 2 | P | 1.4304 | 28.52 | 41 |
| S1 | 1 | S | 1.113 | 28.52 | 32 |
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| V1 | 1 | V | 5.7918 | 28.52 | 165 |
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UPPER LEVEL PLAN
PRINTED AT 3/16" = 1'-0" SCALE (CONFIRM W/GRAPHIC SCALE)

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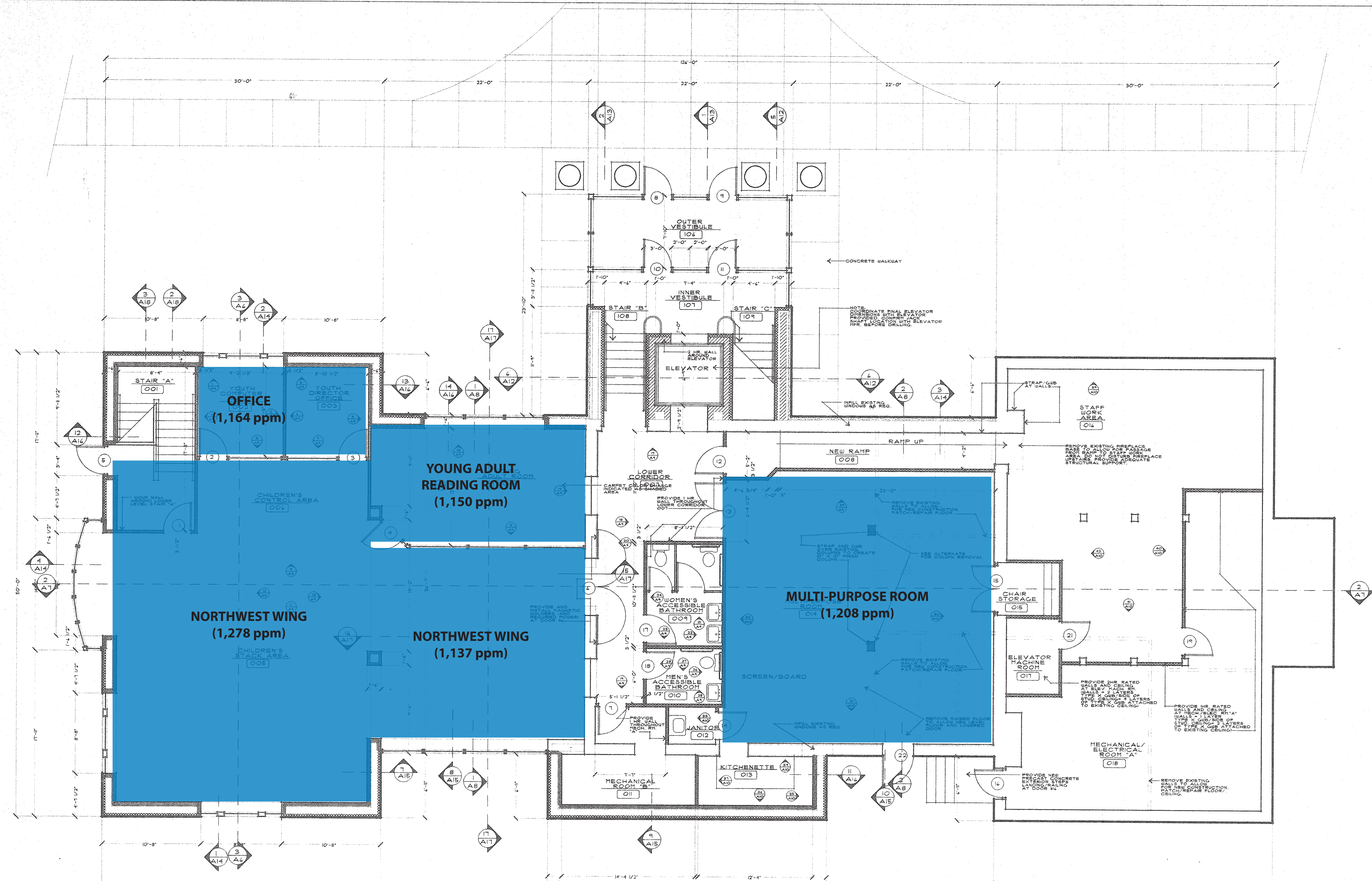
GROUND LEVEL FLOOR PLAN

AUGUST 29, 1997

A2

FIGURE 3

Carbon Dioxide Data Map




**LIBRARY FIRST FLOOR**
**CARBON DIOXIDE MAP**

LEGEND - CO2 Concentrations

| | |
|---|---|
| | 400-700 ppm |
| | 701-1,000 ppm |
| | 1,001-1,300 ppm |
| | 1,301-1,600 ppm |
| | >1,600 ppm |

USEPA Threshold = 1,000 ppm

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**Title:** Carbon Dioxide Map
**Client:** Town of Rye, NH
**Project:** Comprehensive Energy Audit
**Building:** Library
**Date:** June 2009

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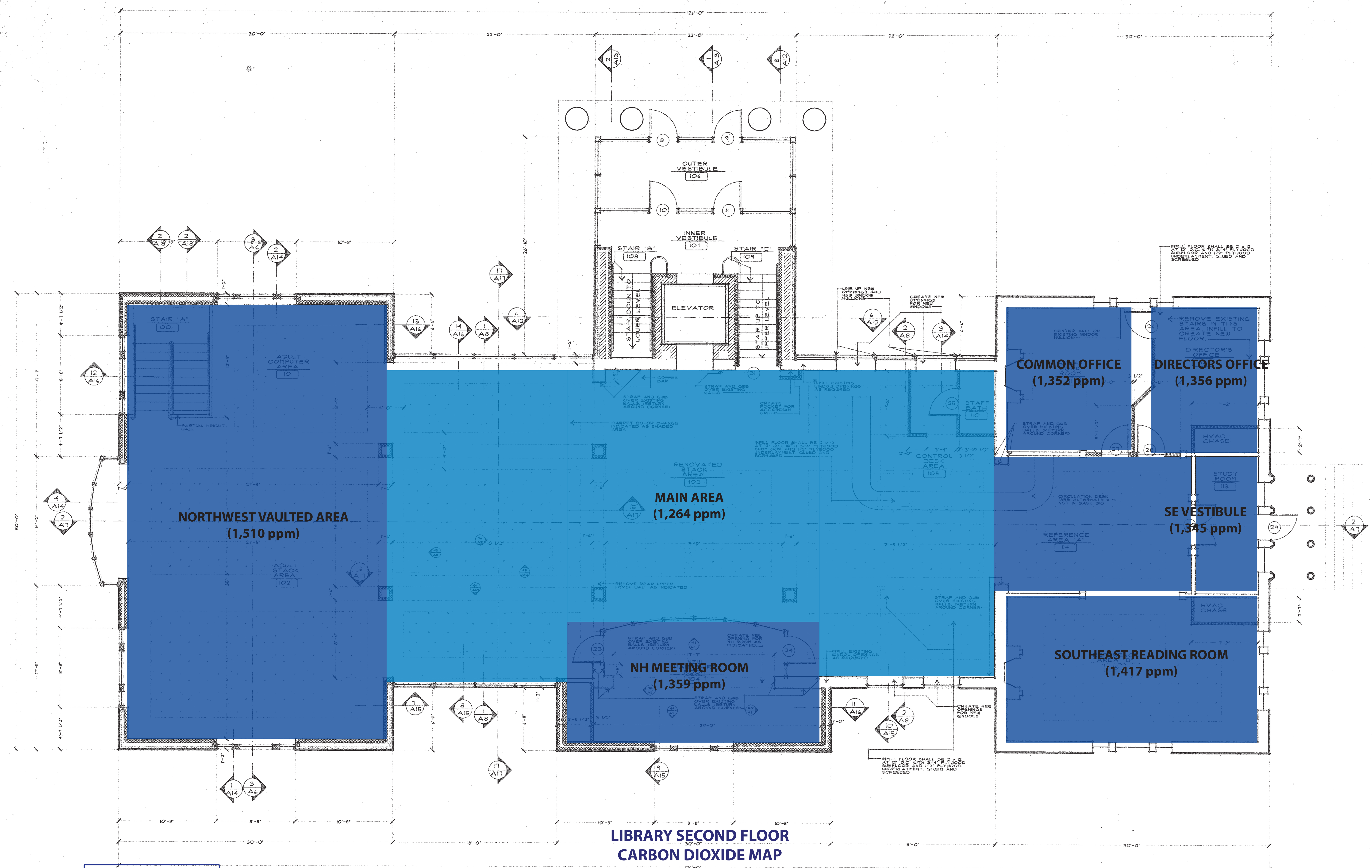
LOWER LEVEL FLOOR PLAN

AUGUST 29, 1997

A1




**LIBRARY SECOND FLOOR**
**CARBON DIOXIDE MAP**

| LEGEND - CO2 Concentrations |
|---|
| 400-700 ppm |
| 701-1,000 ppm |
| 1,001-1,300 ppm |
| 1,301-1,600 ppm |
| >1,600 ppm |

USEPA Threshold = 1,000 ppm

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ADDITION/RENOVATION AT THE RYE PUBLIC LIBRARY

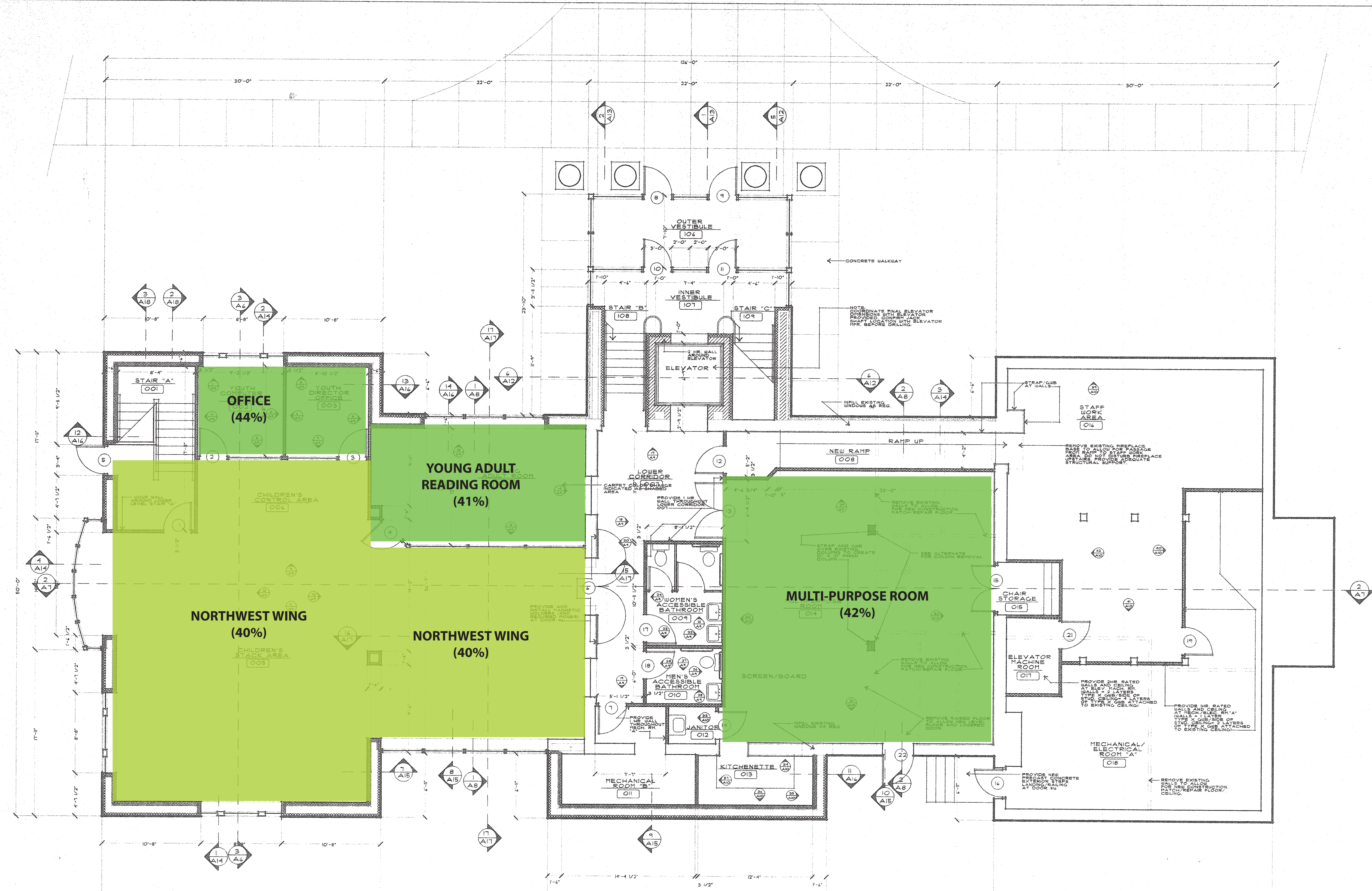
GROUND LEVEL FLOOR PLAN

AUGUST 29, 1997

A2

FIGURE 4

Relative Humidity Data Map




**LIBRARY FIRST FLOOR**
**RELATIVE HUMIDITY MAP**

LOWER LEVEL PLAN

PRINTED AT 3/16" = 1'-0" SCALE (CONFIRM W/GRAPHIC SCALE)

| LEGEND - Relative Humidity (%) |
|---|
| <25 |
| 26 - 40 |
| 41 - 55 |
| 56 - 70 |
| >71 |

Target RH Range = 25% - 60%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ADDITION/RENOVATION AT THE RYE PUBLIC LIBRARY

LOWER LEVEL FLOOR PLAN

AUGUST 29, 1997

A1

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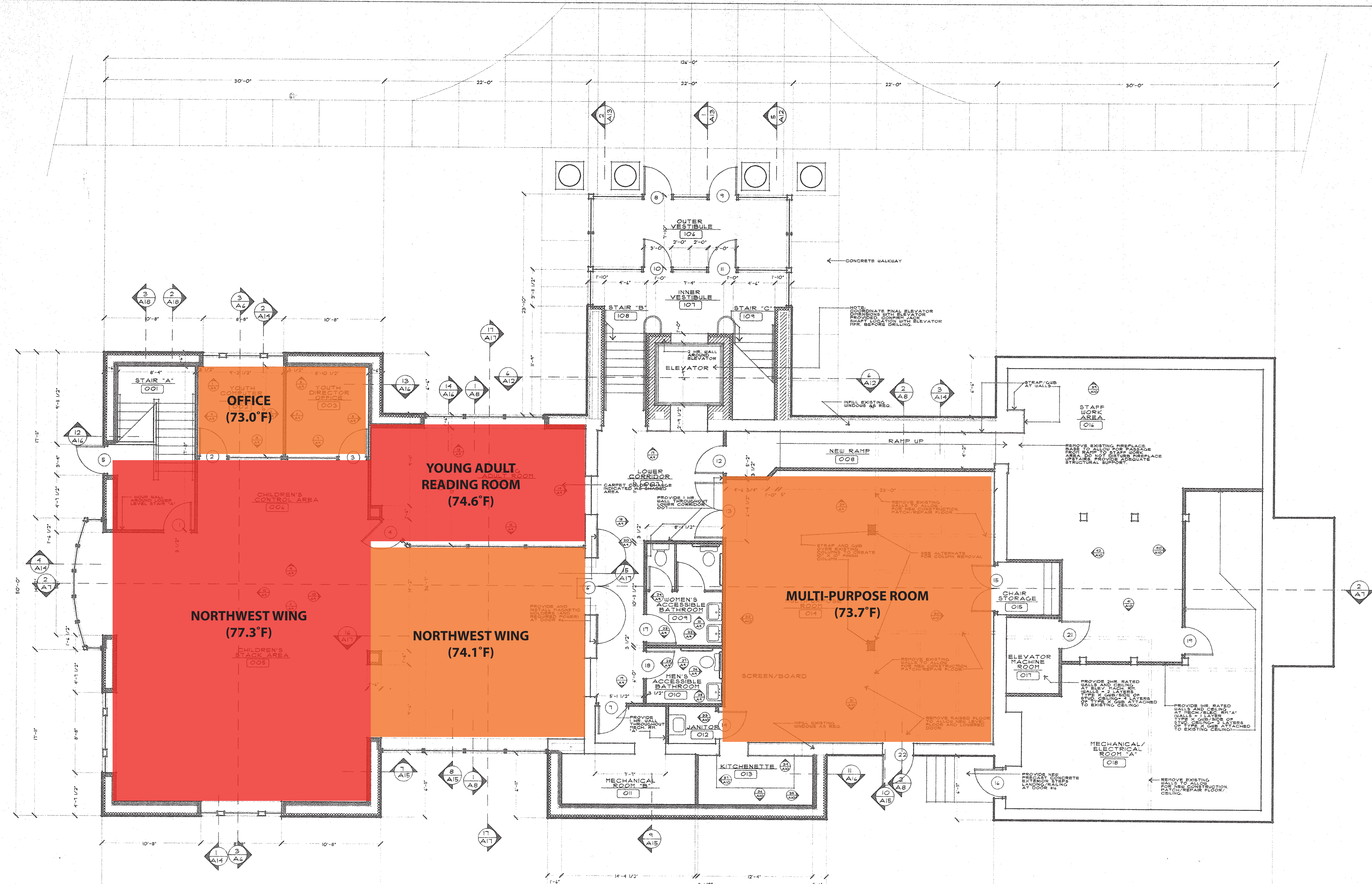
**Title:** Relative Humidity Map
**Client:** Town of Rye, NH
**Project:** Comprehensive Energy Audit
**Building:** Library
**Date:** June 2009

FIGURE 5

Temperature Data Map




## LIBRARY FIRST FLOOR TEMPERATURE MAP

LOWER LEVEL PLAN

PRINTED AT 3/16" = 1'-0" SCALE (CONFIRM W/GRAPHIC SCALE)

REFERENCE NORTH

LEGEND - Temperatures (˚F)

- <63
- 63 - 66
- **67 - 70**
- 71 - 74
- 75 - 78
- >78

Target Temperature Range = 67 - 70

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ADDITION/RENOVATION AT THE RYE PUBLIC LIBRARY

LOWER LEVEL FLOOR PLAN

AUGUST 29, 1997

A1

SET #

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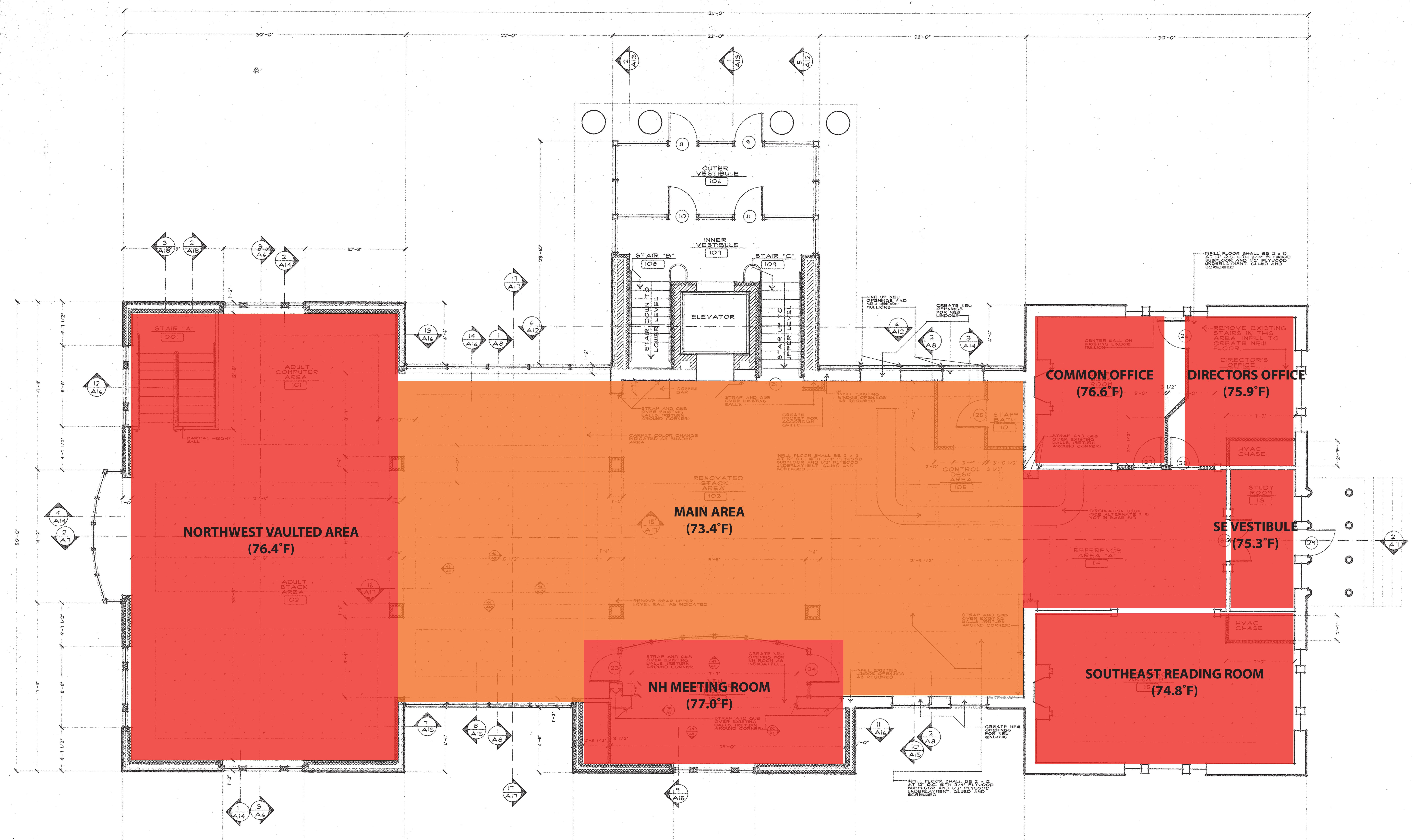
**Title:** Temperature Map

**Client:** Town of Rye, NH

**Project:** Comprehensive Energy Audit

**Building:** Library

**Date:** June 2009




**LIBRARY SECOND FLOOR TEMPERATURE MAP**

LEGEND - Temperatures (˚F)

| | |
|---|---|
| | <63 |
| | 63 - 66 |
| | **67 - 70** |
| | 71 - 74 |
| | 75 - 78 |
| | >78 |

Target Temperature Range = 67 - 70

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**Title:** Temperature Map
**Client:** Town of Rye, NH
**Project:** Comprehensive Energy Audit
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ADDITION/RENOVATION AT THE RYE PUBLIC LIBRARY

GROUND LEVEL FLOOR PLAN

AUGUST 29, 1997

A2

Exhibit A

Photographs

(separate electronic file)

Exhibit B

Infrared Thermal Imaging Report

(separate electronic file)

Exhibit C

Indoor Air Quality Data

# INDOOR AIR QUALITY DATA

**Town of Rye Library**
**Jun-09**

| | | |
|---|---|---|
| Date: | 6/2/09 | 6/3/09 |
| Ambient Temp (°F): | 73 | 65 |
| Ambient RH: | 40% | 60% |

| Date | Location 1 | Location 2 | $CO_2$ (ppm) | Temp. (°F) | RH (%) |
|---|---|---|---|---|---|
| 6/2/2009 | attic east | eave | 535 | 71.0 | 45.8 |
| 6/2/2009 | attic east room | main | 723 | 70.5 | 30.3 |
| 6/2/2009 | attic addition | | 848 | 69.0 | 32.6 |
| 6/3/2009 | 2nd flr center | | 1264 | 73.4 | 43.8 |
| 6/3/2009 | 2nd flr SE Reading area | | 1417 | 74.8 | 44.3 |
| 6/3/2009 | 2nd flr south vestibule | | 1345 | 75.3 | 43.0 |
| 6/3/2009 | 2nd flr NE Directors Office | | 1356 | 75.9 | 42.6 |
| 6/3/2009 | 2nd flr NE general office | | 1352 | 76.6 | 42.0 |
| 6/3/2009 | 2nd flr NH meeting room | | 1359 | 77.0 | 41.7 |
| 6/3/2009 | 2nd flr N vaulted area | | 1510 | 76.4 | 41.6 |
| 6/3/2009 | 2nd flr N sitting area/bay | | 1307 | 77.1 | 40.2 |
| 6/3/2009 | 1st flr N end | | 1278 | 77.3 | 39.9 |
| 6/3/2009 | 1st flr young reading room | | 1150 | 74.6 | 41.1 |
| 6/3/2009 | 1st flr N wing childrens room | | 1137 | 74.1 | 40.3 |
| 6/3/2009 | 1st flr multi-purpose room | | 1208 | 73.7 | 41.6 |
| 6/3/2009 | 1st flr childrens room office | | 1164 | 73.0 | 44.0 |
| | | **AVG.** | **1296** | **75.3** | **42.0** |

CO2 Threshold (EPA and ASHRAE) = 1,000 ppm
Recommended Temp. Range = 67-70°F
Recommended RH Range (ASHRAE) = 25 to 60%

# Exhibit D

Carbon Dioxide Data Graph

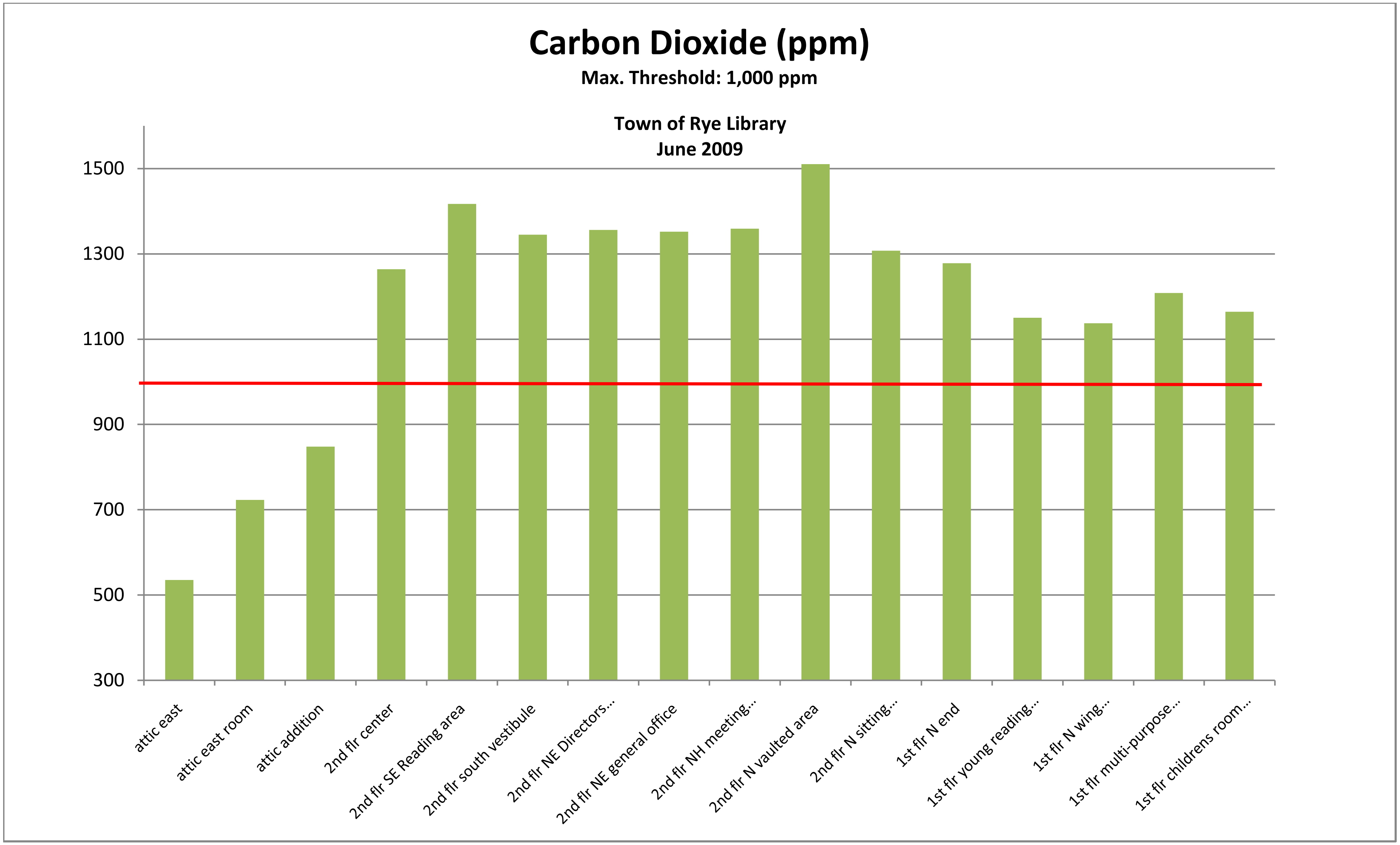

Carbon Dioxide (ppm)
Max. Threshold: 1,000 ppm
Town of Rye Library
June 2009
1500
1300
1100
900
700
500
300
attic east
attic east room
attic addition
2nd flr center
2nd flr SE Reading area
2nd flr south vestibule
2nd flr NE Directors...
2nd flr NE general office
2nd flr NH meeting...
2nd flr N vaulted area
2nd flr N sitting...
1st flr N end
1st flr young reading...
1st flr N wing...
1st flr multi-purpose...
1st flr childrens room...

Exhibit E

Relative Humidity Data Graph

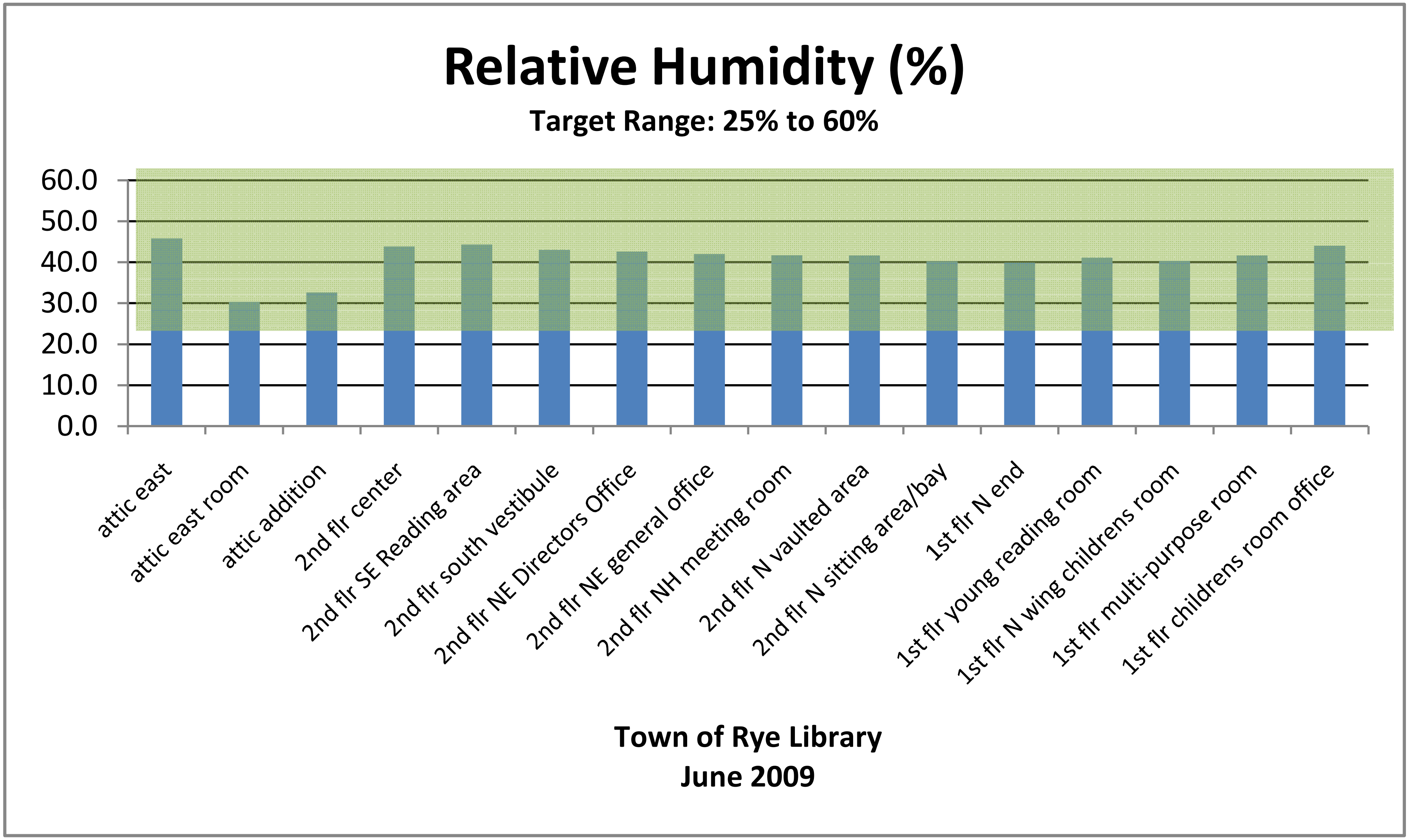
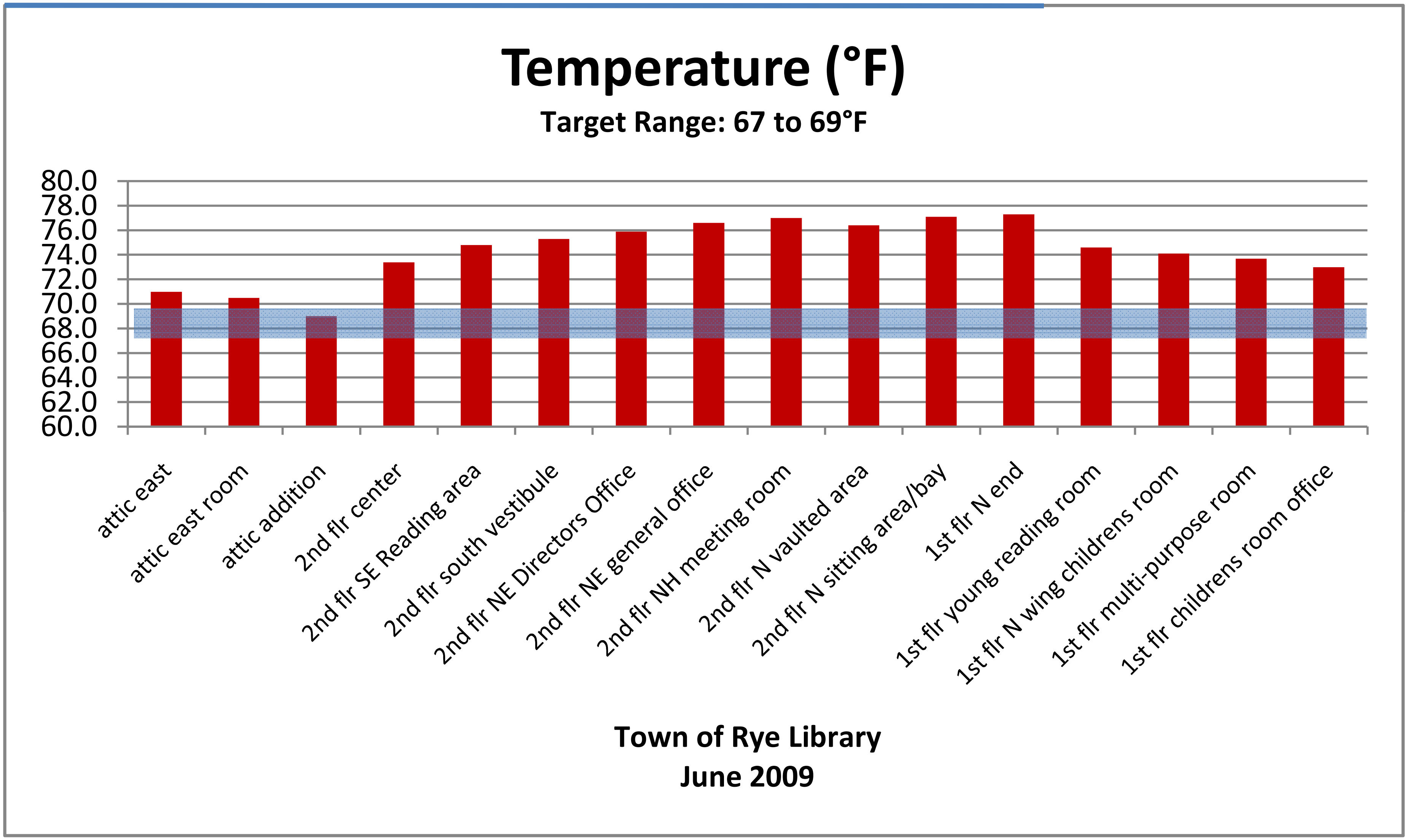

Relative Humidity (%)
Target Range: 25% to 60%
60.0
50.0
40.0
30.0
20.0
10.0
0.0
attic east
attic east room
attic addition
2nd flr center
2nd flr SE Reading area
2nd flr south vestibule
2nd flr NE Directors Office
2nd flr NE general office
2nd flr NH meeting room
2nd flr N vaulted area
2nd flr N sitting area/bay
1st flr N end
1st flr young reading room
1st flr N wing childrens room
1st flr multi-purpose room
1st flr childrens room office
Town of Rye Library
June 2009

Exhibit F

Temperature Data Graph



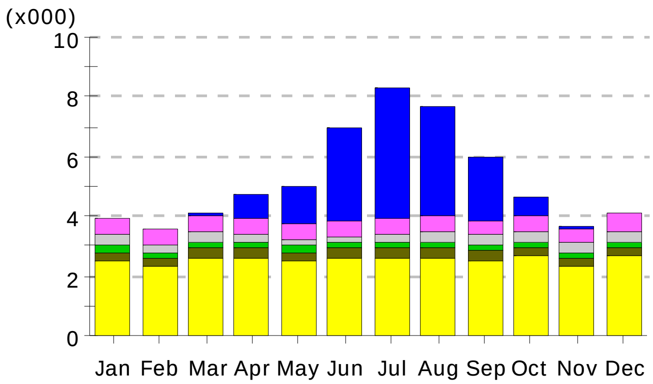
Temperature (°F)
Target Range: 67 to 69°F
80.0
78.0
76.0
74.0
72.0
70.0
68.0
66.0
64.0
62.0
60.0
attic east
attic east room
attic addition
2nd flr center
2nd flr SE Reading area
2nd flr south vestibule
2nd flr NE Directors Office
2nd flr NE general office
2nd flr NH meeting room
2nd flr N vaulted area
2nd flr N sitting area/bay
1st flr N end
1st flr young reading room
1st flr N wing childrens room
1st flr multi-purpose room
1st flr childrens room office
Town of Rye Library
June 2009

Exhibit G

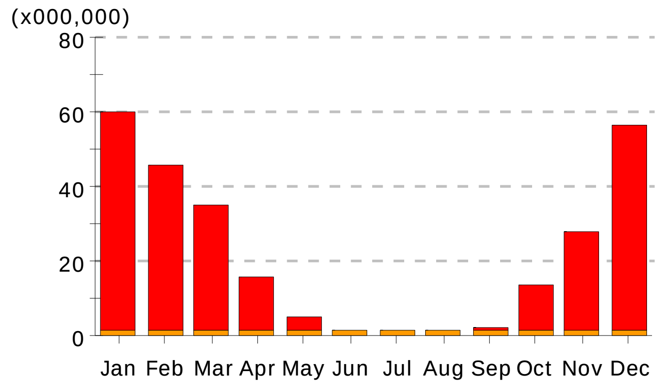
Building Energy Simulation Reports

# Baseline Building Simulation

**Electric Consumption (kWh)**




**Gas Consumption (Btu)**



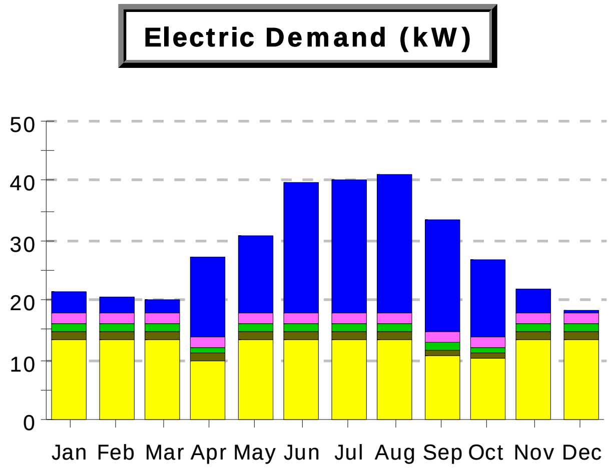

Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

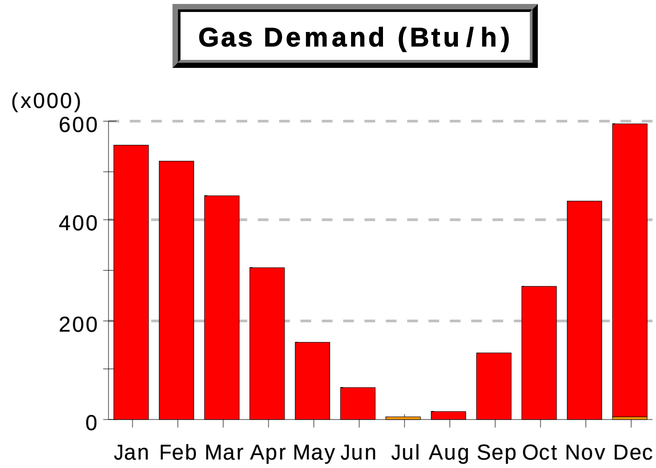
**Electric Consumption (kWh x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | 0.01 | 0.03 | 0.13 | 0.75 | 1.25 | 3.07 | 4.42 | 3.65 | 2.12 | 0.64 | 0.09 | 0.00 | 16.15 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 0.51 | 0.48 | 0.54 | 0.54 | 0.51 | 0.54 | 0.54 | 0.53 | 0.52 | 0.54 | 0.47 | 0.54 | 6.25 |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | 0.36 | 0.27 | 0.30 | 0.29 | 0.21 | 0.20 | 0.21 | 0.34 | 0.33 | 0.34 | 0.34 | 0.36 | 3.56 |
| Misc. Equip. | 0.22 | 0.20 | 0.23 | 0.23 | 0.22 | 0.23 | 0.23 | 0.23 | 0.22 | 0.23 | 0.20 | 0.23 | 2.65 |
| Task Lights | 0.28 | 0.26 | 0.29 | 0.29 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.29 | 3.39 |
| Area Lights | 2.53 | 2.33 | 2.62 | 2.62 | 2.53 | 2.62 | 2.62 | 2.61 | 2.53 | 2.63 | 2.32 | 2.64 | 30.62 |
| **Total** | 3.90 | 3.57 | 4.12 | 4.71 | 5.00 | 6.95 | 8.31 | 7.65 | 6.00 | 4.67 | 3.68 | 4.07 | 62.62 |

**Gas Consumption (Btu x000,000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 58.86 | 44.24 | 33.76 | 14.58 | 3.76 | 0.13 | - | 0.03 | 0.83 | 12.09 | 26.78 | 55.12 | 250.18 |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 1.38 | 1.31 | 1.48 | 1.44 | 1.30 | 1.25 | 1.17 | 1.11 | 1.08 | 1.17 | 1.12 | 1.35 | 15.17 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 60.24 | 45.55 | 35.24 | 16.02 | 5.07 | 1.38 | 1.17 | 1.14 | 1.91 | 13.26 | 27.89 | 56.47 | 265.35 |




Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

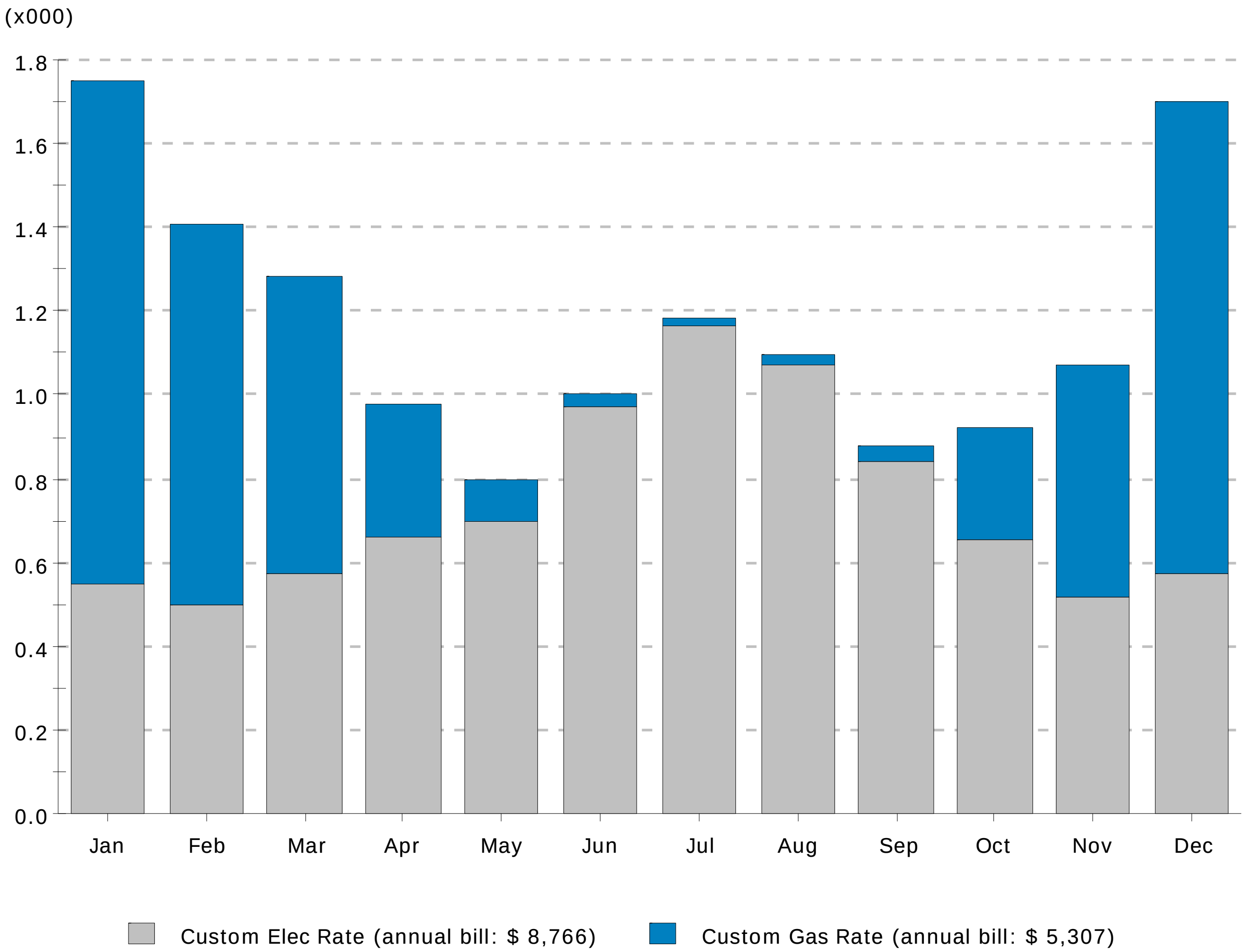
**Electric Demand (kW)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | 3.36 | 2.72 | 2.13 | 13.31 | 12.68 | 21.71 | 22.34 | 22.94 | 18.61 | 12.83 | 3.98 | 0.25 | 136.86 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 23.18 |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | 0.17 | - | - | - | 0.17 |
| Misc. Equip. | 1.24 | 1.24 | 1.24 | 1.06 | 1.24 | 1.24 | 1.24 | 1.24 | 1.00 | 0.71 | 1.24 | 1.24 | 13.93 |
| Task Lights | 1.57 | 1.57 | 1.57 | 1.36 | 1.57 | 1.57 | 1.57 | 1.57 | 1.24 | 1.06 | 1.57 | 1.57 | 17.78 |
| Area Lights | 13.27 | 13.27 | 13.27 | 9.68 | 13.27 | 13.27 | 13.27 | 13.27 | 10.50 | 10.30 | 13.27 | 13.27 | 149.90 |
| **Total** | 21.37 | 20.73 | 20.13 | 27.35 | 30.69 | 39.72 | 40.35 | 40.94 | 33.45 | 26.84 | 21.99 | 18.26 | 341.82 |

**Gas Demand (Btu/h x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 547.4 | 516.4 | 447.4 | 304.0 | 152.2 | 62.7 | - | 16.7 | 132.6 | 268.2 | 436.2 | 593.1 | 3,476.7 |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 2.4 | 1.9 | 1.9 | 1.9 | 1.8 | 1.6 | 5.4 | 1.5 | 1.5 | 1.5 | 1.6 | 3.2 | 26.2 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 549.8 | 518.3 | 449.3 | 305.8 | 153.9 | 64.3 | 5.4 | 18.1 | 134.0 | 269.7 | 437.8 | 596.3 | 3,502.9 |

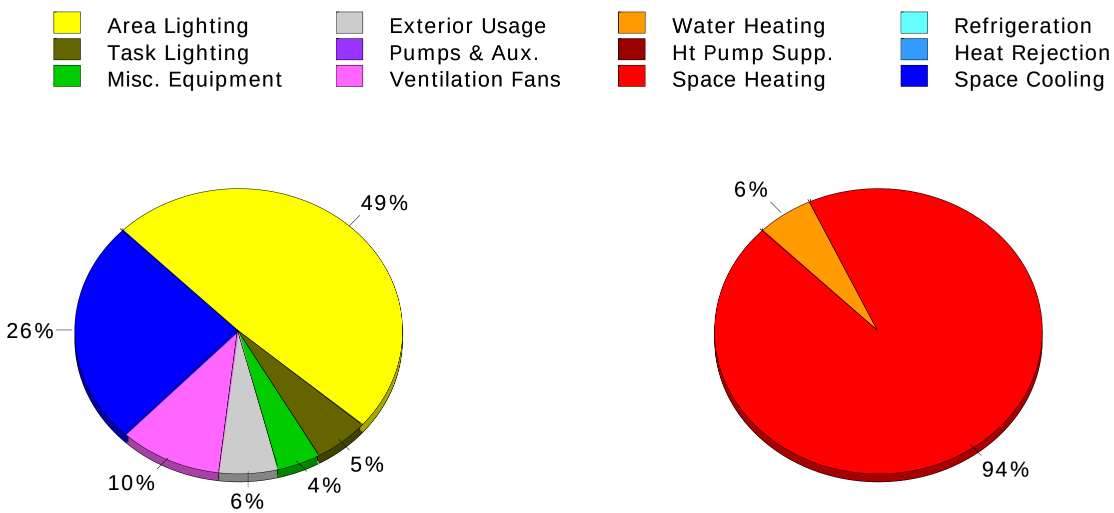
**Monthly Utility Bills ($)**




**Total Annual Bill Across All Rates: $ 14,073**

## Annual Energy Consumption by Enduse

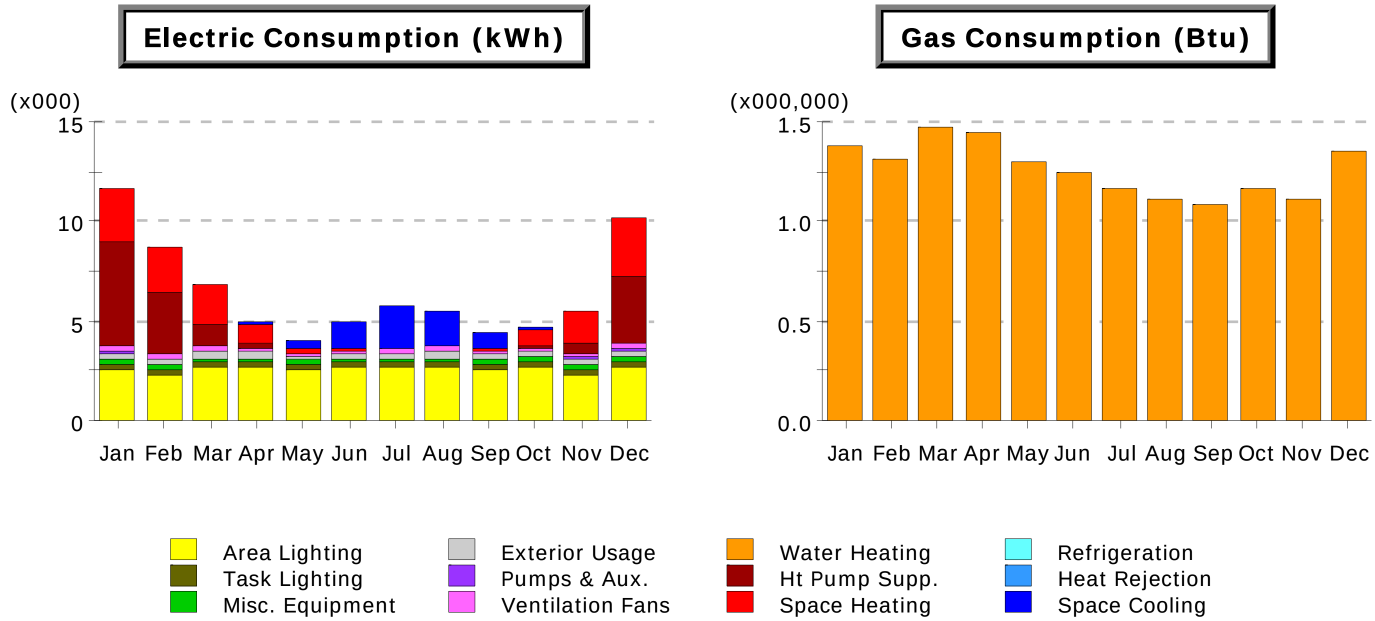
| | Electricity kWh | Natural Gas MBtu | Steam Btu | Chilled Water Btu |
|---|---|---|---|---|
| Space Cool | 16,148 | - | - | - |
| Heat Reject. | - | - | - | - |
| Refrigeration | - | - | - | - |
| Space Heat | - | 250.18 | - | - |
| HP Supp. | - | - | - | - |
| Hot Water | - | 15.17 | - | - |
| Vent. Fans | 6,249 | - | - | - |
| Pumps & Aux. | - | - | - | - |
| Ext. Usage | 3,559 | - | - | - |
| Misc. Equip. | 2,649 | - | - | - |
| Task Lights | 3,390 | - | - | - |
| Area Lights | 30,621 | - | - | - |
| **Total** | 62,615 | 265.35 | - | - |




Electricity

Natural Gas

New HVAC System – Packaged HE Heat Pump System

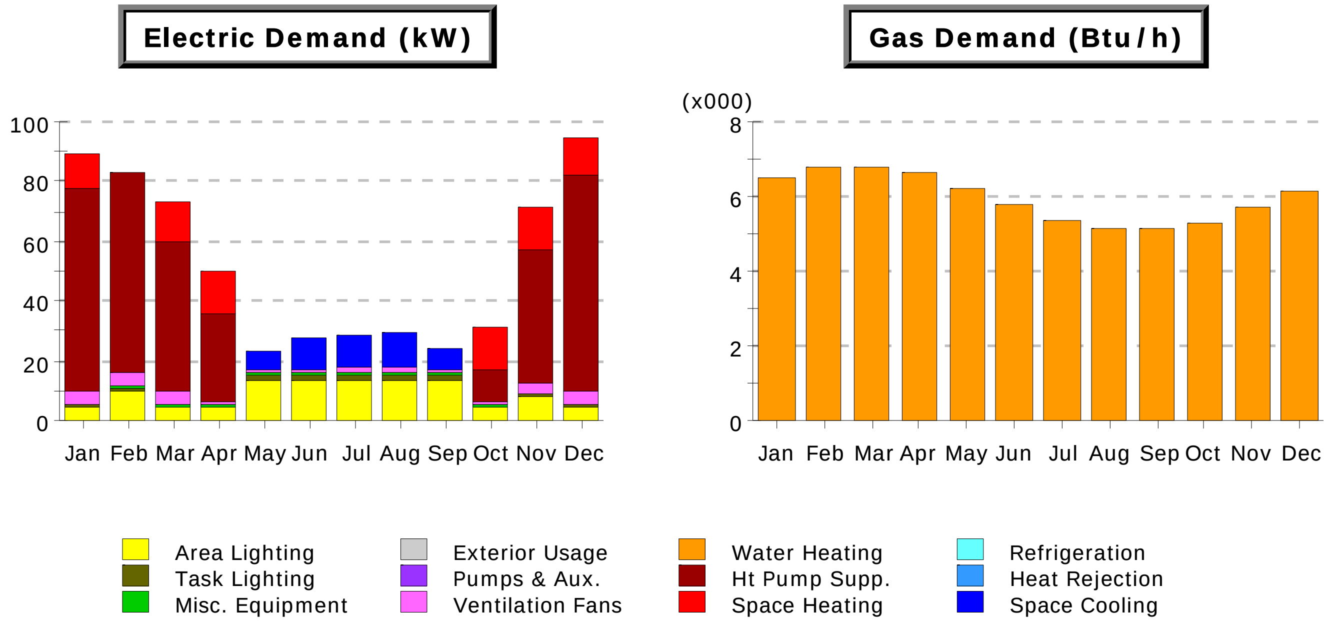



**Electric Consumption (kWh x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | 0.20 | 0.38 | 1.39 | 2.17 | 1.76 | 0.85 | 0.14 | 0.00 | - | 6.88 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 2.73 | 2.26 | 2.09 | 0.99 | 0.28 | 0.02 | - | 0.00 | 0.07 | 0.81 | 1.62 | 2.94 | 13.82 |
| HP Supp. | 5.12 | 3.04 | 1.09 | 0.22 | - | - | - | - | - | 0.05 | 0.58 | 3.40 | 13.50 |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 0.38 | 0.27 | 0.20 | 0.15 | 0.14 | 0.19 | 0.29 | 0.23 | 0.15 | 0.14 | 0.16 | 0.33 | 2.62 |
| Pumps & Aux. | 0.05 | 0.05 | 0.05 | 0.04 | 0.03 | 0.01 | 0.00 | 0.00 | 0.01 | 0.04 | 0.05 | 0.05 | 0.37 |
| Ext. Usage | 0.36 | 0.27 | 0.30 | 0.29 | 0.21 | 0.20 | 0.21 | 0.34 | 0.33 | 0.34 | 0.34 | 0.36 | 3.56 |
| Misc. Equip. | 0.22 | 0.20 | 0.23 | 0.23 | 0.22 | 0.23 | 0.23 | 0.23 | 0.22 | 0.23 | 0.20 | 0.23 | 2.65 |
| Task Lights | 0.28 | 0.26 | 0.29 | 0.29 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.29 | 3.39 |
| Area Lights | 2.53 | 2.33 | 2.62 | 2.62 | 2.53 | 2.62 | 2.62 | 2.61 | 2.53 | 2.63 | 2.32 | 2.64 | 30.62 |
| **Total** | 11.67 | 8.69 | 6.87 | 5.02 | 4.06 | 4.94 | 5.81 | 5.46 | 4.44 | 4.67 | 5.53 | 10.23 | 77.40 |

**Gas Consumption (Btu x000,000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 1.38 | 1.31 | 1.48 | 1.44 | 1.30 | 1.25 | 1.17 | 1.11 | 1.08 | 1.17 | 1.12 | 1.35 | 15.17 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 1.38 | 1.31 | 1.48 | 1.44 | 1.30 | 1.25 | 1.17 | 1.11 | 1.08 | 1.17 | 1.12 | 1.35 | 15.17 |

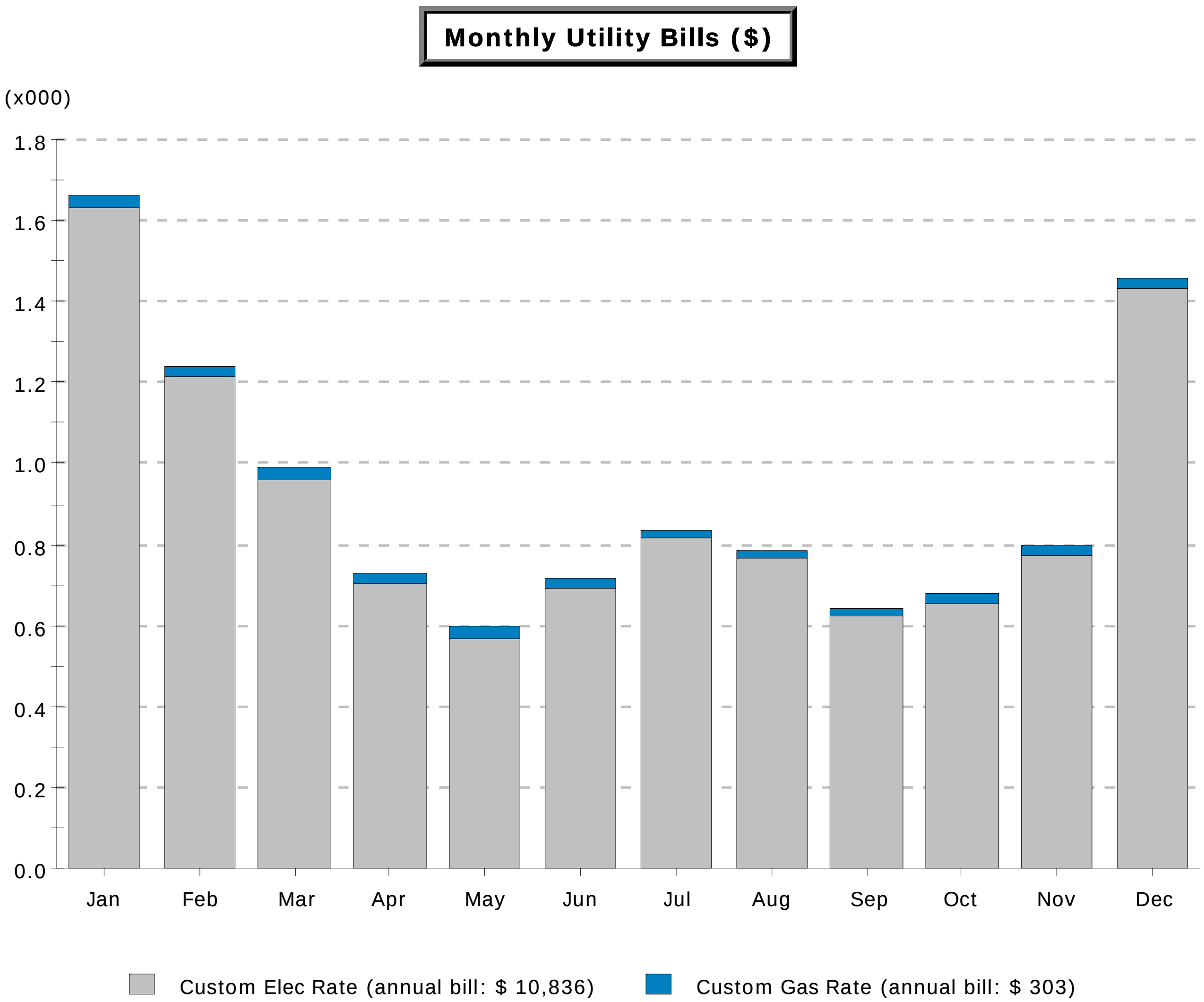



**Electric Demand (kW)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | 6.12 | 10.77 | 11.09 | 11.60 | 7.54 | - | - | - | 47.12 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 11.82 | - | 13.12 | 13.72 | - | - | - | - | - | 14.29 | 13.99 | 12.32 | 79.26 |
| HP Supp. | 67.74 | 67.16 | 50.40 | 29.64 | - | - | - | - | - | 10.47 | 44.61 | 71.77 | 341.79 |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 4.56 | 4.23 | 4.50 | 1.43 | 0.72 | 0.95 | 1.52 | 1.43 | 0.69 | 1.06 | 3.46 | 4.56 | 29.12 |
| Pumps & Aux. | - | 0.10 | - | - | - | - | - | - | - | - | - | - | 0.10 |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | 0.39 | 0.65 | 0.36 | 0.35 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 0.36 | 0.48 | 0.39 | 9.19 |
| Task Lights | 0.52 | 1.02 | 0.47 | 0.46 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 0.47 | 0.77 | 0.52 | 12.06 |
| Area Lights | 4.69 | 10.04 | 4.31 | 4.24 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 4.31 | 7.77 | 4.69 | 106.39 |
| **Total** | 89.72 | 83.21 | 73.16 | 49.84 | 22.92 | 27.80 | 28.68 | 29.10 | 24.31 | 30.95 | 71.08 | 94.26 | 625.02 |

**Gas Demand (Btu/h x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 6.53 | 6.77 | 6.78 | 6.67 | 6.22 | 5.77 | 5.38 | 5.13 | 5.11 | 5.32 | 5.70 | 6.15 | 71.52 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 6.53 | 6.77 | 6.78 | 6.67 | 6.22 | 5.77 | 5.38 | 5.13 | 5.11 | 5.32 | 5.70 | 6.15 | 71.52 |

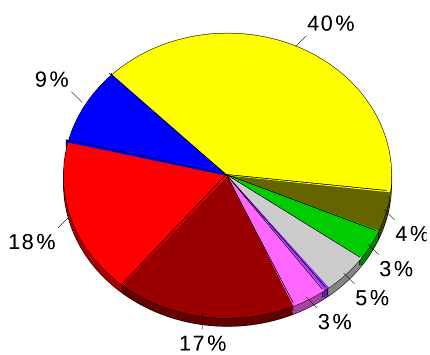



**Total Annual Bill Across All Rates: $ 11,139**

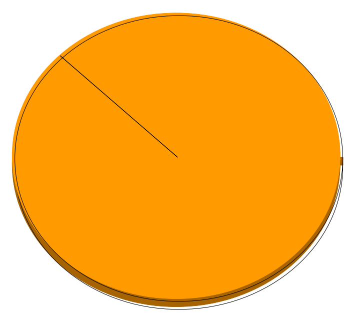
## Annual Energy Consumption by Enduse

| | Electricity kWh | Natural Gas Btu (x000) | Steam Btu | Chilled Water Btu |
|---|---|---|---|---|
| Space Cool | 6,875 | - | - | - |
| Heat Reject. | - | - | - | - |
| Refrigeration | - | - | - | - |
| Space Heat | 13,815 | - | - | - |
| HP Supp. | 13,501 | - | - | - |
| Hot Water | - | 15,174 | - | - |
| Vent. Fans | 2,625 | - | - | - |
| Pumps & Aux. | 365 | - | - | - |
| Ext. Usage | 3,559 | - | - | - |
| Misc. Equip. | 2,649 | - | - | - |
| Task Lights | 3,390 | - | - | - |
| Area Lights | 30,621 | - | - | - |
| **Total** | 77,400 | 15,174 | - | - |

Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

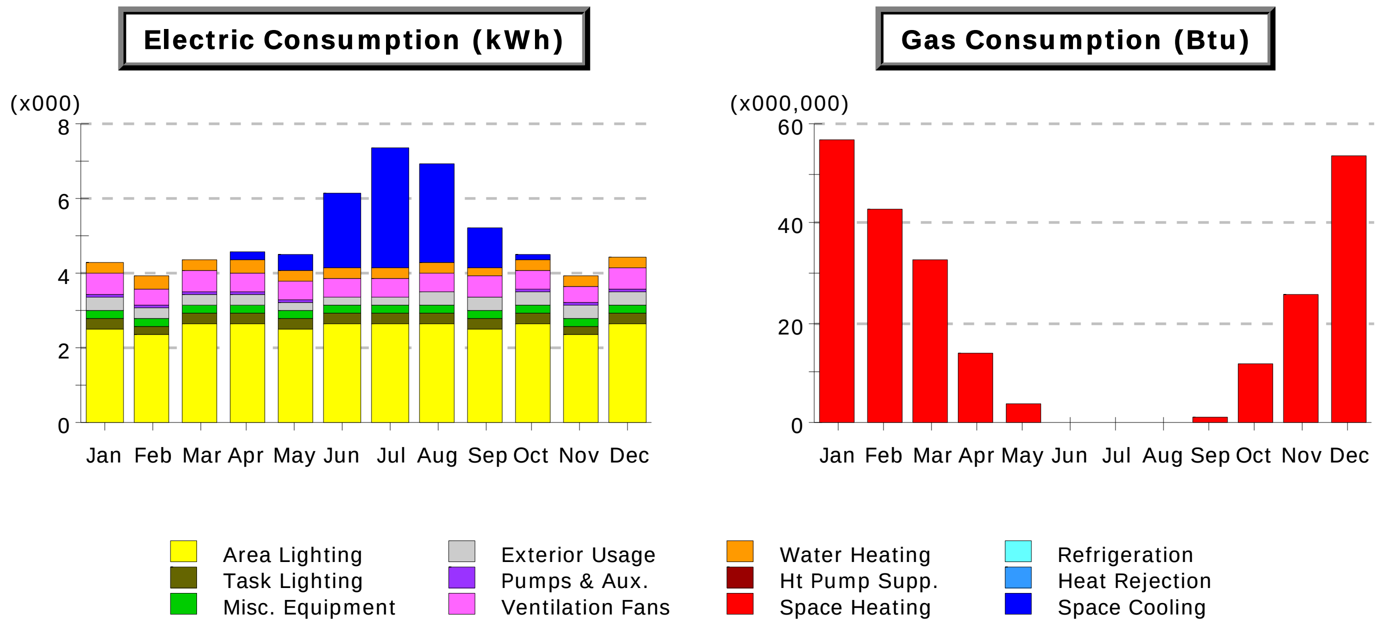



**Electricity**



**Natural Gas**

New HVAC System – Split Gas Furnace and DX System

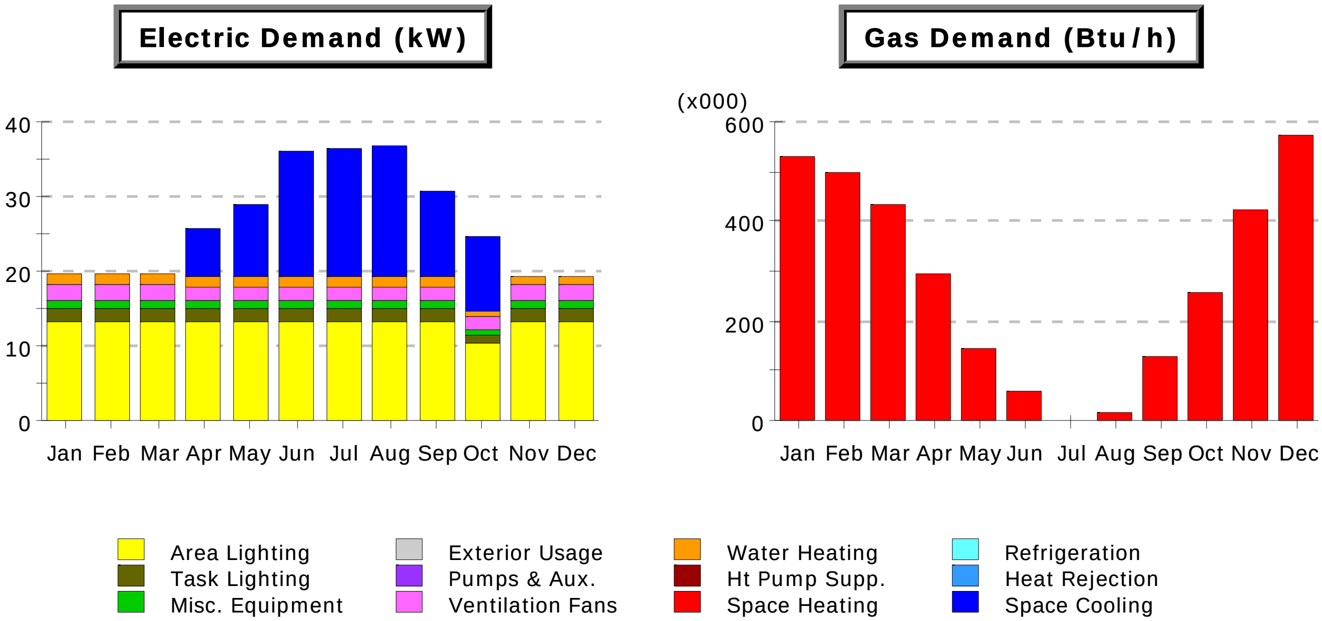



## Electric Consumption (kWh x000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | 0.25 | 0.45 | 1.98 | 3.23 | 2.66 | 1.07 | 0.15 | - | - | 9.79 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 0.31 | 0.30 | 0.33 | 0.32 | 0.29 | 0.28 | 0.26 | 0.25 | 0.24 | 0.26 | 0.25 | 0.31 | 3.41 |
| Vent. Fans | 0.51 | 0.48 | 0.54 | 0.54 | 0.51 | 0.54 | 0.54 | 0.53 | 0.52 | 0.54 | 0.47 | 0.54 | 6.25 |
| Pumps & Aux. | 0.07 | 0.07 | 0.07 | 0.05 | 0.03 | 0.01 | 0.00 | 0.00 | 0.01 | 0.04 | 0.07 | 0.07 | 0.50 |
| Ext. Usage | 0.36 | 0.27 | 0.30 | 0.29 | 0.21 | 0.20 | 0.21 | 0.34 | 0.33 | 0.34 | 0.34 | 0.36 | 3.56 |
| Misc. Equip. | 0.22 | 0.20 | 0.23 | 0.23 | 0.22 | 0.23 | 0.23 | 0.23 | 0.22 | 0.23 | 0.20 | 0.23 | 2.65 |
| Task Lights | 0.28 | 0.26 | 0.29 | 0.29 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.29 | 3.39 |
| Area Lights | 2.53 | 2.33 | 2.62 | 2.62 | 2.53 | 2.62 | 2.62 | 2.61 | 2.53 | 2.63 | 2.32 | 2.64 | 30.62 |
| **Total** | 4.28 | 3.90 | 4.39 | 4.59 | 4.53 | 6.14 | 7.38 | 6.91 | 5.21 | 4.49 | 3.91 | 4.45 | 60.18 |

## Gas Consumption (Btu x000,000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 56.96 | 42.81 | 32.68 | 14.11 | 3.64 | 0.13 | - | 0.03 | 0.81 | 11.70 | 25.91 | 53.34 | 242.12 |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 56.96 | 42.81 | 32.68 | 14.11 | 3.64 | 0.13 | - | 0.03 | 0.81 | 11.70 | 25.91 | 53.34 | 242.12 |



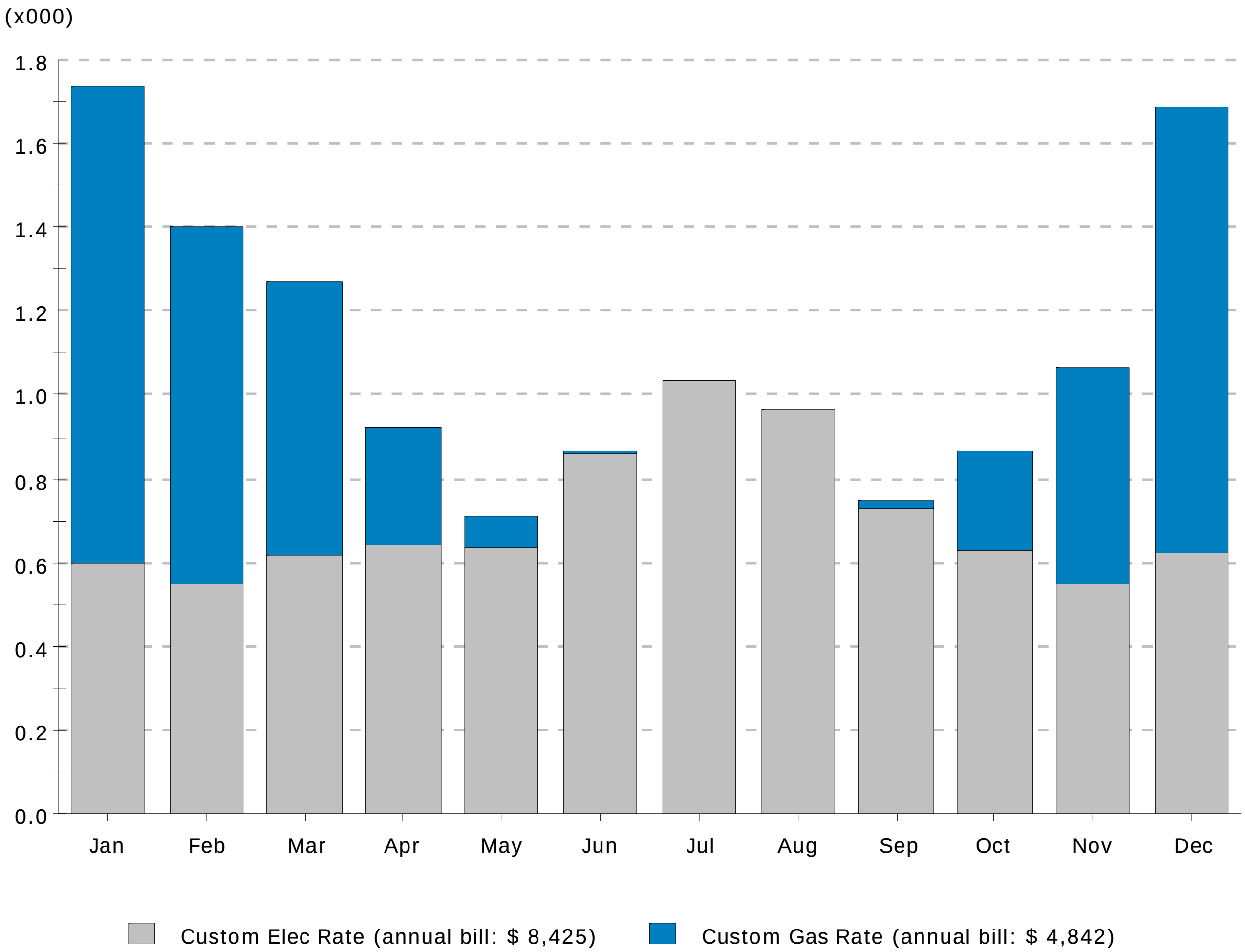

**Electric Demand (kW)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | 6.39 | 9.72 | 16.64 | 17.13 | 17.58 | 11.72 | 9.83 | - | - | 89.02 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 1.42 | 1.47 | 1.47 | 1.44 | 1.35 | 1.25 | 1.17 | 1.11 | 1.11 | 0.67 | 1.24 | 1.33 | 15.02 |
| Vent. Fans | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 1.93 | 23.18 |
| Pumps & Aux. | 0.10 | 0.10 | 0.10 | - | - | - | - | - | - | - | 0.10 | 0.10 | 0.50 |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 0.71 | 1.24 | 1.24 | 14.35 |
| Task Lights | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 1.06 | 1.57 | 1.57 | 18.31 |
| Area Lights | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 10.30 | 13.27 | 13.27 | 156.26 |
| **Total** | 19.52 | 19.57 | 19.58 | 25.84 | 29.07 | 35.90 | 36.30 | 36.71 | 30.84 | 24.51 | 19.35 | 19.44 | 316.63 |

**Gas Demand (Btu/h x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 529.7 | 499.7 | 433.0 | 294.1 | 147.2 | 60.7 | - | 16.2 | 128.4 | 259.5 | 422.1 | 574.0 | 3,364.6 |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 529.7 | 499.7 | 433.0 | 294.1 | 147.2 | 60.7 | - | 16.2 | 128.4 | 259.5 | 422.1 | 574.0 | 3,364.6 |

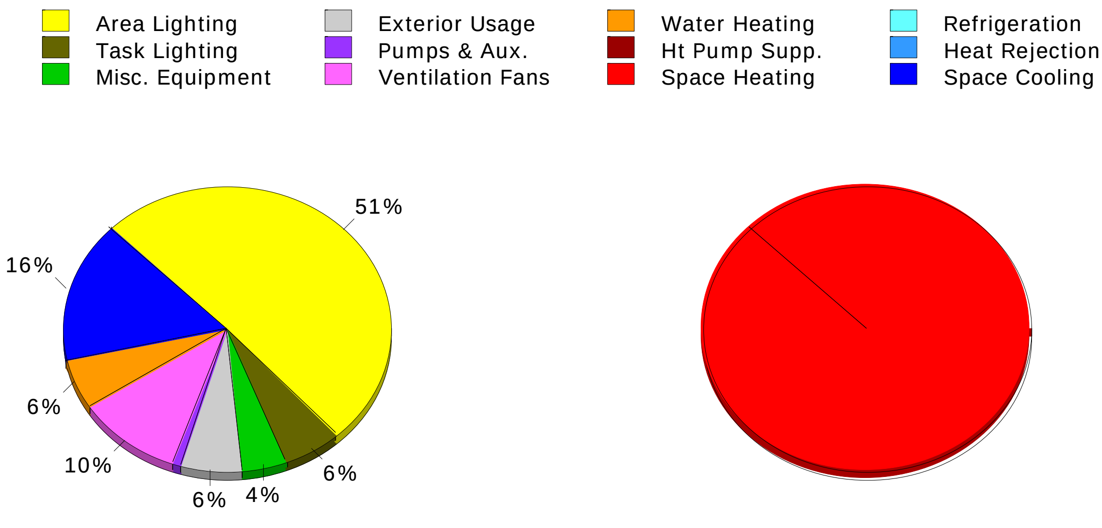
**Monthly Utility Bills ($)**




**Total Annual Bill Across All Rates: $ 13,267**

## Annual Energy Consumption by Enduse

| | Electricity kWh | Natural Gas MBtu | Steam Btu | Chilled Water Btu |
|---|---|---|---|---|
| Space Cool | 9,794 | - | - | - |
| Heat Reject. | - | - | - | - |
| Refrigeration | - | - | - | - |
| Space Heat | - | 242.12 | - | - |
| HP Supp. | - | - | - | - |
| Hot Water | 3,414 | - | - | - |
| Vent. Fans | 6,249 | - | - | - |
| Pumps & Aux. | 504 | - | - | - |
| Ext. Usage | 3,559 | - | - | - |
| Misc. Equip. | 2,649 | - | - | - |
| Task Lights | 3,390 | - | - | - |
| Area Lights | 30,621 | - | - | - |
| **Total** | 60,180 | 242.12 | - | - |

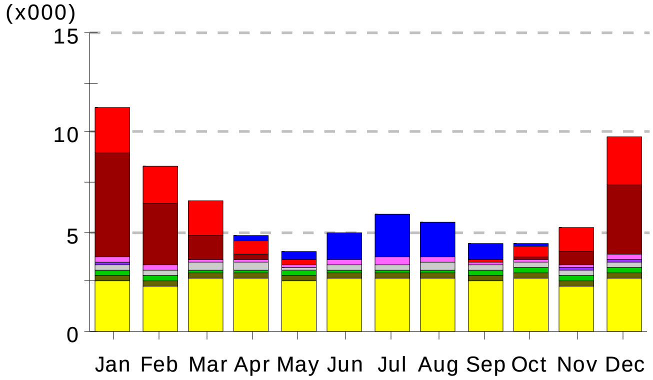



**Electricity**

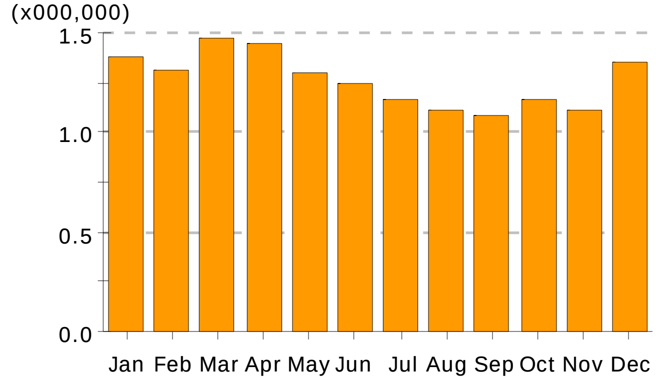
**Natural Gas**

Building Envelope Improvements

**Electric Consumption (kWh)**




**Gas Consumption (Btu)**



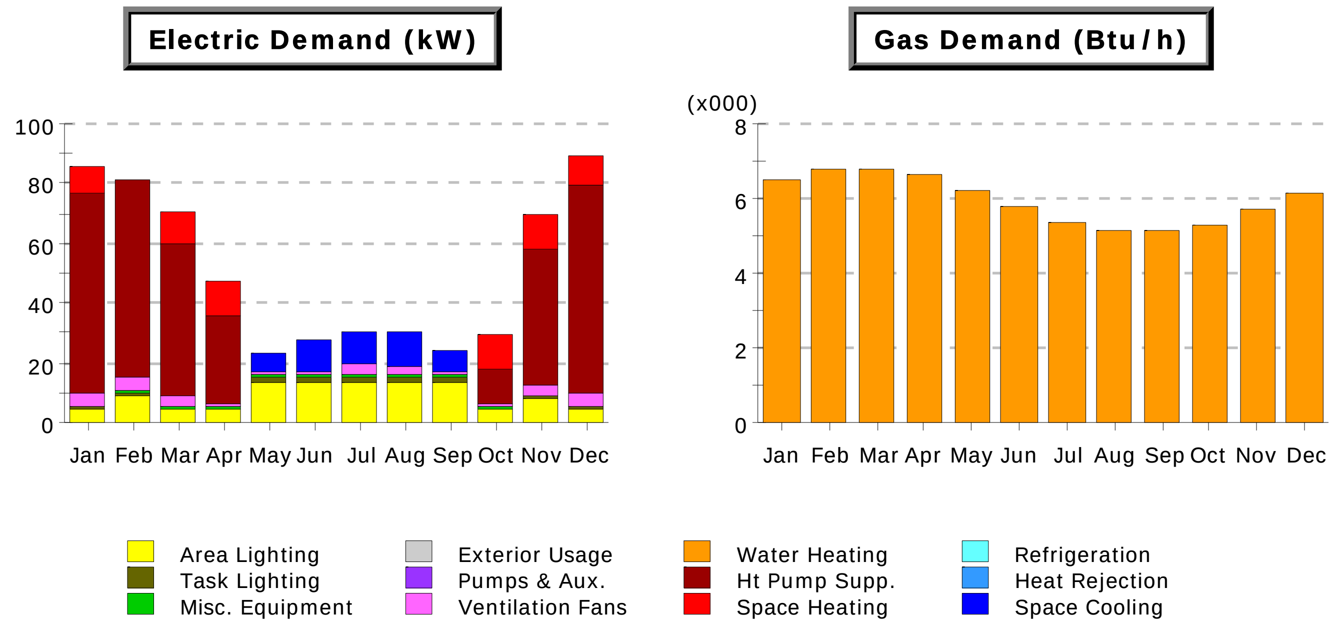

Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

### Electric Consumption (kWh x000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | 0.21 | 0.40 | 1.40 | 2.14 | 1.74 | 0.87 | 0.15 | 0.00 | - | 6.90 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 2.18 | 1.81 | 1.68 | 0.77 | 0.19 | 0.00 | - | 0.00 | 0.04 | 0.62 | 1.33 | 2.41 | 11.02 |
| HP Supp. | 5.24 | 3.11 | 1.15 | 0.23 | - | - | - | - | - | 0.05 | 0.64 | 3.54 | 13.97 |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 0.34 | 0.23 | 0.17 | 0.14 | 0.13 | 0.21 | 0.37 | 0.27 | 0.15 | 0.13 | 0.15 | 0.28 | 2.57 |
| Pumps & Aux. | 0.05 | 0.05 | 0.05 | 0.04 | 0.03 | 0.01 | 0.00 | 0.00 | 0.01 | 0.04 | 0.05 | 0.05 | 0.37 |
| Ext. Usage | 0.36 | 0.27 | 0.30 | 0.29 | 0.21 | 0.20 | 0.21 | 0.34 | 0.33 | 0.34 | 0.34 | 0.36 | 3.56 |
| Misc. Equip. | 0.22 | 0.20 | 0.23 | 0.23 | 0.22 | 0.23 | 0.23 | 0.23 | 0.22 | 0.23 | 0.20 | 0.23 | 2.65 |
| Task Lights | 0.28 | 0.26 | 0.29 | 0.29 | 0.28 | 0.29 | 0.29 | 0.29 | 0.28 | 0.29 | 0.26 | 0.29 | 3.39 |
| Area Lights | 2.53 | 2.33 | 2.62 | 2.62 | 2.53 | 2.62 | 2.62 | 2.61 | 2.53 | 2.63 | 2.32 | 2.64 | 30.62 |
| **Total** | 11.19 | 8.27 | 6.50 | 4.81 | 3.98 | 4.96 | 5.85 | 5.48 | 4.43 | 4.47 | 5.29 | 9.80 | 75.05 |

### Gas Consumption (Btu x000,000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 1.38 | 1.31 | 1.48 | 1.44 | 1.30 | 1.25 | 1.17 | 1.11 | 1.08 | 1.17 | 1.11 | 1.35 | 15.16 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 1.38 | 1.31 | 1.48 | 1.44 | 1.30 | 1.25 | 1.17 | 1.11 | 1.08 | 1.17 | 1.11 | 1.35 | 15.16 |



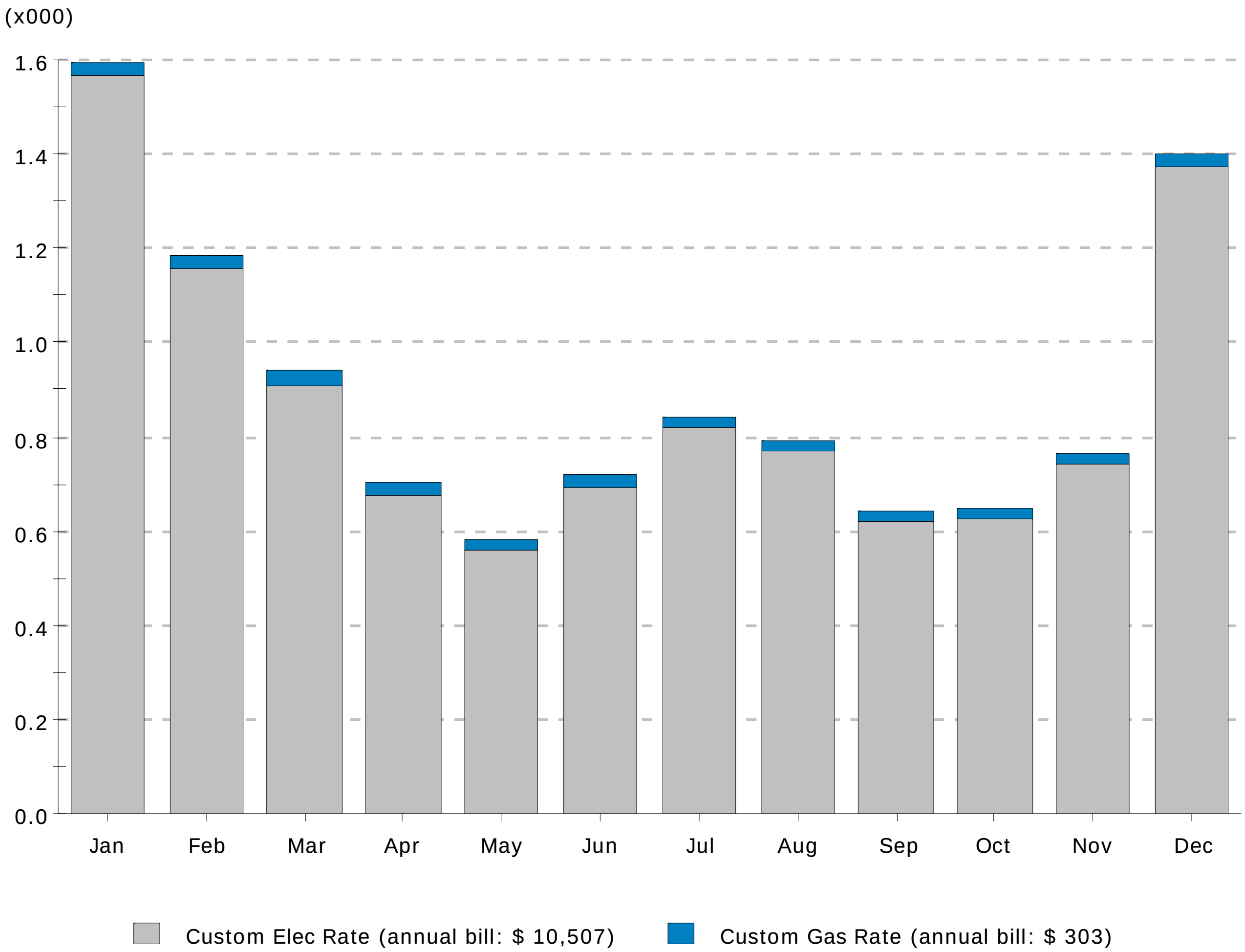

**Electric Demand (kW)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | 6.14 | 10.52 | 11.03 | 10.96 | 7.54 | - | - | - | 46.20 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | 9.40 | - | 10.43 | 10.90 | - | - | - | - | - | 11.57 | 11.12 | 9.80 | 63.22 |
| HP Supp. | 66.56 | 66.15 | 50.53 | 29.75 | - | - | - | - | - | 12.11 | 45.72 | 69.45 | 340.27 |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 4.33 | 4.33 | 4.19 | 1.17 | 0.76 | 0.98 | 3.16 | 2.90 | 0.72 | 0.84 | 3.36 | 4.33 | 31.05 |
| Pumps & Aux. | - | 0.10 | - | - | - | - | - | - | - | - | - | - | 0.10 |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | 0.39 | 0.56 | 0.36 | 0.35 | 1.24 | 1.24 | 1.24 | 1.24 | 1.24 | 0.36 | 0.48 | 0.39 | 9.09 |
| Task Lights | 0.52 | 0.89 | 0.47 | 0.46 | 1.57 | 1.57 | 1.57 | 1.57 | 1.57 | 0.47 | 0.77 | 0.52 | 11.94 |
| Area Lights | 4.69 | 8.98 | 4.31 | 4.24 | 13.27 | 13.27 | 13.27 | 13.27 | 13.27 | 4.31 | 7.77 | 4.69 | 105.33 |
| **Total** | 85.88 | 81.01 | 70.29 | 46.89 | 22.98 | 27.58 | 30.27 | 29.93 | 24.33 | 29.66 | 69.22 | 89.17 | 607.20 |

**Gas Demand (Btu/h x000)**

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 6.53 | 6.77 | 6.78 | 6.67 | 6.22 | 5.77 | 5.38 | 5.13 | 5.11 | 5.32 | 5.70 | 6.15 | 71.51 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 6.53 | 6.77 | 6.78 | 6.67 | 6.22 | 5.77 | 5.38 | 5.13 | 5.11 | 5.32 | 5.70 | 6.15 | 71.51 |

**Monthly Utility Bills ($)**

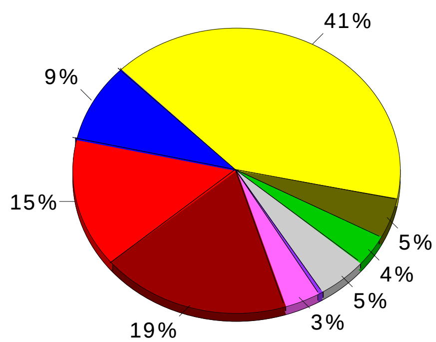



**Total Annual Bill Across All Rates: $ 10,810**

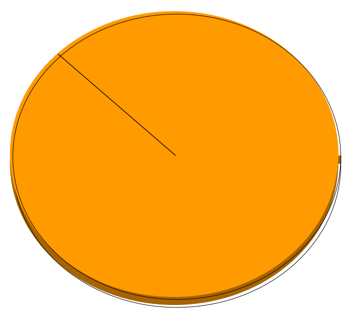
## Annual Energy Consumption by Enduse

| | Electricity kWh | Natural Gas Btu (x000) | Steam Btu | Chilled Water Btu |
|---|---|---|---|---|
| Space Cool | 6,897 | - | - | - |
| Heat Reject. | - | - | - | - |
| Refrigeration | - | - | - | - |
| Space Heat | 11,022 | - | - | - |
| HP Supp. | 13,974 | - | - | - |
| Hot Water | - | 15,161 | - | - |
| Vent. Fans | 2,569 | - | - | - |
| Pumps & Aux. | 368 | - | - | - |
| Ext. Usage | 3,559 | - | - | - |
| Misc. Equip. | 2,649 | - | - | - |
| Task Lights | 3,390 | - | - | - |
| Area Lights | 30,621 | - | - | - |
| **Total** | 75,048 | 15,161 | - | - |

Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling




**Electricity**



**Natural Gas**