Caryl Community Center
Town of Dover, MA

October 20, 2014

HVAC Boiler Replacement
and System Evaluation.

FORTE ENGINEERING
P.O. Box 1157
Middleton, MA 01949
978-777-0484

Caryl Community Center
Town of Dover, MA

October 20, 2014

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October 20, 2014

HVAC Boiler Replacement and System Evaluation

1. Introduction

The purpose of this report on the building heating system (HVAC) is to identify and prioritize important action required for the continued use and reuse of the building as a community facility.

The existing HVAC system was installed circa 1971as part of an addition and alteration to the existing Caryl School (circa 1910 & 1931 addition). The HVAC system has received maintenance and repair as needed throughout its life; however, the practical limit for the age of the equipment is at issue. In particular the heating boilers, but other components will also be addressed.

The existing heating equipment was originally designed to provide heating and ventilation for a classroom environment. Historically schools of this vintage were provided with high outdoor air ventilation rates that resulted in higher overall heating loads. As this school was designed prior to the energy crisis of the early 1970's, energy consumption is expected to be high in the winter due to the higher outdoor air ventilation rates.

The current use of the building has evolved into a community based multiuse facility. The school use ceased to exist in 2001 after construction of a new elementary school. In 2003, a "Deferred Maintenance Study" was conducted to review conditions of the facility, but as of that time, a continuing use for the building had not yet been established. Now that the building's use is known and its future more certain, aspects of the HVAC comments from the 2003 study are being updated in this current report in order to recommend an appropriate approach to system upgrades.

A preschool daycare occupies a portion of the first floor. The COA also has an office on the first floor. The Park & Recreation Department has offices on the second floor. Other spaces on the first and second floors are utilized by various community groups. The former cafeteria is rented out by the Town. There are exercise classes and Yoga classes in the Blue Room. The existing Gym is utilized. The former Library has been utilized by the Police and Fire Departments for training. Uses for various spaces on the Second floor include; martial arts, a drop-in center, Parent Talk, birthday parties and meetings. It is also anticipated that spaces could be rented out for other uses. Occupancy count limits have been determined by the Fire Department.

2. Existing Systems Description

The existing heating system for the building consists of; two hot water boilers fired by oil, a piped hot water distribution system throughout that is pumped via a pair of base mounted centrifugal pumps, terminal units located in the various spaces consisting primarily of unit ventilators that provide heating and ventilation, as well as cabinet heaters and baseboard fin-tube. The former classrooms all utilized unit

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ventilators to provide heating and ventilation. Former classrooms on the second floor have both unit ventilators and supplemental baseboard fin-tube (the library does not have supplemental baseboard).

Automatic Temperature Controls (ATC) incorporate pneumatic control devices that are powered by a centralized air compressor. The pneumatic system was installed by MCC Powers Regulator (the company was acquired by Landis+Gyr in 1987) throughout the building in 1971, and operates thermostats, control valves and dampers, etc., as well as maintaining required set point temperatures and ventilation rates.

A new 3000 gallon exterior aboveground heating oil storage tank was installed in 2012. The original underground storage tank was removed. Fuel usage for the winter of 2014 was approximately 22,000 gallons of no. 2 fuel.

The exhaust component of the former classroom ventilation system consists of a series of roof exhaust fans. This sub-system is non-functional. In addition to classroom exhaust ventilation, roof exhaust fans are provided for toilets rooms throughout the building. These toilet exhaust fans are also non-functioning.

Windows throughout the building have been replaced with new thermally insulated type. The windows typically have an operable sliding section potentially providing occupant controlled ventilation.

The building does not have air-conditioning, although there have been some plans to add cooling to small spaces utilized for department offices.

Natural gas is not available to the building.

3. Observations

With the exception of the oil storage system, it appears that all the equipment that makes up the boiler plant, including the burners, but not the boilers, was replaced in 1971. The boilers themselves predate the 1971 renovation, and are likely original to the 1930's school building. Based on the age and condition of the boilers and our on-site observations there is little doubt that the boilers need replacement as soon as possible. This work should not be delayed any longer than necessary, especially since the boilers have long surpassed their expected life span, and it would not be unanticipated to see an irreversible loss in service from one or the other of the boilers in the near future. Were the boilers to fail in the middle of the heating season, damage could potentially extend to other equipment and piping throughout the building. It is known from experience that if one of the two boilers fails during the heating season and requires repair, an event that happened recently, the other boiler could adequately carry the heating load of the facility. Currently the boilers alternate in operation and rarely both operate simultaneously throughout the winter. This has allowed these aged boilers to continue to serve the facility, but their replacement should be scheduled in the near future in order to adequately protect the facility and its occupants should both boilers fail and be beyond repair. Newer more efficient boilers will realize a minimum of 15% reduction in fuel consumption.

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The unit ventilators have been difficult to maintain and the basic ventilation aspect, as well as the temperature control aspect have been difficult to control. The result can be improper ventilation air introduced into the space and/or poorly controlled heating output due to malfunctioning control valves.

Current uses for the various spaces combined with energy conservation guidelines and the latest ventilation air standards dictate the required performance expectations needed for the spaces. If existing equipment is oversized short cycling can occur, if existing equipment introduces too much outdoor air excessive energy consumption results. In some cases the existing unit ventilators may represent a misapplication of that needed for the current service requirements of the space. In fact, as currently configured, the existing equipment likely provides incorrect ventilation rates, and uses excessive energy while providing poor temperature control. In particular the need for unit ventilator equipment should be scaled back in favor of more appropriate equipment with lower and more targeted outdoor air ventilation rates. In some high occupancy areas it may still make sense to utilize unit ventilators, but the use should be minimized

HVAC controls need to be address along with recommendations for new heating and ventilation equipment. A better control platform for the building would be one that provides the flexibility that responds to changing use and occupancy, as well as occupied/unoccupied conditions. An electronic digital control system with remote control and preprogramming capabilities will go a long way to reducing overall energy usage, as well as improving indoor air quality. See further discussion below in section titled “Controls”. In the 2003 study, the aging pneumatic control system and related HVAC equipment was noted for repairs and maintenance, but that was in the absence of knowing what the future use of the facility might be. Now that the building has been converted into a community center use, maintaining the existing poorly functioning pneumatic control system and the outdated ventilation equipment is not recommended. Required ventilation rates relative to building use have changed significantly over the years, ranging from 20 to 30 CFM per person for classrooms in the pre-energy crises years of the last renovation in 1971, then being reduced to at least half of those quantities and even less for other less dense occupancies. Changes in ventilation rates are still ongoing due to the costs of energy related to this part of an HVAC system. The existing “classroom” equipment was designed for the higher rates required at the time. Less ventilation air results in savings of the energy required to temper the incoming air and for the related operational costs of running the equipment.

A portion of the heating system piping in the 1971 addition was designed to be located within a floor trench. This piping has been a source of continuous maintenance. Due to the inaccessibility of the piping the situation is a liability that needs corrective action.

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4. Recommendations

We are first focusing on the most urgent work needed for the continued use of the building, i.e., the boilers. We have reviewed the heating load for the building based on the 1971 design drawings and considered the changing usage and the current energy conservation standards. We suggest the following parameters in developing a new boiler system configuration. An improvement in overall combustion efficiency to 85 % can be achieved with competitively available equipment. Boilers of the cast iron sectional type assembled on site will simplify the installation. Based on the load profile it appears that a three boiler configuration will provide an efficient part load arrangement. A three boiler configuration also provides a better level of redundancy and allows for greater control and energy efficiency due to the fluctuant nature of heating load requirements. Preliminary calculations indicate that a maximum boiler output of a little over 4 million BTUH is sufficient for this application. The combination of modulating burners used in conjunction with an electronic boiler control will improve fuel utilization. Sizing of the boilers should be based on an equal split that does not increase the overall capacity more than 10 – 15% of that required. Ancillary equipment, i.e., pumps, boiler control, expansion tank, combustion air supply, etc. should all be provided as new. The condition of the existing chimney should be assessed and any corrective action required should be included in the replacement work.

The boiler replacement work is of the highest priority and, if all of the recommendations herein cannot be accommodated into a single project, should precede the implementation of distribution equipment, controls, etc. These other improvements include upgrading ventilation units and temperature controls in order to realize additional energy savings and improved comfort levels. Ideally, the related work would be done simultaneously with the boilers in a single renovation project, saving time and money in comparison to doing multiple projects. If not done as a single project, upgrading of ventilation and control systems could be deferred as long as the existing systems are still serviceable, recognizing that deferral will sacrifice energy savings and improvements to comfort while continuing to require potentially significant maintenance costs.

If the recommendations could not be afforded simultaneously, then the work could be phased as follows:

- Phase One – Boilers: The boilers could be replaced without having to replace the control systems and ventilation units, and without having to prevent their future replacement. Modern boilers are equipped with electronic control systems that can operate on a standalone basis and in compatibility with the building's aging pneumatic controls until those systems are upgraded.
- Phase Two – Ventilation & Controls: While the boilers will reduce fuel oil use by at least 15%, additional savings will be realized when the ventilation and control systems are replaced. Phase Two would also result in improved comfort levels for occupants, whereas the boiler replacement work will have no apparent effect on comfort. The replacement of ventilation and control systems is the more expensive of the two phases, but more

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affordability would not be achieved by doing this work incrementally since the cost would be significantly higher owing to duplication, re-mobilization and construction management costs. Therefore, although possible, taking an incremental approach to this phase of the work is not recommended. Ideally all of the new equipment should be of the same "generation" and manufacturer for both maintenance and compatibility. Controls are no longer strictly proprietary; however, a partial installation of controls installed at one point in time by a bidding controls contractor may need unanticipated reworking (due to technology updating) by a future contractor in the next phase. Also, if controls and ventilation were upgraded in selected areas over time (i.e., incrementally) there would need to be dual control systems in the building (new electronic and old pneumatic) and costly changes to existing systems would be required in order to accommodate replacement and upgrading of only portions of the ventilation units and temperature controls.

- Conceptual Budgets: $0.4m Phase One + $1.3m Phase Two = $1.7 million; see attached details.

Despite the fact that the usage of the building as a school will not continue, the newly evolving uses are similar to the former school. The classroom unit ventilator terminals, typically one or more in each space, have now been in service for over 40 years. They have been difficult to maintain, however more importantly, they no longer meet the design criteria. The newer installed windows and lower ventilation rate requirements allow for a reduction in the overall heating capacity needed. Many of the spaces may no longer need unit ventilators. Automatic Temperature Control (ATC) issues related to the existing unit ventilators are discussed further in the subsequent paragraphs of this report. The ATC devices associated with the equipment cannot be reused if the control system and/or terminal units are modernized. This means the ATC work cannot be separated from the equipment modernization. Replacement of the existing unit ventilators is recommended, due to the age of the equipment, the control issues, and the no longer justified heating output provided by the original system design.

Some of the spaces on the first floor could benefit from the installation of baseboard heat to be utilized in an unoccupied mode. This allows the unit ventilators (or other fan coils) to remain off and thus saves the fan energy. The second floor has existing baseboard heat for the most part (as well as unit ventilators), and therefore could utilize this effectively. The baseboard heat should remain in all cases, but control valves will need replacement. There is an expectation that smaller spaces that currently have unit ventilators may not need them, or could be spaces that are designated for lower occupant density such as offices, where ventilation could be satisfied naturally via operable windows (occupant control).

Pressurization relief via the existing classroom exhausts should not be reinstituted. Currently, with the fans off, air may still be relieving naturally by gravity. As an uncontrolled loss, this wastes energy. Since the building is never fully occupied, any over pressurization control, if needed, should be done locally as part of a dedicated system for the space in question.

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Air conditioning is outside the scope of this report and has been given no consideration. Additional equipment and piping would need to be incorporated into the building resulting in further cost impact. The summer time use of the building is diminished to a few small departments that can be satisfied with small scale dedicated equipment.

5. ATC Controls

The existing pneumatic control system can be considered to be a piece of equipment that needs to be in full working order for the proper functioning of the HVAC system. A control system has historically been installed by a vendor that utilizes proprietary devices. Therefore the proper operation usually requires the vendor's participation to maintain and fine tune the system for continued operation throughout the lifetime of the system. Considering the age of this system, it is likely that there are impairments that prevent proper temperature control as well as ventilation air control. Typically the control equipment such as thermostats and associated control valves, ventilation control dampers, low limit and freeze stats, sensors, etc. needs to be checked for proper operation according to the "sequence of operation" that the devices were originally designed to perform.

A "fine tuning" program that reviews the functionality of each component of the control system can be performed by a qualified subcontractor. This process is time consuming and will result in the need to replace components that cannot be properly calibrated or repaired. It is expected that there will be many unrepairable components in a system of this age. Furthermore, since the application of this type of system has been diminished in favor of state of art digital/electronic type control systems, performing maintenance in the future will become even more difficult.

The cost benefit for instituting a fine tuning program is based on capturing energy efficiencies due to overheating, lack of setbacks, and improper introduction of outdoor ventilation air. However, since the system was originally designed as a school, changes to the HVAC system equipment are being recommended that will require additional control work with the intent of reducing energy use and providing better control. A revised sequence of operation based on the current use will also be needed for some of the spaces. Parameters such as; override of unoccupied cycle, warm-up cycle, ventilation air rate, control of exhaust fans, and occupancy sensors, may all need to be accounted for in a different way. The expectation that the existing control system could be economically upgraded while being adapted to new equipment is highly unlikely. We therefore recommend that the existing control system not be upgraded and that a new control system will be the most sensible approach to minimizing energy use as well as providing accurate temperature control throughout the facility.

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A new control system should allow for programming of spaces based on the usage. In this case the building usage is consistently variable, which makes it difficult to efficiently manage the facility. A control system based on digital/electronic/electric devices with a Local Open Protocol (Lonworks) network or similarly comparable Building Automated Control network (BacNet) system can provide the flexibility needed for the building. Setpoints can be changed easily without having to visit the space, temperatures can be monitored remotely and setbacks can be scheduled and overridden. This allows energy management to be more flexible. This type of system is not proprietary and therefore it can be maintained by any qualified contractor.

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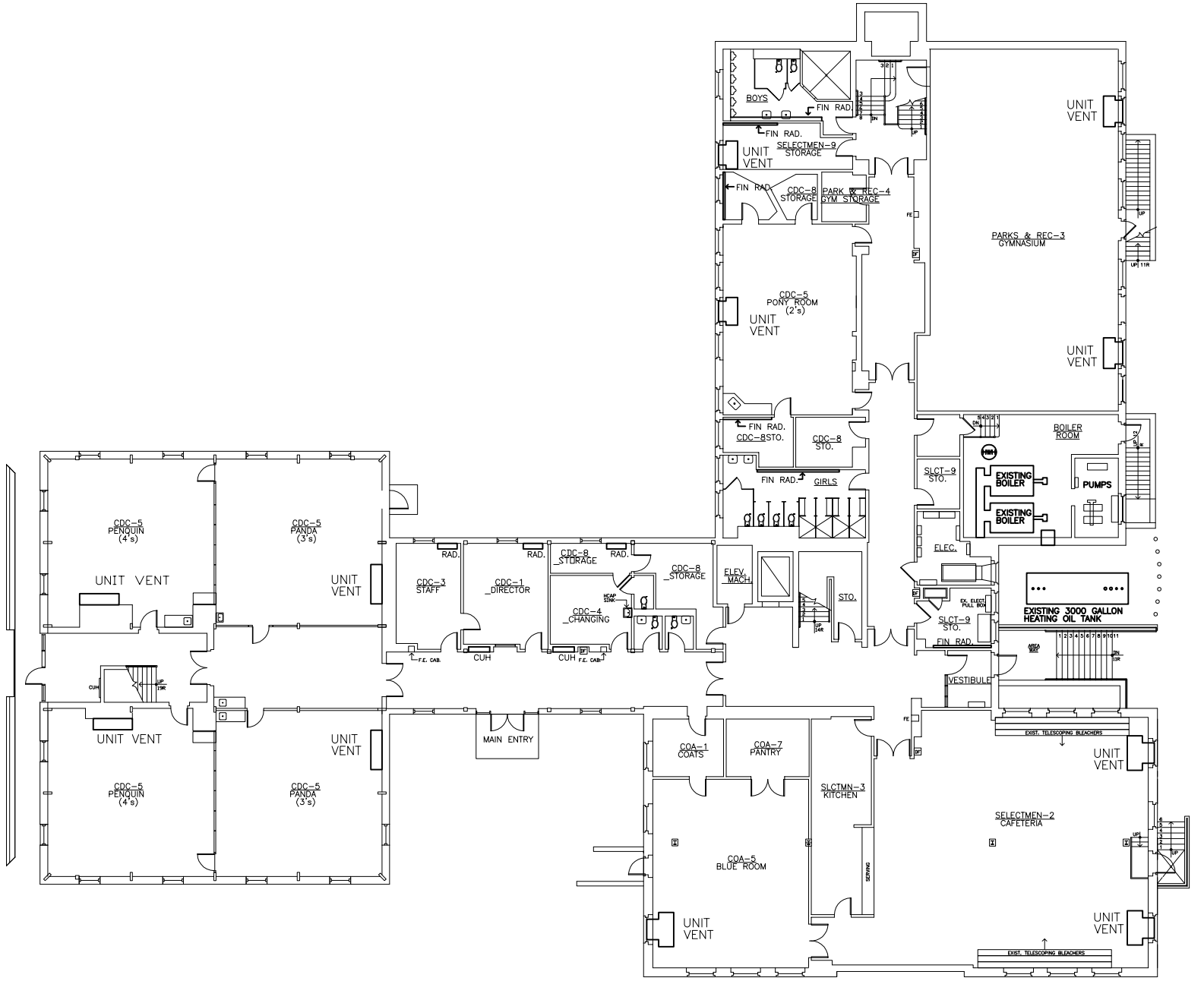
CARYL COMMUNITY CENTER
4 SPRINGDALE AVE.
DOVER, MA

TITLE
EXISTING CONDITIONS PLAN
FIRST FLOOR

DATE: 8-15-14
SCALE: 1"=25' +/-
JOB NO. F14.14

A-1



1 A-1 EXISTING FIRST FLOOR PLAN

-5 0 5 10 20

N

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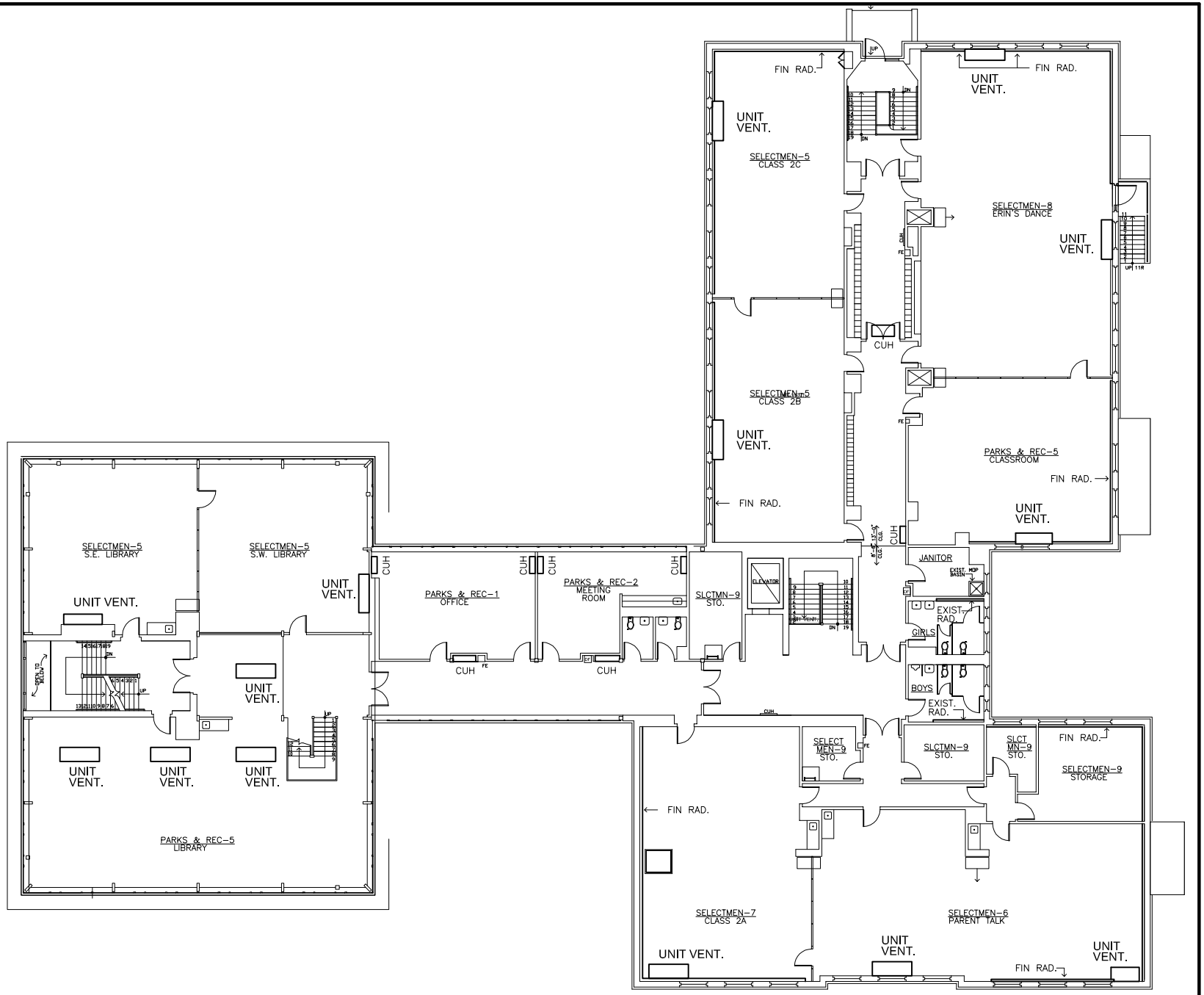
CARYL COMMUNITY CENTER
4 SPRINGDALE AVE.
DOVER, MA

TITLE
EXISTING CONDITIONS PLAN
SECOND FLOOR

DATE: 8-15-14
SCALE: 1"=25' +/-
JOB NO. F14.14

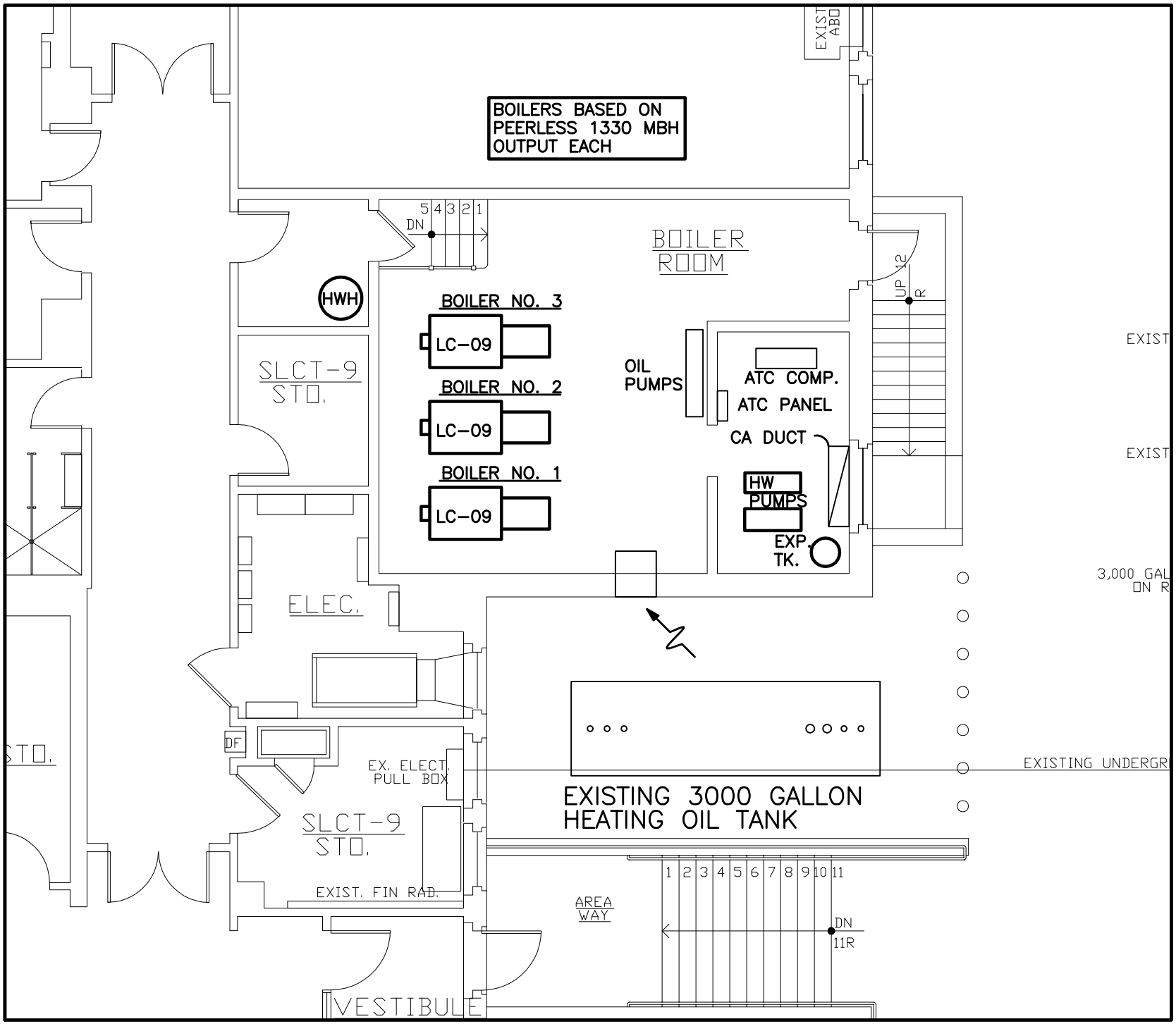
A-2



1 A-2 EXISTING SECOND FLOOR PLAN

-5 0 5 10 20

N



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CARYL COMMUNITY CENTER
4 SPRINGDALE AVE.
DOVER, MA

TITLE
PROPOSED BOILER RM. PLAN
FIRST FLOOR

DATE: 8-15-14
SCALE: 1/8"=1'-0"
JOB NO. F14.14

M-1

Cost Estimate
New Boiler Plant

Section 15500 - HVAC

	Quantity	Unit	Unit $		Total
Demolition:					
Asbestos abatement	1	LS	3,000	$	3,000.00
Remove Piping	1	LS	3,000	$	3,000.00
Remove pumps & converter	1	LS	1,000	$	1,000.00
Remove Boilers	2	ea.	1,500	$	3,000.00
New Work:					
Boilers / Burners & Trim	3	ea.	32,000	$	96,000.00
Pumps & trim	2	ea.	23,450	$	46,900.00
Variable speed pump controller	2	ea.	3,800	$	7,600.00
Expansion Tank	1	ea.	7,000	$	7,000.00
Air separator	1	ea.	4000	$	4,000.00
Heating Piping	300	LF	110	$	33,000.00
OS&Y Valves	4	ea.	1,500	$	6,000.00
Insulation	300	LF	20	$	6,000.00
Boiler controls	1	LS	7,500	$	7,500.00
Oil piping	100	ft	21	$	2,100.00
Backflow preventer	1	LS	2,000	$	2,000.00
Breeching	60	LF	250	$	15,000.00
Chimney Liner	1	LS	5,000	$	5,000.00
Combustion Air ducting	1	LS	3,000	$	3,000.00
Comb. Air controls	1	LS	1,500	$	1,500.00
Concrete pads	5	ea.	510	$	2,550.00
Electrical wiring	1	LS	5,000	$	5,000.00
Water Balancing	1	LS	1,000	$	1,000.00
Permits, Submittals, testing, closeout, etc.	1	LS	3,000	$	3,000.00
Sub-total				$	264,150.00

Contingency, 12.5%	1	0.15		$39,622.50
Sub total			$	303,772.50
O&P, 10%	1	0.1		$30,377.25
Total Construction Cost			**$**	**334,149.75**
New Boiler Plant				
Estimated A&E Fees, 15%		0.15		$50,122.46
Grand Total			**$**	**384,272.21**

Exclusions:

* Interest Expense
* Relocation expenses
* Printing & Advertising
* Police & Fire - Details
* Owner Administration: Legal fees, Advertising, Printing
* Utility Back Charges
* Furnishings & Fixtures
* Escalation

Cost Estimate
Equipment and Controls Modifications

Section 15500 - HVAC

	Quantity	Unit	Unit $		Total
Demolition:					
Asbestos abatement	1	LS	15,000	$	15,000.00
Unit ventilators	25	LS	600	$	15,000.00
Remove ATC Comp. and Access.	1	LS	600	$	600.00
Piping in trench	1	LS	2,500	$	2,500.00
Remove Sys. Isolation Valves	6	LS	100	$	600.00
New Work:					
Unit Ventilators	12	Ea.	8,000	$	96,000.00
Fan coils w/ OA	11	Ea.	1,500	$	16,500.00
Cabinet Exhaust Fans	12	Ea.	1,500	$	18,000.00
Fintube Radiation (1st flr.)	250	LF	120	$	30,000.00
Fintube Radiation (2 nd flr.)	100	LF	120	$	12,000.00
Heating specialties	12	LS	200	$	2,400.00
Heating Piping (new equip)	500	LF	60	$	30,000.00
OS&Y Valve Replacement	4	Ea.	1,300	$	5,200.00
Insulation	1000	LF	20	$	20,000.00
New valve install ETR Equip.	25	Ea.	200	$	5,000.00
Replace Pipe in Trench w/ New	450	Ft.	75	$	33,750.00
Ductwork & insulation	1	LS	40,000	$	40,000.00
Diffusers & Grilles	1	LS	25,000	$	25,000.00
Testing & Balancing	1	LS	5,000	$	5,000.00
Architectural Divisions	35000	SQ FT	6	$	210,000.00
GC Supervision	25	Wks	2,500	$	62,500.00
Electrical wiring	1	LS	10,000	$	10,000.00
ATC Controls	1	LS	175,000	$	175,000.00
Permits, Submittals, testing, closeout, etc.	1	LS	40,000	$	40,000.00
Sub-total				$	870,050.00

Contingency, 18%	1	0.18	$156,609.00
Sub total			$ 1,026,659.00
O&P, 10%	1	0.1	$102,665.90
Total Construction Cost			**$ 1,129,324.90**
New Equipment & Controls			
Estimated A&E fees of 15%		0.15	$169,398.74
Grand Total			**$ 1,298,723.64**

Exclusions:

* Interest Expense
* Relocation expenses
* Printing & Advertising
* Police & Fire - Details
* Owner Administration: Legal fees, advertising, Printing
* Utility Back Charges
* Furnishings & Fixtures
* Escalation

Existing Boilers

Hot water pump (1 of 2)

Existing ATC compressor

New oil pump set

Heavily corroded existing valves

New Oil Tank

Repaired pipe elbows included removal of asbestos insulation

Existing ATC panel

Typical Classroom Unit Ventilator & baseboard radiation below windows

Ceiling Mounted Unit ventilator in former Library

Cabinet heater in Corridor

Pipe Tunnel access

Gym relief vent

Gym Unit Ventilator

Cafeteria Unit Ventilator

Ceiling mounted
Classroom Unit Ventilator

Classroom Relief Vent.

Gym ventlation intake grille

Typical Classroom ventilation intake

Typical thermostat