PULASKI AND DUBLIN MIDDLE SCHOOLS

HVAC/ ELECTRICAL/ WINDOW REPLACEMENT STUDY

DUBLIN MIDDLE SCHOOL

PULASKI MIDDLE SCHOOL

REPORT BY:

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I. INTRODUCTION AND PROJECT BACKGROUND

Pulaski County Public Schools commissioned Spectrum Design, P.C. to conduct a study at the Pulaski and Dublin Middle Schools to investigate feasibility and probable costs to implement the following facility improvements:

- Replacement of classroom and computer lab HVAC systems to provide heating and air conditioning
- Replacement of HVAC systems in Administration offices to provide heating and air conditioning
- Replacement of HVAC systems in library facilities to provide heating and air conditioning
- Improvement of electrical systems to support selected HVAC improvements
- Replacement of exterior windows throughout both facilities

This study excludes HVAC systems in auditoriums, gymnasiums, cafeterias and common areas as well as miscellaneous H&V units and ventilation make-up systems.

Both facilities were substantially constructed in the early to mid-1950's and have not been significantly modified since original construction.

The objectives of this study include the following:

- Establish existing conditions for each school with respect to HVAC and associated electrical systems as well as exterior windows
- Develop a cost effective and constructible solution for providing air conditioning in key areas of each school, keeping in mind that the solution needs to make sense for buildings of this age and construction.
- Develop a cost effective and constructible window replacement strategy that will improve the insulation envelope of the buildings, reduce transmittance of UV light, and

Pulaski Middle School, Historic Brick Façade

Dublin Elementary School, Front Façade

I. INTRODUCTION AND PROJECT BACKGROUND

aesthetically improve the buildings without detracting from historical appearance of each.

Each school was visited by representatives of Pulaski County Public Schools and Spectrum Design to document existing conditions and to review each building for suitability of likely solutions. The following details were examined:

- Electrical room equipment, conditions, and layouts
- Existing HVAC equipment, including equipment that is not in the scope of this study, but will have to remain in service after the classroom HVAC is modified
- Ceiling heights and composition (lay-in, hard ceiling, asbestos ceiling)
- Above ceiling clearance for HVAC and electrical work
- Mechanical room equipment, conditions and layouts
- Wall construction and clear wall space for potential HVAC related penetrations
- Different window types and construction to evaluate potential replacement solutions
- Exterior elevations from all sides for window replacement perspectives

II. EXECUTIVE SUMMARY

Spectrum Design has examined both schools and reviewed as-built documentation to provide recommendations for the air conditioning of classrooms and other selected spaces; electrical support for HVAC improvements; and replacement of all exterior windows. The following high level recommendations are derived from our findings and are supported in detail in the associated report sections.

Recommendation 1: (HVAC)

Replace all existing classroom unit ventilators with individual Variable Refrigerant Flow (VRF) terminal units and install a complete system of VRF control boxes and outside VRF heat pump units in each school. Install Dedicated Outside Air systems and associated ductwork in each section of the schools receiving HVAC updates to replace the outside air formerly provided by the unit ventilators – use Energy Recovery Ventilator systems to support Energy Code compliance. Install packaged rooftop equipment to condition the library at Pulaski Middle School. Remove and replace ceilings as needed to install ductwork and associated refrigerant and electrical lines.

Recommendation 2: (ELECTRICAL)

Add a new 1,200 Amp switchboard section to the existing 1,600 Amp service at Pulaski Middle School and add an additional complete 1,200 Amp service at Dublin Middle School. Install at both schools a series of dedicated HVAC panelboards distributed throughout the facility to serve the new HVAC equipment. Replace hallway lighting fixtures as ceilings are replaced.

II. EXECUTIVE SUMMARY

Recommendation 3: (WINDOW)

Replace all steel exterior windows with aluminum storefront systems utilizing thermally broken window assemblies with insulated glazing. Maintain operable sections in each window assembly currently having operable glass. Replace the historic double-hung wood windows at Pulaski Middle School with aluminum double-hung windows incorporating all of the features of the storefront systems and having internal muntins that replicate the original divided light windows to preserve the original appearance of the school.

Opinions of Probable Construction Cost

	Dublin Middle School	Pulaski Middle School
Recommendation 1 – HVAC Improvements	$1,420,500	$1,717,500
Recommendation 2 – Electrical Improvements	$ 456,523	$ 563,334
Recommendation 3 – Window Replacements	$2,303,190	$2,929,980
Total Recommendations	**$4,180,213**	**$5,210,814**

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

HVAC SYSTEMS

Pulaski Middle School HVAC Systems

Central Plant

A central boiler plant provides heat for the middle school and the shop building. Two natural gas-fired sectional cast iron boilers generate low pressure steam which is distributed to terminal heating units throughout the buildings. The boilers appear to be relatively new and in good condition. Connections of the boiler vents to the existing breeching are not insulated. The boiler feed unit also appears to be relatively new and in good condition. The boiler feed piping is not insulated.

Steam and condensate piping is located in pipe trenches and pipe tunnels below the first floor of the school. Condition of the piping system is not known but piping that is visible appears to be original to the building or 60+ years old.

There is no central cooling system.

The temperature control system is pneumatic with limited control and monitoring by electronic controls that have been added. The pneumatic control system appears to be original to the building except the air compressor, air dryer, and some thermostats have been replaced.

Classrooms

Heating and ventilation for each classroom is provided by a unit ventilator located at the exterior wall below a window. The unit ventilator is connected to an intake grilled in the exterior wall. Each unit ventilator has a supply air fan and a steam heating coil and supplies a mixture of outdoor air and return air to the classroom. The heating coil is provided with a steam valve controlled by a wall mounted thermostat.

One of two cast iron boilers at Pulaski Middle School

Uninsulated boiler feed unit and steam condensate piping at Pulaski Middle School

Uninsulated vent connection to existing breeching at Pulaski Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

A wall or ceiling grille in each classroom provides exhaust through a gravity ventilator on the roof.

Computer Labs: Each computer classroom is cooled by a split system of nominal 5 ton capacity. A vertical air handling unit with supply fan and cooling coil is located in the classroom and supplies air through a short duct riser with outlet grilles. Return air is mixed with outdoor air which enters through a louver installed in a portion of a window. An air cooled condensing unit is located outside the classroom on the ground; refrigerant tubing connects the condensing unit to the cooling coil in the air handling unit. An electric thermostat controls the split system.

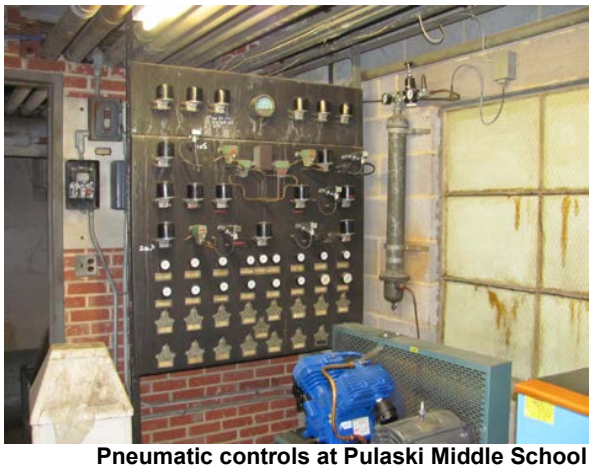
Band Room and Related Spaces (basement): The band room is heated and ventilated by two unit ventilators with outdoor air ducted below floor risers to the exterior wall. Related practice rooms, office, stair, and classroom (former dressing rooms) are heated by steam radiators.

Library: The library is a large space with high ceilings. Heating and ventilation is provided by four unit ventilators. The library also appears to be equipped as a computer lab; 30 desktop computers and a printer are installed. No cooling is provided.

<u>Offices, Corridors, Stairs and Toilets</u>
Heating is provided by a cast iron radiator or a convector in each office. Each is connected to steam and condensate piping and controlled by a pneumatic control valve and wall thermostat or a self-contained thermostatic control valve.

A wall or ceiling grille provides exhaust through a gravity ventilator on the roof.

Guidance and administration offices are cooled by window air conditioners except interior offices have no cooling.



Pneumatic controls at Pulaski Middle School

Steel firetube boiler at Dublin Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Gymnasium

The gym is heated by four vertical-discharge steam unit heaters. Each heater has a steam heating coil and a propeller supply fan. Supply fan operation is controlled by a wall thermostat.

Ventilation is provided by a heating & ventilating unit that supplies 100% outside air through ductwork and diffusers. The heating & ventilating unit includes an outside air damper, air filter, steam heating coil, and supply fan. Cores are missing from two of the four air diffusers.

Air is exhausted through a roof vent with a pneumatic control damper.

Locker Rooms

Locker rooms are heated by horizontal discharge steam unit heaters. Each heater has a steam heating coil and a propeller supply fan. Supply fan operation is controlled by a wall thermostat.

Air is exhausted from each locker room and related toilets and showers through ductwork and roof-mounted exhaust fans.

Auditorium and Stage

Heating and ventilation for the auditorium is provided by two heating and ventilating units located on platforms on each side of the stage. Each unit has an air filter, steam heating coil and supply fan. Return air is ducted to the units from low grilles in the front wall below the stage and on each side of the proscenium opening. Outside air is ducted to the units from louvers in the rear wall of the stage. Air is supplied to the auditorium through a grille array in the front wall on each side of the proscenium opening.

Air is exhausted through low grilles in the rear wall connected to roof vents.

Uninsulated boiler feed unit and steam condensate piping at Dublin Middle School

Uninsulated vent connection to existing breeching at Dublin Middle School

Domestic water heater array and uninsulated hot water piping at Dublin Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Steam convectors built into the exterior wall provide supplemental heat below each window.

The stage is heated by steam radiators.

Cafeteria and Kitchen

Heating and ventilation is provided in the Cafeteria by four unit ventilators.

Heating is provided in the kitchen and related areas by a steam unit heater and cast iron radiators.

Outside air admitted to the cafeteria through the unit ventilators is transferred to the kitchen and exhausted through the cooking hood and the dishwasher hood. Additional exhaust is provided by a propeller fan installed in a window.

An office constructed of wood paneled partitions has been added in the cafeteria. No cooling or ventilation is provided.

Basement Storage Room

Designated for county use has been converted to office space for the school transportation department. Heating is provided by an existing horizontal discharge unit heater. Cooling is provided by a split system; conditioned supply air is distributed through ductwork and ceiling diffusers from an indoor air handling unit. An air cooled condensing unit is located outside the office on the ground.

Shop Building

Steam and condensate piping is extended from the middle school to the shop building through a concrete pipe trench below the sidewalk. A condensate pump in the shop building returns steam condensate to the central plant.

Classrooms in the shop building are heated and ventilated as described for classrooms in the middle school.

Exterior view of classroom and office windows at Pulaski Middle School

Typical classroom unit ventilator at Pulaski Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Shop areas are heated by vertical-discharge steam unit heaters. Each heater has a steam heating coil and a propeller supply fan. Supply fan operation is controlled by a wall thermostat.

Dublin Middle School HVAC Systems

Central Plant

A central boiler plant provides heat for the middle school and the shop building. A single natural gas-fired steel fire-tube boiler generates low pressure steam which is distributed to terminal heating units throughout the buildings. The boiler is approximately 12 years old and appears to be in good condition. Connection of the boiler vent to the existing breeching is not insulated. The boiler feed unit also appears to be relatively new and in good condition. The boiler feed piping is not insulated. Two existing boilers are abandoned in place; the larger boiler is connected to the building heating system and the other was dedicated to generate domestic hot water. The abandoned boilers were originally coal-fired but were converted to burn natural gas.

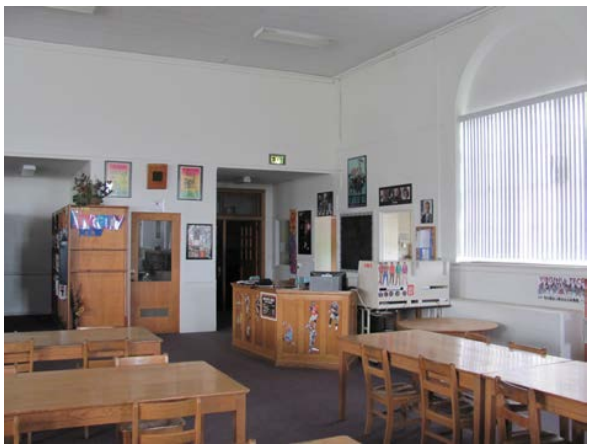
Steam and condensate piping is located in pipe trenches below the first floor of the school. Condition of the piping system is not known but piping that is visible appears to be original to the building or 60+ years old.

There is no central cooling system.

The temperature control system is pneumatic with limited control and monitoring by electronic controls that have been added. The pneumatic control system appears to be original to the building except the air compressor, air dryer, and some thermostats have been replaced.

Typical unit ventilator louver at Pulaski Middle School

Library at Pulaski Middle School



Unit ventilator in library at Pulaski Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Classrooms

Heating and ventilation for each classroom is provided by a unit ventilator located at the exterior wall below a window. The unit ventilator is connected to an intake grilled in the exterior wall. Each unit ventilator has a supply air fan and a steam heating coil and supplies a mixture of outdoor air and return air to the classroom. The heating coil is provided with a steam valve controlled by a wall mounted thermostat.

A wall or ceiling grille in each classroom provides exhaust through a gravity ventilator on the roof.

Computer Labs: Each computer classroom is cooled by a split system of nominal 5 ton capacity. A vertical air handling unit with supply fan and cooling coil is located in the classroom and supplies air through a short duct riser with outlet grilles. Return air is mixed with outdoor air which enters through a louver installed in a portion of a window. An air cooled condensing unit is located outside the classroom on the ground; refrigerant tubing connects the condensing unit to the cooling coil in the air handling unit. An electric thermostat controls the split system.

Offices, Corridors, Stairs and Toilets

Heating is provided by a convector in each office. Each is connected to steam and condensate piping and controlled by a pneumatic control valve and wall thermostat or a self-contained thermostatic control valve.

A wall or ceiling grille provides exhaust through a gravity ventilator on the roof.

Gymnasium

The gym is heated by four vertical-discharge steam unit heaters. Each heater has a steam heating coil and a propeller supply fan. Supply fan operation is controlled by a wall thermostat.

Residential air conditioning unit added to computer lab at Pulaski Middle School

Exterior view of classroom windows at Dublin Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Ventilation is provided by a heating & ventilating unit that supplies 100% outside air through ductwork and two supply air outlets. The heating & ventilating unit includes an outside air damper, air filter, steam heating coil, and supply fan. The steam pipe has been disconnected from the unit heating coil.
Air is exhausted through a roof vent with a pneumatic control damper.

Typical classroom unit ventilator at Dublin Middle School

Locker Rooms

Locker rooms are heated by steam convectors. Pneumatic steam valves in all each unit are controlled by a wall thermostat.

Air is exhausted from each locker room and related toilets and showers through ductwork and exhaust fans.

Auditorium and Stage

Heating and ventilation for the auditorium is provided by two heating and ventilating units located on platforms on each side of the stage. Each unit has an air filter, steam heating coil and supply fan. Return air is ducted to the units from low grilles in the front wall on each side of the proscenium opening. Outside air is ducted to the units from louvers in the rear wall of the stage. Air is supplied to the auditorium through a grille array in the front wall on each side of the proscenium opening.

Typical unit ventilator louver at Dublin Middle School

Air is exhausted through low grilles in the rear wall connected to roof vents.

The stage is heated by steam convectors.

Cafeteria and Kitchen

Heating and ventilation is provided in the Cafeteria by two unit ventilators and three convectors.

Heating is provided in the kitchen and related areas by a steam unit heater and convectors.

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Outside air admitted to the cafeteria through the unit ventilators is transferred to the kitchen and exhausted through the cooking hood and the dishwasher hood. Additional exhaust is provided by a propeller fan installed in a window.

Shop Building

Steam and condensate piping is extended from the middle school to the shop building through a concrete pipe trench below grade. A condensate pump in the shop building returns steam condensate to the central plant.

Classrooms in the shop building are heated and ventilated as described for classrooms in the middle school.

One classroom is a computer lab and has a split system air conditioning system installed. The air conditioning system is comprised of a residential vertical air handling unit with supply ductwork exposed below the ceiling and an air cooled condensing unit located outdoors on the ground. The cooling capacity of the system is nominally 5 tons. No ventilation air is provided by the air conditioning system.

Shop areas are heated by vertical-discharge steam unit heaters. Each heater has a steam heating coil and a propeller supply fan. Supply fan operation is controlled by a wall thermostat.

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

ELECTRICAL SYSTEMS

The electrical systems review presented in this report is developed from the standpoint of compatibility of the electrical systems with supporting the recommended HVAC upgrades. No scope is included in electrical recommendations for general rehabilitation of the electrical systems throughout the facilities. It should be noted that with the exception of the main service equipment in each school, the electrical equipment in general is obsolete and in poor condition.

Changing the schools over from a fossil-fuel fired heating system to a predominantly electric heating and cooling system with some natural gas support leads to a much greater electrical demand in each building and will require a great deal of new electrical infrastructure be built.

Pulaski Middle School Electrical Systems

Main Service:

The Pulaski Middle School is served by Appalachian Power Company through a recently replaced 1,600 Amp 208/120 Volt switchboard located in the basement level of the building in the former transformer vault off the boiler room. The main switchboard was replaced in the 2005 time frame as evidenced by nameplate data on the equipment. At the time of the main service replacements, a few panels serving kitchen equipment and some HVAC related loads were also replaced or added. The new service equipment is acceptable for the addition of new HVAC equipment, and calculations indicate that the main service is marginally sized to support the anticipated new HVAC loads. There is, however, not adequate space in the distribution section of the switchboard to add new feeder breakers for HVAC loads, so modifications would have to be made to the main service to install a new HVAC main panel or switchboard section.

Main 1600 A Switchboard at Pulaski Middle School

New Main Incoming Service at Pulaski Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

Building Distribution Systems:
The remainder of the electrical distribution system in the building appears to be original to the structure, and is well beyond its expected service life. The original panels were by Kinney Electric, and most of the remaining panels are of matching design and vintage. These panels are no longer complaint with current standards, and replacement parts are unavailable. There is no possibility of extending new HVAC circuits from the panels distributed throughout the building, meaning that even though the overall service size appears to be adequate for the HVAC project, new HVAC distribution panels and circuitry will have to be extended throughout the facility from the main service equipment.

Dublin Middle School Electrical Systems

Main Service:
The Dublin Middle School is served by Appalachian Power Company through a recently replaced 1,200 Amp 208/120 Volt switchboard located in the basement level of the building. Similar to the Pulaski Middle School service upgrades, the main switchboard and service entrance was replaced in the 2005 time frame. At the time of the main service replacements, several selected distribution panels in the building were also replaced; however the majority of the building's power system remains original to the structure. The new service equipment would be acceptable for the addition of new HVAC equipment; however there is not adequate capacity available to support the recommended new HVAC loads. In order to support the HVAC recommendations, major modifications would have to be made to the main service to support and install a new HVAC main switchboard.

Building Distribution Systems:
The remainder of the electrical distribution system in the building appears to be original to the structure, and is well beyond its expected service life. As with Pulaski Middle School,

New Utility Transformer at Pulaski Middle School

Typical Original Panel at Pulaski Middle School

Typical Original Panel at Pulaski Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

original panels were by Kinney Electric, and most of the remaining panels are of matching design and vintage. These panels are no longer complaint with current standards, and replacement parts are unavailable. There is no possibility of extending new HVAC circuits from the panels distributed throughout the building.

Updated Panels at Pulaski Middle School

New 1200 Amp Main Switchgear at Dublin Middle School

III. SUMMARY OF FINDINGS AND EXISTING CONDITIONS

ARCHITECTURAL

Pulaski Middle School Windows

The existing windows at both schools are aluminum and steel with non-insulated glazing. In addition to the existing metal windows, Pulaski Middle School contains wood windows with non-insulated glazing (see top right image). The windows are in poor condition with the sealant having failed in many windows. Air infiltration through the existing windows is causing increased heating and cooling costs. The existing window treatments are in poor condition and many are inoperable. The glazing is non-insulated. This non-insulated glass allows the transmission of heat or cold from the outside into the building. This increases the heating load on the building in the winter and the potential cooling load on the building in the summer, adversely affecting energy costs. Though some of the windows contain operable awning window components, many are difficult to operate.

Window sills contain noticeable rust and damage (see right image). Most sills do not contain adequate flashing and water penetration issues are noticeable. Existing precast sill members are in fair condition and can be preserved with proper sub-sill and flashing above the existing precast.

Dublin Middle School Windows

The existing windows at Dublin Middle School are aluminum and steel with non-insulated glazing. These windows are in poor condition with visible sealant failure, rust, and inadequate flashing protection.

Existing precast sill members are in fair condition and can be preserved with proper sub-sill and flashing above the existing precast.

Pulaski Middle School – Wood Windows

Pulaski Middle School – Steel Windows Interior Sill

Dublin Middle School - Steel Windows

IV. ANALYSIS AND RECOMMENDATIONS

HVAC SYSTEMS ANALYSIS OF OPTIONS:

Existing conditions

The existing heating and ventilating systems at both schools are the same type, about the same age, and were designed by the same consultants, so our comments will apply to both schools except where differences are noted.

The functioning boilers are replacements for the original boilers and are relatively new and appear to be in very good condition. Before being replaced, original boilers had been converted from coal-fired to natural gas-fired operation. Two new boilers replaced three original boilers at Pulaski Middle School and one new boiler replaced an original boiler at Dublin Middle School with two original boilers abandoned in place. The new boilers should provide satisfactory service for a number of years to come.

Steam and condensate piping that is visible in the boiler rooms and pipe tunnels appear to be in good condition. The original condensate return units have been replaced with newer duplex condensate return/boiler feed units. The condition of steam and condensate piping concealed in concrete pipe trenches below the first floor is not known. The piping and insulation is approximately 60+ years old; when it becomes necessary to replace the piping and insulation, the work will be difficult and expensive. For this reason, none of the systems considered for application in these schools would rely on the existing steam system for heat.

Insulation of piping and equipment in the boiler rooms: Insulation of steam piping is generally complete and appears to be in good condition although some at Pulaski is labeled as containing asbestos and steam pipe connection to boiler at Dublin is not insulated. Flanges and valves are not insulated. Gravity and pumped condensate in the boiler room are not insulated. Domestic hot water piping in

IV. ANALYSIS AND RECOMMENDATIONS

the boiler room is not insulated. Breeching from the new boilers to the existing breeching is not insulated. We recommend the following not only to save energy but to reduce heat gain from the boiler room to the cafeteria directly above (Pulaski and Dublin):

- Repair damaged or missing insulation.
- Insulate flanges, valve bodies and other specialties on steam piping.
- Insulate condensate piping including valves and fittings.
- Insulate domestic hot water piping including valves and fittings.
- Insulate boiler breeching.

The classroom unit ventilators all appear to be original to the building and have far exceeded their expected service life. At this point it is questionable whether the fans, dampers, damper operators, and steam control valves are operating as designed.

The original pneumatic control systems remain in use at both schools. Each has a replacement compressor and refrigerated air dryer. Most room thermostats have been replaced. Honeywell electronic controls have been added to provide limited remote monitoring and control. The remainder of the system appears to be original. The split systems that provide cooling in the computer classrooms, the ductless split systems, and the window air conditioners each have their own electric controls that are not connected to the pneumatic systems or the Honeywell systems.

<u>General Objectives:</u>
All of the HVAC systems considered for application at Dublin and Pulaski Middle Schools would upgrade ventilation and energy conservation capabilities of the equipment to comply with current requirements of the Virginia Uniform Statewide Building Code. The result in the classrooms and offices would be improved indoor air quality and improved operation of the classroom temperature control system.

IV. ANALYSIS AND RECOMMENDATIONS

HVAC SYSTEMS CONSIDERED

SELF-CONTAINED UNIT VENTILATORS

Classrooms: Heating and cooling would be provided by self-contained unit ventilators that would replace the existing unit ventilators. Each self-contained unit would include a supply fan, an air-to-air heat pump, dampers, exterior louver, controls and supplemental electric heating coil. Ventilation air would be introduced to the space through the unit ventilator by mixing outdoor air with return air. Each unit would intake air for ventilation and for the condenser coil through the louver in the exterior wall. A unit ventilator would be provided for each classroom, providing individual temperature control for each classroom. There would be no connection to existing heating and ventilating systems.

Energy Conservation: The unit controls would lower heating setpoints and raise cooling setpoints when the classroom is unoccupied. Introduction of outside air (ventilation) would be shut off when the classroom is unoccupied. Each unit will use up to 100% outside air for "free" cooling when the outside temperature is sufficiently low and the outside relative humidity is not high.

Advantages: Each unit is self-contained. No external piping or controls are required. Controls may be connected to a building automation system if desired. Ventilation system is built in. Separate ventilation systems and ductwork are not required. Individual temperature control is provided for each classroom.

Disadvantages: Administration and Guidance Offices: Unit ventilators are not suitable for small and interior spaces such as administration and guidance offices. Another type of HVAC system would be required for these spaces such as a ducted split system heat pump or ductless split system heat pump in conjunction with a dedicated outdoor air

IV. ANALYSIS AND RECOMMENDATIONS

system. Supplemental electric heat would be required for each unit. Self-contained unit ventilators are significantly larger than the existing units and will occupy more floor space in each classroom. The exterior louvers required for self-contained unit ventilators are much larger in width and height than the existing louvers. There is not sufficient height available below existing windows to provide the louver height required and to accommodate the structure necessary to support the window above each unit.

Vertical Classroom Air Conditioners (Bard or Airedale units similar to those being installed at Dublin Elementary School):

Classrooms: Heating and cooling would be provided by air to air heat pumps. The heat pumps would be packaged vertical classroom air conditioning units located in each classroom at the exterior wall. Air would be distributed by a discharge air plenum with adjustable registers on the air conditioning units. Ventilation air would be introduced to the space through the heat pumps by mixing outdoor air with return air. Ventilation air would be partially heated or cooled by the energy recovery ventilator section of each unit prior to mixing with return air. Each unit would have air intake and exhaust through a louver in the exterior wall. A heat pump would be provided for each classroom, providing individual temperature control for each classroom. There would be no connection to existing heating and ventilating systems.

Energy Conservation: The unit controls would lower heating setpoints and raise cooling setpoints when the classroom is unoccupied. Introduction of outside air (ventilation) and corresponding exhaust air would be shut off when the classroom is unoccupied.

Advantages: Each unit is self-contained. No external piping or controls are required. Controls may be connected to a building automation system if desired. Ventilation

IV. ANALYSIS AND RECOMMENDATIONS

system is built in. Separate ventilation systems and ductwork are not required. Individual temperature control is provided for each classroom.

Disadvantages: Administration and Guidance Offices: Vertical classroom air conditioners are not suitable for small and interior spaces such as administration and guidance offices. Another type of HVAC system would be required for these spaces such as a ducted split system heat pump or ductless split system heat pump in conjunction with a dedicated outdoor air system. Supplemental electric heat is required for each unit. (Similar to units being installed at Dublin Elementary School.) Exterior wall space is required for installation of the units and outdoor louvers. None of the classrooms have sufficient exterior wall area to install the units. Removal of a window in each classroom to create exterior wall space is not being considered because of the additional installation cost and the detrimental effect to the appearance of the building.

Packaged Single-Zone Roof Top Air Conditioning Units

Each roof top unit would include a supply fan, air filters, air-cooled DX cooling system, natural gas heating section, dampers and controls. Conditioned air would be supplied to classrooms and offices through ductwork located above corridor ceilings and discharged into each room through sidewall grilles. Multiple rooms, grouped by floor and by exterior exposure, would be supplied from each roof top unit. Corridor ceilings would be lowered to provide space for new ductwork. Vertical duct chases would be created at several locations on the second floor to route ductwork from roof top units to rooms on the first floor.

Energy Conservation: The unit controls would lower heating setpoints and raise cooling setpoints when the associated classrooms are

IV. ANALYSIS AND RECOMMENDATIONS

unoccupied. Introduction of outside air (ventilation) and corresponding exhaust air would be shut off when the classroom is unoccupied. Each roof top unit will use up to 100% outside air for "free" cooling when the outside temperature is sufficiently low and the outside relative humidity is not high.

Advantages: Control and operation of the roof top units are relatively simple. No supplemental electric heat is required.

Disadvantages: Classrooms are grouped into zones so that a thermostat in one room controls the temperature in all the rooms in that zone. Requires the addition of vertical duct chases on the second floor to route ductwork to first floor rooms.

Variable Refrigerant Flow (VRF) System And Dedicated Outdoor Air Systems

Variable Refrigerant Flow Systems: The systems consist of multiple indoor fan coil units connected by refrigerant tubing to high efficiency heat pumps located outdoors. Multiple systems would be provided with multiple classrooms or offices connected to each system. Heating and cooling capacities of the outdoor heat pumps would be selected to provide sufficient heating and cooling for the connected indoor spaces; individual system capacities of up to approximately 35 tons would be provided, based on the requirements of the connected indoor units. Each room would have individual temperature control. Indoor units in one room have the ability to cool while units in another room are simultaneously heating which improves system efficiency by allowing energy to be moved from one space to another.

Indoor Units: The indoor units include a heating/cooling coil, fan, filter, condensate pump and controls and are available in several configurations. For most classrooms and offices either wall-mounted units or surface-mounted ceiling units would be used. The

IV. ANALYSIS AND RECOMMENDATIONS

wall-mounted units would be installed high on the wall, near the ceiling. Most classrooms would require two units and both would be controlled by a single wall-mounted temperature sensor.

Outdoor Units: The outdoor units include a variable capacity refrigerant compressor, condenser coil, variable speed condenser fan, and controls. The units are available in several capacities, are modular, and can be manifolded together to provide the appropriate total capacity for each system. Outdoor units for each system would be mounted to a steel support frame and installed at various locations on the roof, generally above corridors, to serve the indoor units in classrooms and offices.

Refrigerant Tubing and Header/Mode Control Units: Corridor ceilings would be lowered to provide space for new refrigerant tubing and new ductwork. Vertical duct chases would be created at several locations on the second floor to route refrigerant tubing and ductwork from roof top units to rooms on the first floor. The physical arrangement of refrigerant tubing and controls varies by manufacturer and some manufacturers use a header/mode control unit that is connected to several indoor units; several header/mode control units are then connected to refrigerant tubing that is connected to the outdoor units. The header/mode control units contain refrigerant valves and controls to facilitate independent cooling or heating operation of each indoor unit; they would be located above the corridor ceiling.

Controls: The control system would be electronic and would include a temperature sensor/controller in each classroom and office and a central controller located in the Administration office. Each room temperature sensor/controller would control operation of the indoor unit(s) in that room including temperature control and setback schedule. Each room temperature sensor/controller

IV. ANALYSIS AND RECOMMENDATIONS

would also communicate with the central controller. The central controller would have the ability to monitor operation of all indoor and outdoor units and to override temperature settings, schedules, and other operating parameters of these systems. The central controller would also have the ability to interface with a building automation system such as the existing Honeywell system.

Dedicated Outdoor Air Systems: Ventilation and exhaust will be provided through ductwork from packaged roof-mounted energy recovery ventilators. Each unit will include:

- Exhaust fan.
- Air-to-air energy recovery wheel.
- Air filters.
- Natural gas-fired heating section.
- Direct expansion evaporator (cooling) coil, refrigerant compressor, and an air-cooled condenser coil.
- Supply fan.
- Automatic dampers and controls.

100% outdoor air would be filtered, partially heated or cooled by recovered energy transferred through the energy recovery wheel from the air being exhausted, additionally heated by the gas heating section or cooled by the DX cooling coil, and supplied through ductwork located above corridor ceilings and discharged into classrooms and offices through sidewall registers. Air to be exhausted would be removed from classrooms, offices and toilets, and carried through ductwork back to the energy recovery ventilator on the roof. The exhaust air would be filtered, pass through the energy recovery wheel, and would be discharged outdoors by the exhaust fan. Corridor ceilings would be lowered to provide space for new ductwork. Vertical duct chases would be created at several locations on the second floor to route ductwork from the energy recovery ventilators to rooms on the first floor.

Energy Conservation: The VRF system is very efficient, requires no supplemental electric heat, and allows energy transfer from

IV. ANALYSIS AND RECOMMENDATIONS

one space to another when appropriate to improve efficiency. The energy recovery ventilators would be selected to provide 70% or greater effectiveness which would greatly reduce the energy required to heat and cool the required ventilation air. The energy recovery ventilators would be shut down when the related indoor spaces are unoccupied. The energy recovery ventilators would provide "free" cooling when the outside temperature is sufficiently low and the outside relative humidity is not high.

Advantages: The VRF system would provide individual temperature control and scheduling for each room. The VRF system is very efficient and would not require any supplemental electric heat. The VRF system provides a sophisticated and powerful control system which can also interface with a building automation system. The dedicated outdoor air systems and the VRF systems require vertical chases on the second floor but the chases would be much smaller than those required for the packaged roof top systems since they would contain refrigerant tubing and ventilation ducts instead of ductwork sized to move ventilation air plus the air required to heat and cool the spaces. For the same reason described above, space required above corridor ceilings would be less than that required for packaged roof top systems.

IV. ANALYSIS AND RECOMMENDATIONS

HVAC RECOMMENDATIONS

Similarities between the Schools:
Pulaski Middle School and Dublin Middle School are not identical but the similarities are sufficient for our analysis and recommendations to apply to both.

Original Systems to Remain:
The system we recommend for the classrooms and offices will not require any connection to the existing steam system but it appears that the steam system will remain in use to provide heat to the gym, auditorium, cafeteria, and other areas of the buildings. Both schools have steam condensate piping, boiler vent connections to existing breeching, and domestic hot water piping that is not insulated. Dublin Middle School has steam piping near the boiler that is not insulated. We recommend that all of these items be insulated, not only to prevent heat loss and improve system efficiency, but to reduce unwanted heat transfer to the occupied spaces above the boiler room (cafeteria and kitchen).

Classrooms and Offices:
Self-contained unit ventilators and vertical classroom air conditioners are not recommended because both would require significant modifications to the exterior wall in each classroom. The wall modifications would add construction time, complexity, and cost and would greatly detract from the appearance of each building, both interior and exterior. Also neither of these systems is applicable to small rooms and offices.

Installation of multiple packaged roof top air conditioning units is a viable option and is applicable to both classrooms and offices. Roof top units are not our recommendation because of the large space requirement for ductwork above corridor ceilings and in second floor duct chases and for lack of individual temperature and scheduling control of each classroom and office.

IV. ANALYSIS AND RECOMMENDATIONS

Our recommendation is to provide variable refrigerant flow systems for classrooms and offices because they are more efficient than the other systems, would provide individual temperature and schedule control for each room, and would be less difficult to install in the existing buildings than the other systems. Duct chases and space above corridor ceilings would still be required but would be less than required for roof top units. A dedicated outdoor air system would be provided in conjunction with each VRF system to provide required ventilation and exhaust. We estimate that six to eight VRF systems and ventilation systems would be required for each school. At each school, one VRF system and ventilation system would be dedicated to administration and guidance offices and one VRF system and ventilation system would be provided for classrooms in the shop building.

Specific Recommendations for Pulaski Middle School:

The VRF systems and ventilation systems described above are recommended for Pulaski Middle School except for the library. Because the library is a large space with multiple exposures, high ceiling and large volume, we recommend installation of a packaged roof top air conditioning unit. The roof top unit would provide DX cooling, natural gas heating, and would supply conditioned air through ductwork and ceiling diffusers. Ventilation air would be provided by the roof top unit and all supply air would be filtered.

Recommendations Specific to Dublin Middle School:

The VRF systems and ventilation systems described above are recommended for Dublin Middle School. Because the library is not so large and has limited exterior exposure it can be included with the classroom systems.

IV. ANALYSIS AND RECOMMENDATIONS

ELECTRICAL RECOMMENDATIONS

Pulaski Middle School

Based upon calculations of existing building loads and anticipated HVAC loads associated with the recommended HVAC installation above, we feel that the 1600 A service installed at Pulaski Middle school can accommodate the proposed HVAC systems upgrades. The following actions are recommended.

Main Service Upgrades:
Install a new 1,200 Amp distribution section tapped off the main 1,600 Amp switchboard exclusively for the new HVAC loads. Locate this new switchgear section in the basement / boiler room area in a space with adequate working clearances in front of and around the gear. Due to conditions in the existing switchgear area, there is not a suitable space immediately adjacent to the 1,600 Amp main gear. Connect the new 1,200 Amp distribution section with bus duct or individual conduits and cable, as proves most feasible during detailed design. This activity does not require coordination with AEP, as all work is completed behind the meter.

Building Distribution Upgrades:
Install a series of 200 and 400 Amp distribution panels throughout the building to serve the VRF control boxes (and thus room units), VRF compressor units, Energy Recovery Ventilators, and Packaged Rooftop Units. One panel per multi-story wing should be sufficient to serve the new loads throughout the building. We estimate that approximately six panels will be required.

Routing of Electrical Infrastructure:
Route new electrical wiring through hallway ceiling spaces along with VRF refrigerant lines and outside air ductwork. Establish one or more vertical chases through each multi-story wing and share the space between HVAC equipment and electrical conduits.

IV. ANALYSIS AND RECOMMENDATIONS

ELECTRICAL RECOMMENDATIONS

Dublin Middle School

Main Service Upgrades:
Install a new 1,200 Amp main service switchboard exclusively for the new HVAC loads. Locate this new switchgear section in the basement / boiler room area in a space with adequate working clearances in front of and around the gear. Due to conditions in the existing switchgear area, there is not a suitable space immediately adjacent to the existing 1,200 Amp main gear. The new 1,200 Amp main switchboard will be a second service disconnect for the building, and will have to be rated as service entrance equipment and placarded as a second service disconnect for the building. This activity does require extensive coordination with AEP, and will require that a new service be installed and potentially the service transformer be replaced.

Building Distribution Upgrades:
This section is identical to the recommendations for Pulaski Middle School. Install a series of 200 and 400 Amp distribution panels throughout the building to serve the VRF control boxes (and thus room units), VRF compressor units, Energy Recovery Ventilators, and Packaged Rooftop Units. One panel per multi-story wing should be sufficient to serve the new loads throughout the building. We estimate that approximately six panels will be required.

Routing of Electrical Infrastructure:
This section is identical to the recommendations for Pulaski Middle School. Route new electrical wiring through hallway ceiling spaces along with VRF refrigerant lines and outside air ductwork. Establish one or more vertical chases through each multi-story wing and share the space between HVAC equipment and electrical conduits.

IV. ANALYSIS AND RECOMMENDATIONS

ARCHITECTURAL RECOMMENDATIONS

WINDOW REPLACEMENTS

A complete replacement of the windows with a thermally broken storefront window system is recommended at existing metal and wood windows. This will result in improved energy performance and improved occupant comfort. It is recommended to provide new manual window shades for optimal solar control.

The new aluminum-framed storefront system will be specified as YKK YES 45 TU or equivalent system. YES 45 TU is a 2" by 4-1/2" thermally broken, center set, flush glazed storefront system for 1" insulating glazing. This system will replace an existing 2" x 4" frame and 1" intermediate, horizontal framing members. Glazing is retained mechanically with gaskets on four sides. The framing system is thermally broken by means of a poured and debridged pocket that employs a patented process, ThermaBond Plus, to improve adhesion of the polyurethane to the extruded aluminum (see top right image).

The YKK storefront system integrates Low-E (low-emissivity) insulating glass with a Visible Light Transmittance of 35 percent. This provides adequate reflectance of sunlight thus protecting against undesirable heat gains.

The historical wood windows at Pulaski Middle School will be replaced with 2200 Series Double Hung AW45 window system (see right image). This system is operable and compatible with the historic configuration of the existing windows. Existing sash and muntins will be repeated which revitalizes the historic character of the front façade.

Portions of existing window construction are believed to incorporate asbestos containing materials (ACM's) of some degree. Further determination of the extent and degree by physical inspection is being considered. For the purpose of this reporting, an assumption

YKK YES 45TU
Thermally Broken Center Set Storefront

2200 Series Double Hung AW45
Graham Architectural Products

IV. ANALYSIS AND RECOMMENDATIONS

that all windows contain some level of ACM's is recommended and, as related to budgeting, that demolition require abatement procedures be met.

Window replacement projects of this magnitude traditionally result in energy savings on heating and cooling costs by reducing infiltration, adding insulation and reductions in solar heat gain. Our historical experience in applications where 1950's window technology is replaced with modern efficient systems can typically yield significant annual energy savings. In addition, the window and window treatment designs, once options are presented and approved, will have the ability to enhance and revitalize the building's facade.

WINDOW SHADES

New manual shades are recommended for all windows. The shades can be installed with housing anchored to the head of new window frames. Providing new, operational shades will increase the user-comfort within the space by allowing users to control the daylight infiltration.

The recommended manual roller shades are made by MechoShade Systems. These roller shades are single vinyl fabric, woven shadecloth, and are visually transparent. The MechoShade Systems are comprised of 21% polyester and 79% reinforced vinyl, in colors selected from manufacturer's available range. These roller shades are lightweight and contain 5% open, dense linear-weave pattern of fabric.

Before proceeding with construction documents, it is recommended that one window in each unique construction section of each building be removed to evaluate and confirm the existing wall construction. The windows can be taken out of unoccupied spaces, and can be then replaced in the openings or blanked out for the time being

IV. ANALYSIS AND RECOMMENDATIONS

pending decisions. This activity will greatly help to provide clarification on the construction documents in terms of anchoring new windows to existing wall components.

V. OPINIONS OF PROBABLE CONSTRUCTION COST

The cost summary includes recommendations made in this report outlining replacement of existing HVAC systems including Variable Refrigerant Flow classroom systems, Dedicated Outside Air Units, and Packaged Rooftop HVAC units. Construction cost opinions include demolition of existing systems.

Costs are based on an assumed construction in 2016. Cost should be escalated for construction occurring after the assumed date. In addition, variables in construction cost include but are not limited to the following: air monitoring methods, dust protection procedures, and relocation of staff. While certain costs attributable to these potential variations have been assumed and reflected in overhead and contingency categories, it should be understood that further discovery during development and design may result in cost fluctuation and the figures presented have been projected based upon the best information available at this time.

Dublin Middle School	**COST**
VRF Systems	
Dedicated Outside Air Systems	
SUB-TOTAL	$992,592
CONTRACTORS O & P - 15%	$148,889
GENERAL CONDITIONS - 10%	$99,259
CONTINGENCY – 10%	$99,259
PROJECT TOTAL	**$1,340,000**
ADDITIONAL SOFT COSTS	
A/E Fees	$80,500
SOFT COSTS SUBTOTAL	**$80,500**
TOTAL PROJECT COST	**$1,420,500**

Pulaski Middle School	**COST**
VRF Systems	
Dedicated Outside Air Systems	
Packaged Rooftop Units	
SUB-TOTAL	$1,200,000
CONTRACTORS O & P - 15%	$180,000
GENERAL CONDITIONS - 10%	$120,000
CONTINGENCY – 10%	$120,000
PROJECT TOTAL	**$1,620,000**
ADDITIONAL SOFT COSTS	
A/E Fees	$97,500
SOFT COSTS SUBTOTAL	**$97,500**
TOTAL PROJECT COST	**$ 1,717,500**

V. OPINIONS OF PROBABLE CONSTRUCTION COST

The cost summary includes recommendations made in this report outlining replacement of and improvements to existing electrical systems including main service upgrades, additional main switchgear, and new distribution systems to support HVAC improvements.

Costs are based on an assumed construction in 2016. Cost should be escalated for construction occurring after the assumed date. In addition, variables in construction cost include but are not limited to the following: air monitoring methods, dust protection procedures, and relocation of staff. While certain costs attributable to these potential variations have been assumed and reflected in overhead and contingency categories, it should be understood that further discovery during development and design may result in cost fluctuation and the figures presented have been projected based upon the best information available at this time.

Dublin Middle School	**COST**
New 1,200 A Service and Switchboard	
New Distribution and Panelboards Throughout	$162,360
Replacement of Lighting in New Ceilings	$150,768
SUB-TOTAL	$313,128
CONTRACTORS O & P - 15%	$46,969
GENERAL CONDITIONS - 10%	$31,313
CONTINGENCY – 10%	$31,313
PROJECT TOTAL	**$422,723**
ADDITIONAL SOFT COSTS	
A/E Fees	$33,800
SOFT COSTS SUBTOTAL	**$33,800**
TOTAL PROJECT COST	**$456,523**

Pulaski Middle School	**COST**
New 1,200 A Switchboard Section	
New Distribution and Panelboards Throughout	$171,723
Replacement of Lighting in New Ceilings	$214,635
SUB-TOTAL	$386,358
CONTRACTORS O & P - 15%	$57,954
GENERAL CONDITIONS - 10%	$38,636
CONTINGENCY – 10%	$38,636
PROJECT TOTAL	**$521,584**
ADDITIONAL SOFT COSTS	
A/E Fees	$41,750
SOFT COSTS SUBTOTAL	**$41,750**
TOTAL PROJECT COST	**$563,334**

V. OPINIONS OF PROBABLE CONSTRUCTION COST

The cost summary includes recommendations made in this report outlining replacement of existing windows with new, thermally broken storefront windows and insulated glazing. Structural modifications, finishes work, and window shades are included in the cost estimate. Demolition and hazardous materials abatement associated with window sealants and ceiling removals/replacements are included as a separate line item.

Costs are based on an assumed construction in 2016. Cost should be escalated for construction occurring after the assumed date. In addition, variables in construction cost include but are not limited to the following: air monitoring methods, dust protection procedures, and relocation of staff. While certain costs attributable to these potential variations have been assumed and reflected in overhead and contingency categories, it should be understood that further discovery during development and design may result in cost fluctuation and the figures presented have been projected based upon the best information available at this time.

Dublin Middle School	**COST**
New Windows (Basis of Design- YKK 45TU Alum Storefront)	$1,010,240
Interior Finishes (includes furring, drywall, painting, etc.)	$230,900
Window Shades	$129,900
SUB-TOTAL	$1,371,040
CONTRACTORS O & P - 15%	$205,650
GENERAL CONDITIONS - 10%	$137,100
CONTINGENCY – 10%	$137,100
PROJECT TOTAL	**$1,850,890**
ADDITIONAL SOFT COSTS	
Construction Testing and Inspections	$1,000
A/E Fees	$110,000
Bidding Costs (printing and advertisement)	$1,000
SOFT COSTS SUBTOTAL	**$112,000**
DEMOLITION & ABATEMENT	
Demolition	$173,200
Hazardous Materials Abatement - Windows	$23,100
Hazardous Materials Abatement - Hallway Ceiling R&R - 14,400 sq. ft.	$144,000
DEMOLITION & ABATEMENT TOTAL	**$340,300**
TOTAL PROJECT COST	**$2,303,190**

V. OPINIONS OF PROBABLE CONSTRUCTION COST

Pulaski Middle School	**COST**
New Alum Windows – Replace Wood Windows (Basis of Design – 2200 Series Double Hung AW45 – Graham Architectural Products)	$331,250
New Aluminum Storefront (Basis of Design: YKK 45TU Alum Storefront)	$936,110
Interior Finishes (includes furring, drywall, painting, etc)	$279,800
Window Shades	$157,390
SUB-TOTAL	$1,704,550
CONTRACTORS O & P - 15%	$255,680
GENERAL CONDITIONS - 10%	$170,450
CONTINGENCY – 10%	$170,450
PROJECT TOTAL	**$2,301,130**
ADDITIONAL SOFT COSTS	
Construction Testing and Inspections	$1,000
A/E Fees	$138,000
Bidding Costs (printing and advertisement)	$1,000
SOFT COSTS SUBTOTAL	**$140,000**
DEMOLITION & ABATEMENT	
Demolition	$209,850
Hazardous Materials Abatement - Windows	$23,000
Hazardous Materials Abatement - Hallway Ceilings R&R - 25,600 sq.ft.	$256,000
DEMOLITION & ABATEMENT TOTAL	**$488,850**
TOTAL PROJECT COST	**$2,929,980**

APPENDIX

HVAC Replacement Equipment Schedule and Electrical Load Summary by School

Dublin Middle School	*quantity*	*cooling tons each*	*vent cfm each*	*indoor VRF units*	*cooling tons*	*vent cfm*	*indoor VRF units*	*approx floor area, sf*	*kW per unit*	*total kW*
classrooms	35	4.00	400	2	140.0	14,000	70	21,790	0.06	4.2
band	1	7.50	1,200	4	7.5	1,200	4	1,065	0.06	0.2
library	1	7.50	750	4	7.5	750	4	2,045	0.06	0.2
admin / guidance	1	10.00	1,000	9	10.0	1,000	9	2,140	0.06	0.5
shop bldg classrooms	3	4.00	400	2	12.0	1,200	6	2,645	0.06	0.4
totals					**177.0**	**18,150**	**93**	**29,685**		**5.6**
	quantity									
VRF systems	7								36	252
DOA systems	7								27	189
Grand Total							**VA / Sq. Ft.**	**15**		**447 KW**

Pulaski Middle School	*quantity*	*cooling tons each*	*vent cfm each*	*indoor VRF units*	*cooling tons*	*vent cfm*	*indoor VRF units*	*approx floor area, sf*	*kW per unit*	*total kW*
classrooms	39	4.00	400	2	156.0	15,600	78	28,060	0.06	4.7
band	1	7.50	1,200	4	7.5	1,200	4	1,770	0.06	0.2
library	1	12.50	1,500	0	15.0	1,500	0	3,430	0.06	0.0
admin / guidance	1	7.50	1,000	8	7.5	1,000	8	1,420	0.06	0.5
shop bldg classrooms	2	4.00	400	2	8.0	800	4	1,425	0.06	0.2
totals					**194.0**	**20,100**	**94**	**36,105**		**5.6**
	quantity									
VRF systems	7								36	252
DOA systems	7								27	189
packaged roof top sys	1								18	18
Grand Total							**VA / Sq. Ft.**	**13**		**464.84 KW**

Load Calculations

Dublin Middle School

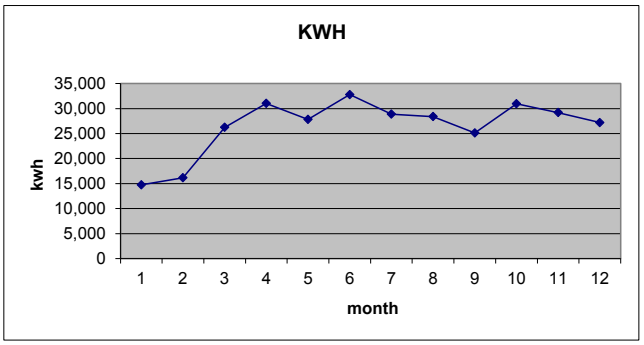
Existing Loads (Based upon 12 month Utility billing records)	136	KW
125% of Existing Load per NEC 220.87	170	KW
First 3 VA / sq. ft. HVAC load @ 100% per NEC 220.86	89	KW
Next 17 VA / sq. ft. HVAC load at 75% per NEC 220.86	268	KW
Calculated Service Load	**527**	**KW**
Total load in Amps at 208/120V	**1,464**	**Amps**

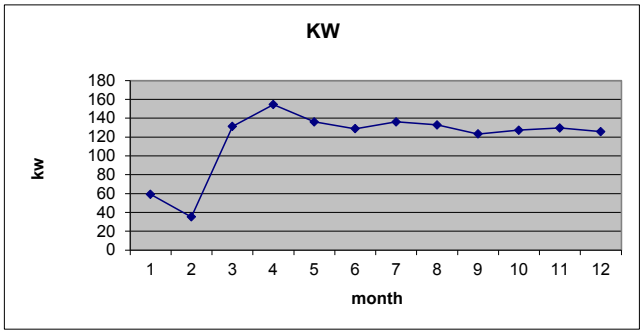
Pulaski Middle School

Existing Loads (Based upon 12 month Utility billing records)	139	KW
125% of Existing Load per NEC 220.87	174	KW
First 3 VA / sq. ft. HVAC load @ 100% per NEC 220.86	107	KW
Next 17 VA / sq. ft. HVAC load at 75% per NEC 220.86	268	KW
Calculated Service Load	**549**	**KW**
Total load in Amps at 208/120V	**1,524**	**Amps**

Dublin Middle School HVAC Study - Electricity Usage Records 07/2014 - 06/2015

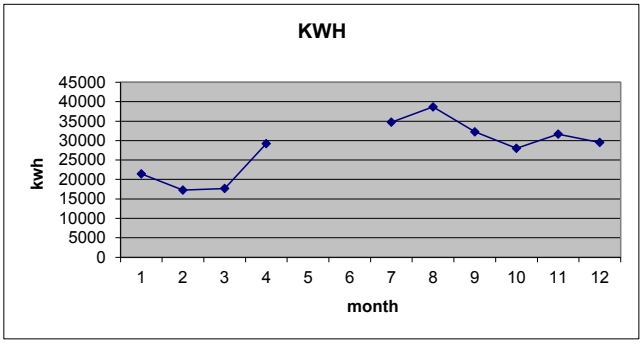
YEAR	MONTH	KWH	KW
2014	JUL	14,720	59
2014	AUG	16,160	35
2014	SEP	26,240	131
2014	OCT	31,040	154
2014	NOV	27,840	136
2014	DEC	32,800	129
2015	JAN	28,880	136
2015	FEB	28,400	133
2015	MAR	25,120	123
2015	APR	30,960	127
2015	MAY	29,200	130
2015	JUN	27,200	126
MONTHLY AVG=		26,547	118

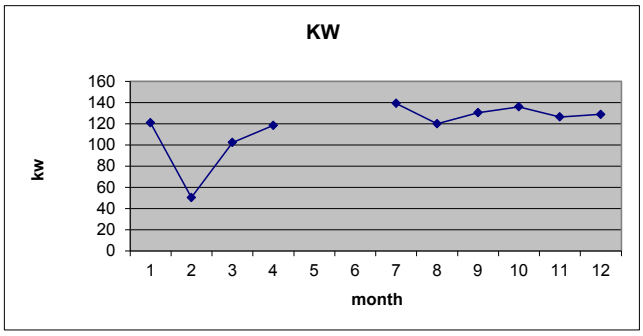




Pulaski Middle School HVAC Study - Electricity Usage Records 07/2014 - 06/2015

YEAR	MONTH	KWH	KW
2014	JUL	21,440	121
2014	AUG	17,280	50
2014	SEP	17,680	102
2014	OCT	29,200	118
2014	NOV		
2014	DEC		
2015	JAN	34,720	139
2015	FEB	38,640	120
2015	MAR	32,240	130
2015	APR	28,000	136
2015	MAY	31,680	126
2015	JUN	29,520	129
MONTHLY AVG=		28,040	117





Existing Window Schedule for ***Dublin*** Middle School - Main Building						
Mark	**Construction**	**Width (feet)**	**Height (feet)**	**Quantity**	**Square Feet (each)**	**Square Feet (SF total)**
A	Metal	7.500	8.500	118	63.750	7522.500
B	Metal	5.500	8.333	12	45.832	549.978
C	Metal	5.500	9.833	7	54.082	378.571
D	Metal	4.500	8.667	9	39.002	351.014
E	Metal	11.000	5.833	4	64.163	256.652
F	Metal	2.167	7.167	2	15.531	31.062
G	Metal	5.500	5.833	11	32.082	352.897
H	Metal	4.500	7.167	6	32.252	193.509
I (n/a)	Metal				0.000	0.000
J	Metal	3.833	8.333	3	31.940	95.821
K	Metal	2.167	4.333	2	9.390	18.779
L	Metal	5.500	4.333	2	23.832	47.663
M	Metal	3.667	4.333	2	15.889	31.778
N	Metal	4.500	5.833	2	26.249	52.497
O	Metal	15.000	8.833	1	132.495	132.495
P	Metal	13.000	12.000	11	156.000	1716.000
Q	Metal	5.500	5.000	1	27.500	27.500
			Quantity Total	193	Grand Total SF	11758.715

Existing Window Schedule for ***Dublin*** Middle School - Shop Building						
Mark	**Construction**	**Width (feet)**	**Height (feet)**	**Quantity**	**Square Feet (each)**	**Square Feet (SF total)**
Q	Metal	8.333	8.083	5	67.356	336.778
R	Metal	4.000	8.083	3	32.332	96.996
S	Metal	7.000	10.000	14	70.000	980.000
T	Metal	12.500	10.000	8	125.000	1000.000
U	Metal	4.083	5.667	1	23.138	23.138
V	Metal	3.417	5.667	2	19.364	38.728
W	Metal	7.000	5.667	1	39.669	39.669
X	Metal	4.083	4.333	1	17.692	17.692
Y	Metal	5.083	10.000	1	50.830	50.830
Z	Metal	7.000	8.500	1	59.500	59.500
AA	Metal	7.000	4.167	1	29.169	29.169
			Quantity Total	38	Grand Total SF	2672.500

Existing Window Schedule for *Pulaski* Middle School - Main Building						
Mark	**Construction**	**Width (feet)**	**Height (feet)**	**Quantity**	**Square Feet (each)**	**Square Feet (SF total)**
A	Wood	5.583	9.250	22	51.643	1136.141
B	Metal	9.250	15.583	4	144.143	576.571
C	Metal	8.333	6.750	3	56.248	168.743
D	Metal	7.000	9.417	1	65.919	65.919
E	Metal	4.083	6.750	11	27.560	303.163
F	Metal	8.333	4.083	1	34.024	34.024
G	Metal	7.000	8.083	12	56.581	678.972
H	Metal	9.000	9.417	4	84.753	339.012
I	Metal	8.333	9.417	3	78.472	235.416
J	Metal	4.083	8.083	2	33.003	66.006
K	Metal	14.667	8.083	4	118.553	474.213
L	Metal	12.333	8.083	25	99.688	2492.191
M	Metal	3.417	6.750	2	23.065	46.130
N	Metal	7.000	4.083	4	28.581	114.324
O	Metal	10.333	8.083	1	83.522	83.522
P	Metal	5.083	6.750	2	34.310	68.621
Q	Metal	12.667	8.083	4	102.387	409.549
R	Metal	5.083	8.083	2	41.086	82.172
S	Metal	10.333	5.417	1	55.974	55.974
T	Metal	4.083	9.417	2	38.450	76.899
U	Metal	13.667	8.083	30	110.470	3314.111
V	Metal	3.417	8.083	2	27.620	55.239
W	Security	5.083	5.417	1	27.535	27.535
X	Security	10.333	5.417	1	55.974	55.974
Y	Metal	5.083	4.083	4	20.754	83.016
Z	Metal	5.083	5.417	1	27.535	27.535
AA	Metal	10.333	9.417	3	97.306	291.918
BB	Metal	4.083	4.083	2	16.671	33.342
CC	Metal	3.417	4.083	2	13.952	27.903
DD	Metal	9.250	14.583	4	134.893	539.571
EE	Metal	1.750	4.083	2	7.145	14.291
FF	Metal	8.333	8.083	5	67.356	336.778
GG	Metal	3.750	4.083	3	15.311	45.934
HH	Metal	7.500	11.000	8	82.500	660.000
II	Metal	7.500	8.083	2	60.623	121.245
JJ (n/a)	Metal				0.000	0.000
KK(?)	Metal	3.750	4.083		15.311	0.000
LL(?)	Metal	1.750	4.073		7.128	0.000
MM (?)	Metal				0.000	0.000
Exist	Wood	12.000	9.000	8	108.000	864.000
Exist	Wood	10.000	9.000	1	90.000	90.000
Exist	Wood	3.000	5.000	3	15.000	45.000
Exist	Wood	7.000	5.000	1	35.000	35.000
Exist	Wood	8.000	9.000	1	72.000	72.000
Exist	Wood	7.500	5.000	1	37.500	37.500
Exist	Wood	12.000	9.000	17	108.000	1836.000
			Quantity Total	212	Grand Total SF	16121.450

Existing Window Schedule for *Pulaski* Middle School - Shop Building						
Mark	**Construction**	**Width (feet)**	**Height (feet)**	**Quantity**	**Square Feet (each)**	**Square Feet (SF total)**
A	Metal	10.333	9.417	8	97.306	778.447
B	Metal	13.583	8.083	2	109.791	219.583
C	Metal	12.333	8.083	2	99.688	199.375
D	Metal	4.083	9.417	1	38.450	38.450
E	Metal	4.083	6.750	3	27.560	82.681
F	Metal	7.000	2.750	1	19.250	19.250
G	Metal	7.000	4.083	1	28.581	28.581
			Quantity Total	18	Grand Total SF	1366.366