Minneapolis Public Schools
Special School District #1

Air Conditioning Cost Estimating Study Roosevelt High School

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INTRODUCTION / KEY INFORMATION:

Wold Architects and Engineers was hired May 2021 to develop options with a recommended approach and construction cost estimate to expand the air conditioned area at Roosevelt High School. The study also reviewed dehumidification capabilities and outlines additional work necessary to provide active dehumidification control. The study approach included a tour of the building site, review of available building construction documents, and a review of previous ventilation studies. Wold collaborated with the District's facility leadership team to establish criteria and guiding principles for developing options and to determine the recommended approach. Cost estimates are developed to reflect construction bids to be received on January 1, 2022 and includes a semi-annual cost inflation escalation to extend bids to January 1, 2025. .

Key Information:

- Building Address: **Roosevelt High School**
  Minneapolis Public Schools
  4029 28th Ave S
  Minneapolis, MN 55406
  Phone: (612) 668-4800
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EXECUTIVE SUMMARY:

Wold Architects and Engineers completed a study to determine the recommended approach and project budget to expand the air conditioned area at the Roosevelt High School. The options developed are organized around the priorities established by the District based on the use of each space and by grouping areas within each building geographically as served by common systems. In collaboration with the District, the recommendation was developed to serve the highest priority areas within the overall budget constraints. In addition, the building as a whole was evaluated to determine additional features and systems that are required to provide active dehumidification control.

Criteria / Guiding Principles:

Initial discussions provided a common understanding of the guiding principles to be used to develop options and a hierarchy of priorities based on the use of each space.

Guiding Principles:

- High quality proven system solutions preferred
- Systems shall be easy to operate and maintain
- A high level of temperature zone control required
- Centralized systems preferred
- Vertical unit ventilators may be an option depending on site factors
- DX or chilled water may be options depending on site factors
- Separate systems to serve administration areas should be considered
- COVID risk mitigation measures to focus on ventilation and filtration
- Window AC unit are not an option. Mini-splits may be is limited applications
- Heating for systems may be steam or hot water depending on site factors
- Systems shall be configured to allow for active dehumidification

Air-conditioning classrooms is the primary goal of this study. Additional spaces may be considered where possible within the overall budget constraints. Options were considered where space adjacencies allow opportunities to economically include additional areas. Gymnasiums are not typically air-conditioned but options were considered where they are central to a building and/or used as gathering spaces. It is not an intended outcome of the study to add ventilation and air conditioning to all spaces where it does not currently exist. The summary diagrams for each building identify the remaining unconditioned areas.

In addition, opportunities within each option were determined to provide added value scope where it is economically feasible to accomplish additional deferred maintenance needs within the scope of the air conditioning project i.e. ceilings, lights, and other room finishes.

Recommended Scope Summary:

<u>Classrooms Building Areas #1, #2, and #3 (187,495 Sq Ft):</u> Install a new dedicated outside air ventilation system with perimeter displacement and chilled beams air delivery to serve the classrooms and similar areas. Install an air-cooled chiller on grade to serve the system cooling needs. The chiller capacity will be sized for the building cooling loads on the west half of the building. Install a steam-to-hot water convertor and high efficiency boiler for summer operation to serve the system heating needs. Further study is required to determine if the basement area would be better served with a variable air volume system space permitting in the mechanical room. The base project includes routing supply ductwork exposed within the classrooms and similar areas.

For consideration, an added scope option is included for providing a new lay-in ceiling and new LED lighting and controls. A perimeter soffit is included as may be required to accommodate the height of the exterior windows.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible. Options to optimize the space include combining air-handling zone, determining and alternate outside airflow path, and maybe alternate locations for heat recovery equipment.
- Determining outside air pathways for options that include interior air handling units.
- Integrity of the existing steam and condensate systems to accommodate modifications necessary for the steam-to-hot water convertor installation.
- Adequacy of the existing structure to support the new rooftop units as an option to allow for phased implementation. Resolution of this risk requires a specific air handling unit selection and an analysis by a structural engineer.

Construction Cost Estimate:	**$ 20,256,000**
Add for Ceiling and Lights:	**$ 3,800,000**

<u>Office Building Area #4 (6,435 Sq Ft):</u> Install a new variable air volume air handling unit in the basement in the same location as the existing unit S-10. Install new insulated supply ductwork and variable air volume boxes with hot water reheat. Connect to the chilled water and hot water system provided in the classroom option.

For consideration, an added scope option is included for providing a new lay-in ceiling and new LED lighting and controls. A perimeter soffit is included as may be required to accommodate the height of the exterior windows.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible.
- Determining pathways for supply, return, relief, and outside air ductwork. The existing structure is poured concrete. New openings require review by a structural engineer.
- Integrity of the existing steam and condensate systems to accommodate modifications necessary for the steam-to-hot water convertor installation.
- Adequacy of the existing structure to support the new rooftop units as an option to allow for phased implementation. Resolution of this risk requires a specific air handling unit selection and an analysis by a structural engineer.

Construction Cost Estimate: $ 581,000
Add for Ceiling and Lights: $ 135,000

Gymnasiums Building Area #5 (12,420 Sq Ft): Install new constant volume air handling units in the basement in the same location as the existing units. Install new supply ductwork exposed within each gymnasium. Connect to the chilled water and hot water system provided in the classroom option. An option is to modify the existing steam system for connection to the air handling unit.

For consideration, an added scope option is included for providing a new LED lighting and controls and de-stratification fans.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible.
- Determining pathways for supply, return, relief, and outside air ductwork. The existing structure is poured concrete. New openings require review by a structural engineer.

- Integrity of the existing steam and condensate systems to accommodate modifications necessary for the steam-to-hot water convertor installation.

Construction Cost Estimate: $ 558,000
Add for de-stratification Fans $ 40,000

Gymnasiums and Locker Rooms Building Area #6 (36,285 Sq Ft): Install new constant volume air handling units in the mezzanine mechanical room in the same location as the existing units. Install new supply ductwork exposed within each gymnasium. Install an air-cooled chiller to serve the cooling needs of the east half of the building. Modify the existing steam system for connection to the air handling unit.

For consideration, an added scope option is included for providing a new LED lighting and controls and de-stratification fans.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible.
- Determining pathways for supply, return, relief, and outside air ductwork. The existing structure is poured concrete. New openings require review by a structural engineer.
- Integrity of the existing steam and condensate systems to accommodate modifications necessary for the steam-to-hot water convertor installation.

Construction Cost Estimate: $ 2,350,000
Add for de-stratification Fans $ 40,000

Shop Classrooms Building Area #7 (3,410 Sq Ft): Install new constant volume single zone fan coil units to serve each of the 6 shop classrooms. Install new supply ductwork exposed within each classrooms. Connect to the chilled water and hot water system provided in the Gymnasium and Locker Room work scope. As an option, if the chiller is not installed, these rooms could be cooled with remote roof mounted DX systems. Modify the existing steam systems for heating.

For consideration, an added scope option is included for providing a new LED lighting and controls and de-stratification fans.

The cost estimate includes a design contingency to cover risks identified that require further investigation. Identified risks include the following:

- Space heating and cooling loads are estimated to determine preliminary equipment selections as a basis for cost estimating. Final heating and cooling loads need to be completed.
- The optimal new air-handling unit configuration. A guiding principal is to locate as much of the new equipment inside the existing fan room as possible.
- Determining pathways for supply, return, relief, and outside air ductwork. The existing structure is poured concrete. New openings require review by a structural engineer.
- Integrity of the existing steam and condensate systems to accommodate modifications necessary for the steam-to-hot water convertor installation.

Construction Cost Estimate:	**$**	**693,000**
Add for Ceiling and Lights:	**$**	**72,000**

EXISTING BUILDING INFORMATION

The original building was constructed in 1921. The original project typically ventilated the classrooms with two large heating only single zone supply fans located in a basement mechanical room. Major classroom additions were added in 1958 and 1966. The classroom additions are typically ventilated with horizontal unit ventilators. A major addition was added in 1968 that includes gymnasiums and locker rooms. A science classroom addition was added in 1997.

There is not a centralized cooling plant. The 1997 science room addition is cooled with a split DX condensing unit. Window AC units or mini-split units serve a small portion of the rest of the building.

The building is heated with three large dual fuel fire tube steam boilers.

A complete summary of the existing building systems is shown graphically in Appendix A.

Building Area Summary:

Year	Area (sq. ft.)
1921	199,147
1950	557
1958	27,547
1963	577
1966	18,977
1968	47,586
1997	12,638
Total	**307,029**

AIR CONDITIONING OPTIONS SUMMARY

The Primary driver of the overall project scope and budget is the decision about the air delivery method. The size of the equipment and the configuration within the building affects the work scope of multiple trades to provide pathways for ductwork and piping and to restore building finishes. With each air delivery method, there are multiple options to provide cooling and multiple options to provide heating which typically are part of the overall building central heating and cooling plant strategy. There are long-term benefits to the overall maintenance and operation of the facility to consider the heating and cooling approach for each air delivery option within the overall plan for the central heating and cooling plants that serve the building.

The range of air delivery options presented in this summary are narrowed to those that fit the District's criteria that includes centralizing systems to the extent possible to minimize regular and periodic maintenance. These options typically include vertical unit ventilators, variable air volume central air handling, and dedicated outside air displacement systems. The full range of options are discussed in more detail in the "Air Conditioning Options Detail" section of this report.

In addition to the first cost, the attributes of each system also have an effect on the quality of the learning environment and the on-going operational costs related to energy efficiency and the requirements for regular and periodic maintenance. As an aid for discussion, each of the air delivery options presented are rated relative to each other in terms of good, better, best in each of these performance categories as follows.

Attribute	Vertical Unit Vents	Central VAV	DOAS / Displacement
Environment Quality	Good	Better	Best
Energy Efficiency	Good	Better	Best
Maintenance	Good	Better	Best

A summary of the cost range for viable options for each of the air delivery methods is as follows. The options prioritize adding cooling to the classrooms and are summarized in total to cover all of the currently unconditioned classrooms in the building. Other areas that may include gymnasiums, auditoriums or other common areas are listed separately. All cost are presented as construction costs.

Vertical Unit Ventilators:

Install a vertical unit ventilator along the perimeter of each classroom. The work will include installing a new exterior louver through either a window or cutting a louver through the exterior wall. The range of costs is defined by the following approach to heating and cooling.

Low Cost Option: Integral DX, Modify existing steam

Medium Cost Option: Air-cooled chiller, Modify existing steam

High Cost Option: Air-cooled chiller, Steam to HW convertor

Vertical Unit Ventilators					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	140,435			
#2	Classrooms	36,930			
#3	Classrooms	10,130			
Total		**187,495**	**$5,872,000**	**$8,975,000**	**$11,568,000**

Central Variable Air Volume:

Install a variable central air handling system in each of the building areas. Install a new air-handling unit in the location of the existing. Replace the existing ductwork with new insulated ductwork along the same pathways. Building Are #2 is served by a rooftop unit installed in 1999 that was planned for the addition of a future cooling coil.

Low Cost Option: Air-cooled chiller, Modify existing Steam System, cooling only VAV's

Medium Cost Option: Air-cooled chiller, Steam to HW convertor

High Cost Option: Air-cooled chiller, Convert boiler to HW

Central Variable Air Volume					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	140,435			
#2	Classrooms	36,930			
#3	Classrooms	10,130			
Total		**187,495**	**$12,870,500**	**$18,013,000**	**$19,863,500**

Dedicated Outside Air/Displacement:

Install a central dedicated outside air system to serve all classroom areas. The dedicated outside air unit would be located in the boiler room. Install a new air-handling unit in the location of the existing. Replace the existing ductwork with new insulated ductwork along the same pathways. There are considerable challenges to create new pathways for ductwork and piping because of the wood structure.

Low Cost Option: Displacement requires both chilled and hot water. Work is necessarily required on the central heating plant

Medium Cost Option: Displacement requires both chilled and hot water. Work is necessarily required on the central heating plant

High Cost Option: Air-cooled chiller, Steam to HW convertor

Dedicated Outside Air / Displacement					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	140,435			
#2	Classrooms	36,930			
#3	Classrooms	10,130			
Total		**187,495**	**N/A**	**N/A**	**$20,256,000**

Additional Scope:

Additional work that may be considered with each of these options includes the following:

New Ceilings and LED Lights: **Construction Budget** **$ 3,800,000**

AIR CONDITIONING SCOPE DETAIL

The following options to expand air conditioning are noted as "Building Area #'s". The area to be air-conditioned is annotated on the Proposed Systems Diagrams in Appendix B.

Building Area 1: 1921 Classrooms (140,435 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
1 – 1921 Classrooms	A - Mini-Split	B - Remote DX	A - None	1-ABA
	B - Vertical Unit Ventilators	A - Integral DX	B - Steam	1-BAB
			C - Hot Water*	1-BAC
		B - Remote DX	B - Steam	1-BBB
			C - Hot Water*	1-BBC
		C - Chilled Water*	B - Steam	1-BCB
			C - Hot Water*	1-BCC
	C - Central VAV	B - Remote DX	B - Steam	1-CBB
			C - Hot Water*	1-CBC
		C - Chilled Water*	B - Steam	1-CCB
			C - Hot Water*	1-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	1-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: Two large CV heating only supply fans installed in the original 1921 construction ventilate the classrooms and support areas. The supply fans are located in the basement and they supply vertically from air tunnels to each space. The return air path is open to the attic. The outside air intakes are located on the roof adjacent to the return air path to the basement. Projects in 1996 and 1999 provided horizontal unit ventilators in a few rooms on the second floor. The area is not air-conditioned. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Vertical Unit Ventilators: Install new vertical unit ventilators to replace the central system. Modifications will be required to the perimeter steam finned tube radiation. Outside and relief would be available for the rooms on an exterior wall by replacing one of the windows adjacent to each unit ventilator. The perimeter casework is minimal in most classrooms with the exception of the science and FACS classrooms. There are several interior spaces that do not have direct access to an outside wall for ventilation.

Central Variable Air Volume (VAV): Provide a new central variable air volume system. The existing mechanical room would be used to the extent possible for new equipment. Further investigation is required to determine the optimal configuration. It is anticipated that the current MN Energy code will require heat recovery to be incorporated into the system. Pathways for vertical duct distribution need to be determined. The existing structure is poured concrete pan and joist, which creates challenges for creating large vertical openings.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

<u>Cooling Plant:</u> Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the vertical unit ventilators and there is precedent with this type of system in the District. Design considerations need to include meeting the classroom ambient sound levels. Integral cooling systems have an impact on future maintenance by distributing possible failure points of the system.

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems, vertical unit ventilators, and central variable air volume solutions. Condenser locations for remote DX locations need to be determined. Structural constraints of the roof need to be evaluated.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

<u>Heating Plant:</u> Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by multiple large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping.

The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining vertical pathways for new ductwork as necessary for the central air handling unit options. The existing vertical pathways will be reused to the extent possible. The existing pathways do not appear to be ducted.
- Determining a design solution for outside ventilation air with interior the central air handling unit options. Pathways for outside air and building relief air need to be determined.
- Determine structural capacity limitations with options that include roof mounted equipment.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

Typical Photos:

Typical Classroom – Rm 359

Media Center – Second Floor

Building Area 2 – 1958/1966 Classrooms (36,930 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

<table>
<tr><th>Building Area</th><th>Air Delivery Method</th><th>Cooling Plant</th><th>Heating Plant</th><th>Option</th></tr>
<tr><td rowspan="12">2 – Classrooms</td><td>A - Mini-Split</td><td>B - Remote DX</td><td>A - None</td><td>2-ABA</td></tr>
<tr><td rowspan="6">B - Vertical Unit Ventilators</td><td rowspan="2">A - Integral DX</td><td>B - Steam</td><td>2-BAB</td></tr>
<tr><td>C - Hot Water*</td><td>2-BAC</td></tr>
<tr><td rowspan="2">B - Remote DX</td><td>B - Steam</td><td>2-BBB</td></tr>
<tr><td>C - Hot Water*</td><td>2-BBC</td></tr>
<tr><td rowspan="2">C - Chilled Water*</td><td>B - Steam</td><td>2-BCB</td></tr>
<tr><td>C - Hot Water*</td><td>2-BCC</td></tr>
<tr><td rowspan="4">C - Central VAV</td><td rowspan="2">B - Remote DX</td><td>B - Steam</td><td>2-CBB</td></tr>
<tr><td>C - Hot Water*</td><td>2-CBC</td></tr>
<tr><td rowspan="2">C - Chilled Water*</td><td>B - Steam</td><td>2-CCB</td></tr>
<tr><td>C - Hot Water*</td><td>2-CCC</td></tr>
<tr><td>D - DOAS</td><td>C - Chilled Water*</td><td>C - Hot Water*</td><td>2-DCC</td></tr>
</table>

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: The classroom area was originally constructed in 1958 with a second floor addition completed in 1966. Horizontal heating only unit ventilators typically ventilated and heated the classrooms. The unit ventilators were replaced in two phase in 1996 and 1999. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Vertical Unit Ventilators: Install new vertical unit ventilators to replace the existing horizontal unit ventilators in approximately the same location. Outside and relief would be available through the outside wall. The perimeter casework in science and FACS classrooms will need to be modified.

Central Variable Air Volume (VAV): Provide a new central variable air volume system. The most likely location is on the roof above the classrooms or adjacent hallway. It is anticipated that the current MN Energy code will require heat recovery to be incorporated into the system. Further investigation is necessary to determine the structural capacity limitations.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

Cooling Plant: Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the vertical unit ventilators and there is precedent with this type of system in the District. Design considerations need to include meeting the classroom ambient sound levels. Integral cooling systems have an impact on future maintenance by distributing possible failure points of the system.

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems and vertical unit ventilator solutions. The condensing units could be located on grade adjacent to the building or on the roof.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by multiple large dual fuel steam fire tube boilers. Steam is converted to hot water to serve the terminal heating devices in this area. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining vertical pathways for new ductwork as necessary for the central air handling unit options. The existing structure is precast concrete slabs supported by a steel frame structure. Options that require large openings will require additional structural review.
- Determining a design solution for outside ventilation air with the central air handling unit options.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.
- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.
- Space constraints for options that include locating new central air handling units in the storage room. Final load calculations and air handling unit selections are necessary to determine the final design to fit the new equipment.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

Typical Photos:

Room 229

Building Area 3 – 1958 Interior Core (10,130 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
3 – 1958 Interior Core	A - Mini-Split	B - Remote DX	A - None	2-ABA
	C - Central CV	B - Remote DX	B - Steam	2-CBB
			C - Hot Water*	2-CBC
		C - Chilled Water*	B - Steam	2-CCB
			C - Hot Water*	2-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	2-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: Two multi-zone heating only air-handling units provide heating and ventilation to the interior areas of the 1958 addition. The air-handling units are located in a mechanical space to the south of the music rooms. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Central Variable Air Volume (VAV): Replace the existing multi-zone system with a new variable air volume air handling system. It is anticipated that the current MN Energy code will require heat recovery to be incorporated into the system. Further investigation is necessary to determine the optimal configuration of the new mechanical systems and if the new unit will fit in the existing mechanical room. An option is to locate the new unit on the roof above. Pathways for vertical duct distribution need to be determined.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

Cooling Plant: Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The location of the chiller plant needs to consider sound levels at the adjacent property line. There is a large space to the east of the building. The following outlines possible cooling plant options:

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems and vertical unit ventilator solutions. The condensing units could be located on grade adjacent to the building or on the roof.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by two large dual fuel steam fire tube boilers. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining a design solution for outside ventilation air with the central air handling unit options.
- Determine the optimal layout for air handling unit installation in the existing mechanical room. It would work best to reconfigure the other equipment in the room.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing hot water convertor system and associated pumps and piping. Piping in poor condition may necessitate additional pipe removal. The best

method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

Typical Photos:

Building Area 4 – Office (6,435 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
4 – Office	A - Mini-Split	B - Remote DX	A - None	2-ABA
	C - Central CV	B - Remote DX	B - Steam	2-CBB
			C - Hot Water*	2-CBC
		C - Chilled Water*	B - Steam	2-CCB
			C - Hot Water*	2-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	2-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report. .

Air Delivery: A single zone constant volume heating and ventilation units installed in 1921 and 1965 serve the office areas. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Central Variable Air Volume (VAV): Replace the existing constant volume systems with a new variable air volume air handling system. Further investigation is necessary to determine the optimal configuration of the new mechanical systems and if the new unit will fit in the existing mechanical room. Pathways for vertical duct distribution need to be determined.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

Cooling Plant: Viable options studied include integral DX, remote DX, and construction of a new central chilled water plant. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the rooftop unit replacement.

Remote Direct Expansion (DX): A remote DX condensing unit is an option to provide cooling for a replacement unit. The location on the first floor presents challenges to locate the condenser in a location within the limits of the refrigerant piping length.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a two large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that can modulate to very low load conditions. Active dehumidification is not practical with a gas-fired option. The building is heated with two large steam boilers. Reheat for dehumidification is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining a design solution for outside ventilation air with the central air handling unit options.
- Determine if a new central air-handling unit will fit with the space constraints in the existing mechanical room. It may be necessary to reconfigure the adjacent equipment in the room.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal.

The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.

Typical Photos:

Building Area 5 – 1921 Gymnasiums (12,420 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Cost Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
5 – 1921 Gymnasiums	C - Central CV	B - Remote DX	B - Steam	2-CBB
			C - Hot Water*	2-CBC
		C - Chilled Water*	B - Steam	2-CCB
			C - Hot Water*	2-CCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: A single zone constant volume heating and ventilation units installed in 1921 serve each of the gymnasiums. The units are located in the basement level mechanical rooms. The following outlines possible new air delivery methods:

Central Constant Volume (CV): Replace the existing constant volume systems with a new constant volume air handling system. Further investigation is necessary to determine the optimal configuration of the new mechanical systems and if the new unit will fit in the existing mechanical room.

Cooling Plant: Viable options studied include integral DX, remote DX, and construction of a new central chilled water plant. The following outlines possible cooling plant options:

Remote Direct Expansion (DX): A remote DX condensing unit is an option to provide cooling for a replacement unit. The location on the first floor presents challenges to locate the condenser in a location within the limits of the refrigerant piping length.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a two large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that can modulate to very low load conditions. Active dehumidification is not practical with a gas-fired option. The building is heated with two large steam boilers. Reheat for dehumidification is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining a design solution for outside ventilation air with the central air handling unit options.
- Determine if a new central air-handling unit will fit with the space constraints in the existing mechanical room. It may be necessary to reconfigure the adjacent equipment in the room.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

Typical Photos:

North 1921 Gymnasium

Building Area 6 – 1967 Gyms and Locker Rms (36,285 Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
6 – 1967 Gyms and Locker Rms	C - Central CV	B - Remote DX	B - Steam	2-CBB
			C - Hot Water*	2-CBC
		C - Chilled Water*	B - Steam	2-CCB
			C - Hot Water*	2-CCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: A single zone constant volume heating and ventilation units installed in the original 1967 construction serve the gymnasiums and adjacent locker rooms. The locker rooms typically transfer air from the gymnasiums and do not have a direct source of ventilation air. The gymnasium units are located on a mechanical mezzanine adjacent to the gymnasium. The following outlines possible new air delivery methods:

Central Constant Volume (CV): Replace the existing constant volume systems with a new constant volume air handling system. Further investigation is necessary to determine the optimal configuration of the new mechanical systems and if the new unit will fit in the existing mechanical room.

Cooling Plant: Viable options studied include integral DX, remote DX, and construction of a new central chilled water plant. The following outlines possible cooling plant options:

Remote Direct Expansion (DX): A remote DX condensing unit is an option to provide cooling for a replacement unit. The location on the first floor presents challenges to locate the condenser in a location within the limits of the refrigerant piping length.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by a two large dual fuel steam fire tube boiler. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping.

The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that can modulate to very low load conditions. Active dehumidification is not practical with a gas-fired option. The building is heated with two large steam boilers. Reheat for dehumidification is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation. An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determining a design solution for outside ventilation air with the central air handling unit options.
- Determine if a new central air-handling unit will fit with the space constraints in the existing mechanical room. It may be necessary to reconfigure the adjacent equipment in the room.
- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.

Typical Photos:

Building Area 7 – Shop Classrooms (?????? Sq. Ft.): The following is a summary of the range of possible options considered.

Options Summary:

Building Area	Air Delivery Method	Cooling Plant	Heating Plant	Option
7 – Classrooms	A - Mini-Split	B - Remote DX	A - None	7-ABA
	B - Vertical Unit Ventilators	A - Integral DX	B - Steam	2-BAB
			C - Hot Water*	7-BAC
		B - Remote DX	B - Steam	7-BBB
			C - Hot Water*	7-BBC
		C - Chilled Water*	B - Steam	7-BCB
			C - Hot Water*	7-BCC
	C - Central VAV	B - Remote DX	B - Steam	7-CBB
			C - Hot Water*	7-CBC
		C - Chilled Water*	B - Steam	7-CCB
			C - Hot Water*	7-CCC
	D - DOAS	C - Chilled Water*	C - Hot Water*	7-DCC

Notes: * There are multiple central plant options for chilled and hot water. Refer to the Central Plant section of this report.

Air Delivery: The shop areas were constructed in 1921, 1950, and 1967. A total of 6 classrooms are located adjacent to each shop and are served by either horizontal unit ventilators or small air handling units. The following outlines possible new air delivery methods:

Mini-split: The systems would be installed while leaving the existing heating and ventilation systems in place. Because unconditioned ventilation air is delivered to the space through the existing unit ventilator, there is a risk of creating high humidity conditions.

Vertical Unit Ventilators: Install new vertical unit ventilators to replace the existing horizontal unit ventilators in approximately the same location. Outside and relief would be available through the outside wall. The perimeter casework in science and FACS classrooms will need to be modified.

Central Variable Air Volume (VAV): Provide a new central variable air volume system. The most likely location is on the roof above the classrooms or adjacent hallway. It is anticipated that the current MN Energy code will require heat recovery to be incorporated into the system. Further investigation is necessary to determine the structural capacity limitations.

Dedicated Outside Air (DOAS): Options for locating a new DOAS unit are similar to locating the VAV unit as describe above. The advantage of a DOAS unit is that the volume of air it is moving is approximately 1/3 as compared to the VAV system. The equipment and associated ductwork are smaller and easier to retrofit.

Cooling Plant: Viable options studied include integral packaged DX, remote DX, and construction of a new central chilled water plant. The tight site and proximity to the neighboring residential areas presents challenges in designing new equipment to meet the noise criteria at the property line. The following outlines possible cooling plant options:

Integral Direct Expansion (DX): Integral DX is an option with the vertical unit ventilators and there is precedent with this type of system in the District. Design considerations need to include meeting the classroom ambient sound levels. Integral cooling systems have an impact on future maintenance by distributing possible failure points of the system.

Remote Direct Expansion (DX): Remote DX in an option for mini-split systems and vertical unit ventilator solutions. The condensing units could be located on grade adjacent to the building or on the roof.

Chilled Water: There are multiple options to generate chilled water to meet the cooling needs of the building. Refer to the central plant options in this report for a discussion of each.

Heating Plant: Viable options include leaving the existing steam systems in place and installing a cooling only system, connecting to the existing steam plant, installing a steam to hot water convertor, or installing a new high efficiency hot water plant. The following outlines possible heating plant options.

Steam: The building is currently heated by multiple large dual fuel steam fire tube boilers. Steam is converted to hot water to serve the terminal heating devices in this area. The steam option includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: Includes the installation of a new steam-to-hot water heat exchanger, pumps and distribution system to deliver hot water to the new systems. Hot water distribution piping is more flexible to route to location as necessary than steam piping. The installation of a heat exchanger will easily accommodate future conversion of the stem plant to hot water.

Hot Water Plant: There are multiple options to generate hot water to meet the heating needs of the building. Refer to the central plant options in this report for a discussion of each.

Dehumidification: Active dehumidification requires a heating source that is currently not available with the existing steam plant during the summer months. Options for active dehumidification will depend on the extent of hot water that is installed with the new systems. If hot water distribution is included as the heating source, the heating coils will be located in the reheat position downstream of the cooling coils. If hot water is generated through a steam-to-hot water convertor, then reheat will only be possible when the steam boiler is in operation.

An option to extend the time that hot water is available is to add a small high efficiency gas boiler. If the project include replacing the steam plant, the boiler capacity would be selected to provide adequate turn down during low load periods.

Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Space heating and cooling loads are estimated based on typical loads for this type of space. Final heating and cooling loads need to be completed.
- Integrity of the existing steam and condensate systems for options that include steam heating. Piping in poor condition may necessitate additional pipe removal. The best method to mitigate this risk is to pursue the hot water heating solution as outlined in the heating section above.
- Structural capacity for options that locate new equipment on the roof. If roof options are considered, further structural evaluation will be necessary.
- Space constraints for options that include locating new central air handling units in the storage room. Final load calculations and air handling unit selections are necessary to determine the final design to fit the new equipment.

Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *Provide new ceilings and lights:* Provide new lay-in ceilings typically throughout with new LED lighting and controls. With the vertical unit ventilator options, new ceilings would allow for the air distribution above the ceiling to reduce the system noise. The ceiling condition likely will require a soffit along the exterior walls to accommodate the existing windows elevations.

9 - Central Plant Options: Centralizing the heating and cooling plants has benefits of replacing aged infrastructure, improving the overall operating efficiency of the building and reducing on-going maintenance cost by reducing the number of failures points in the building systems. The building currently has a centralized steam plant. The building does not have a centralized cooling systems approach. The following options have been considered.

Options Cost Summary:

Building Area	Cooling Approach	Heating Approach	Option
9 - Central Plant	A - Air Cooled Chiller	A - STM Distribution	4-AA
		B - STM w/ HW HX	4-AB
		C - HW Plant	4-AC
	C - Geo Thermal	A - STM Hybrid	4-CA
		B - HW Hybrid	4-CB
		C - Full Size Heat	4-CC

Cooling Plant: Centralizing the building cooling plant will improve the overall building operating efficiency and reduce the on-going maintenance requirements. The tight urban location and proximity to residential neighbors presents a risk of noise from centralized systems having a negative impact. Any centralized solution that has outside equipment will need to be evaluated for the sound levels at the adjacent property line. Final load calculations are necessary to determine the final chiller size.

Air Cooled Chiller: Because of site constraints and the proximity to the neighbors, the most likely option for locating the chiller is in the parking lot to the North adjacent to the boiler room. The area has limited space and several parking stalls will be lost. A study of the chiller sound output at the school property line needs to be completed. For the purposes of estimating, it is assumed that the chiller will have all of the available factory sound attenuation features and will be installed in a masonry enclosure with sound attenuating panels. It is possible that this option will not be viable due to excessive noise concerns.

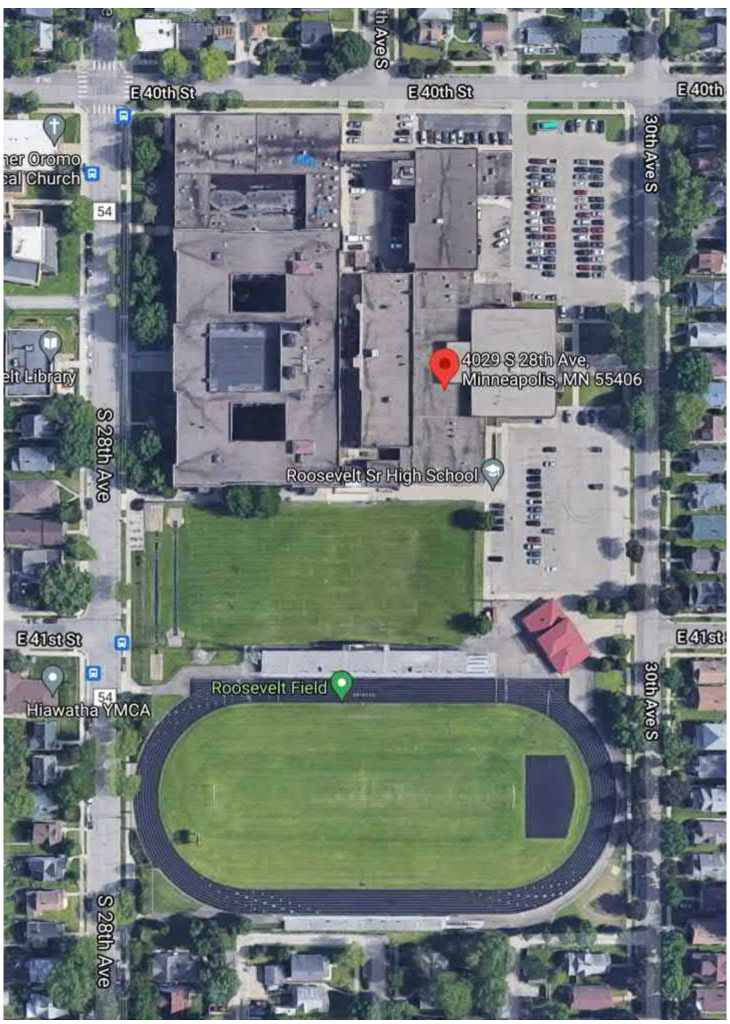
Ground Coupled Geo-thermal: A ground coupled geothermal solution has the advantage in eliminating the risk of a sound impact to the adjacent residential neighbors. The adjacent field to the north is a possible location for the well field. Further study and a test well is necessary to determine the site specific well conditions to optimize the depth, capacity, and cost. Alternate geothermal technologies including Darcy Solutions closed loop systems should be considered to further reduce the cost and size of the well field.

Heating Plant: Two dual fuel steam fire-tube boiler currently serves the building for heating. Converting the building to hot water for heating will reduce the overall operating cost of the building, reduce the regular maintenance requirements, and allow greater flexibility in routing piping to terminal heating systems throughout the building.

Hot Water Boilers: Includes replacing the existing steam systems with a new high efficiency hot water dual fuel boiler plant. The plant will consist of multiple boilers to provide redundancy in the event of equipment failure. The existing steam and condensate piping will be removed. A variable primary hot water supply and return with multiple supply pumps will be distribute hot water throughout the building.

Ground Coupled Geo-thermal: If the ground coupled geo-thermal option is selected for cooling, the plant would also provide heating capacity for the building. Options for geo-thermal would be to increase the size of the well field and deliver all of the building heating needs from the central plant or provide a hybrid plant that includes high efficiency boiler capacity for peak heating loads. Because of the limited site available for the well field, increasing to size to match the building heating loads may not be possible. Further evaluation and a test well is necessary to determine the maximum heating capacity potential.

Typical Photo:



Possible Geothermal Location - South Side of Building

Appendix A:

Existing Systems Diagram

Redacted

Appendix B:

Proposed Systems Diagrams

Redacted

Appendix C:

Dehumidification Capabilities

The recommended solution to provide air conditioning to the classrooms includes providing a high efficiency boiler for summer operation. Areas included in the scope for a new variable air volume system will be capable of active de-humidification.

Appendix D:

Cost Estimate Detail

SSD#1 Minneapolis Public Schools
Air Conditioning Cost Estimating

Cost Basis - June 2021

		Ventilation Area	Bldg Total										
BUILDING AREA 1 - 1921 Classrooms	140,435												
BUILDING AREA 2 - 1958/1966 Classrooms	36,930												
BUILDING AREA 3 - 1958 Interior Core	10,130												
Area - SQ FT	187,495	187,495	307,029		Office Building Area #4	6,435 SQ FT		Gymnasium Building Area #5	12,420 SQ FT		Gymnasium/Locker Rms Building Area #6	36,285 SQ FT	
Specification Division		DOAS / Displacement - Air-colled Chiller, HW Plant			Building Area #4 - AHU CV, CHW, Modify STM			Building Area #4 - AHU CV, CHW, Modify STM			Building Area #4 - AHU CV, CHW, Modify STM		
		Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost
Division 02 - Demolition (excludes Div 21, 22, 23, and 26)				**$ 140,621**			**$ 4,826**			**$ 12,420**			**$ 36,285**
Miscellaneous		187,495	$ 0.75	$ 140,621	6,435	$ 0.75	$ 4,826	12,420	$ 1.00	$ 12,420	36,285	$ 1.00	$ 36,285
Division 03 - Concrete				**$ 12,000**			**$ -**			**$ -**			**$ 6,000**
Floor Patch and Repair				$ -			$ -			$ -			$ -
Cast-in-place / Misc		1	$ 12,000	$ 12,000			$ -			$ -	1	$ 6,000	$ 6,000
Division4 - Masonry				**$ 160,000**			**$ -**			**$ -**			**$ 120,000**
Non-bearing Infill		1	$ 160,000	$ 160,000			$ -			$ -	1	$ 120,000	$ 120,000
Load bearing - new wall construction				$ -			$ -			$ -			$ -
Division 5 - Metals				**$ 180,000**			**$ 4,500**			**$ 9,000**			**$ 4,500**
Structural Steel / Misc. Fabrications Allowance		4	$ 45,000	180,000	1	$ 4,500	4,500	2	$ 4,500	9,000	1	$ 4,500	4,500
Division 6 - Carpentry				**$ -**			**$ -**			**$ -**			**$ -**
Rough Carpentry				$ -			$ -			$ -			$ -
Casework Modifications				$ -			$ -			$ -			$ -
Division 7 - Thermal / Moisture Protection				**$ 26,000**			**$ -**			**$ 9,000**			**$ 4,500**
Roof Patch and Repair		4	$ 6,500	$ 26,000			$ -	2	$ 4,500	$ 9,000	1	$ 4,500	$ 4,500
Roof New Construction				$ -			$ -			$ -			$ -
Fire Stopping / Miscellaneous				$ -			$ -			$ -			$ -
Division 8 - Openings				**$ -**			**$ -**			**$ -**			**$ -**
Access Panels				-			-			-			-
Doors / Hardware				-			-			-			-
Windows				-			-			-			-
Louvers				-			-			-			-
Division - 9 Finishes				**$ 581,235**			**$ 3,218**			**$ 6,210**			**$ 18,143**
Soffits / Chases		187,495	$ 2.00	$ 374,990			$ -			$ -			$ -
Floor Patch and Repair		187,495	$ 0.50	$ 93,748			$ -			$ -			$ -
Acoustic Ceilings		37,500	$ 0.50	$ 18,750			$ -			$ -			$ -
Painting		187,495	$ 0.50	$ 93,748	6,435	$ 0.50	$ 3,218	12,420	$ 0.50	$ 6,210	36,285	$ 1	$ 18,143
Division 10 - Specialties				**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				-			-			-			-
Division 11 - Equipment				**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				$ -			$ -			$ -			$ -
Division 12 - Furnishings				**$ -**			**$ -**			**$ -**			**$ -**
Casework				$ -			$ -			$ -			$ -
Miscellaneous				$ -			$ -			$ -			$ -
Division 21 - Fire Protection				**$ 374,990**			**$ 3,218**			**$ 12,420**			**$ 18,143**
Demolition		-		$ -			$ -			$ -			$ -
New / Modify Existing		187,495	$ 2.00	$ 374,990	6,435	$ 0.50	$ 3,218	12,420	$ 1.00	$ 12,420	36,285	$ 0.50	$ 18,143
Division 22 - Plumbing				**$ -**			**$ -**			**$ -**			**$ -**
Demolition				$ -			$ -			$ -			$ -
Plumbing Fixtures				$ -			$ -			$ -			$ -
Micellaneous				$ -			$ -			$ -			$ -
Division 23 - HVAC				**$ 12,428,458**			**$ 400,185**			**$ 336,525**			**$ 1,465,764**
Air Handling Equipment (VUV's / AHU's / RTU's)		6	$ 85,000	$ 510,000	1	$ 20,000	$ 20,000	2	$ 24,000	$ 48,000	4	$ 30,000	$ 120,000
Cooling Plant Equipment (Chiller / DX / Heat Pump)		2	$ 180,000	$ 360,000			$ -			$ -	1	$ 120,000	$ 120,000
Heating Plant Equipment (Boiler)		2	$ 55,000	$ 110,000			$ -		$ -	$ -			$ -
Demolition		187,495	$ 1.00	$ 187,495	6,435	$ 1.00	$ 6,435	12,420	$ 0.75	$ 9,315	36,285	$ 0.75	$ 27,214
AHU Equipment Installation / Start-up		6	$ 20,000	$ 120,000	1	$ 10,000	$ 10,000	2	$ 10,000	$ 20,000	4	$ 15,000	$ 60,000
Cooling Plant Equipment Installation		2	$ 30,000	$ 60,000			$ -			$ -	1	$ 30,000	$ 30,000
Heating Plant Installation		2	$ 120,000	$ 240,000			$ -			$ -			$ -
Chilled Water Distribution		187,495	$ 5.50	$ 1,031,223	1	$ 30,000	$ 30,000	2	$ 30,000	$ 60,000			$ -
Steam / Condensate Distribution		1	$ 60,000	$ 60,000	1	$ 12,000	$ 12,000	2	$ 7,500	$ 15,000	1	$ 20,000	$ 20,000
Hot Water Distribution		187,495	$ 12.00	$ 2,249,940	6,435	$ 10.00	$ 64,350			$ -			$ -
Ductwork Distribution Misc. (VAV's / Exhaust)		187,495	$ 32.00	$ 5,999,840	6,435	$ 32.00	$ 205,920	2	$ 65,000	$ 130,000	36,285	$ 22.00	$ 798,270
Controls		187,495	$ 7.50	$ 1,406,213	6,435	$ 7.50	$ 48,263	2	$ 24,000	$ 48,000	36,285	$ 7.50	$ 272,138
Test and Balance		187,495	$ 0.50	$ 93,748	6,435	$ 0.50	$ 3,218	12,420	$ 0.50	$ 6,210	36,285	$ 0.50	$ 18,143
Division 26 - Electrical				**$ 899,980**			**$ 10,718**			**$ 21,210**			**$ 48,143**
Demolition		187,495	$ 0.50	$ 93,748	6,435	$ 0.50	$ 3,218	12,420	$ 0.50	$ 6,210	36,285	$ 1	$ 18,143
Electrical Service		1	$ 150,000	$ 150,000			$ -			$ -			$ -
Power Connections		187,495	$ 2.50	$ 468,738	1	$ 7,500	$ 7,500	2	$ 7,500	$ 15,000	4	$ 7,500	$ 30,000
Lighting and Controls		187,495	$ 1.00	$ 187,495			$ -			$ -			$ -
Division 27 - Technology				**$ 187,495**			**$ 3,218**			**$ 6,210**			**$ 18,143**
Demolition Allowance				$ -			$ -			$ -			$ -
Fire / Sound / Data Allowance		187,495	$ 1.00	$ 187,495	6,435	$ 0.50	$ 3,218	12,420	$ 0.50	$ 6,210	36,285	$ 0.50	$ 18,143
DIVISION SUB-TOTAL				**$ 14,990,779**			**$ 429,881**			**$ 412,995**			**$ 1,739,619**
Division 1 - General Conditions				**$ 2,623,386**			**$ 75,229**			**$ 72,274**			**$ 304,433**
OH & P	10%			$ 1,499,078			$ 42,988			$ 41,300			$ 173,962
Liability Insurance	1%			$ 149,908			$ 4,299			$ 4,130			$ 17,396
Performance Bond	2%			$ 224,862			$ 6,448			$ 6,195			$ 26,094
General Contractor Misc.	5%			$ 749,539			$ 21,494			$ 20,650			$ 86,981
CONSTRUCTION SUB-TOTAL				**$ 17,614,165**			**$ 505,110**			**$ 485,269**			**$ 2,044,052**
CONTINGENCY	15%			**$ 2,642,125**			**$ 75,767**			**$ 72,790**			**$ 306,608**
CONSTRUCTION GRAND-TOTAL				**$ 20,256,290**			**$ 580,877**			**$ 558,059**			**$ 2,350,660**
COST per SQ FT				**$ 108.04**			**$ 90.27**			**$ 44.93**			**$ 64.78**

	Shop Classrooms Building Area #7	3,410 SQ FT		Building Area Tot	187,495 SQ FT		Building Area	6,435 SQ FT		Building Area	3,410 SQ FT	
Specification Division	Building Area #7 - AHU CV, CHW, Modify STM			Area #1, #2, and #3 - Add for Ceilings and Lights			Area #4 - Add for Ceilings and Lights			Area #4 - Add for Ceilings and Lights		
	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost	Sq. Ft. / Qty	Unit Cost	Cost
Division 02 - Demolition (excludes Div 21, 22, 23, and 26)			**$ 3,410**			**$ 93,748**			**$ 3,218**			**$ 1,705**
Miscellaneous	3,410	$ 1.00	$ 3,410	187,495	$ 0.50	$ 93,748	6,435	$ 0.50	$ 3,218	3,410	$ 0.50	$ 1,705
Division 03 - Concrete			**$ -**			**$ -**			**$ -**			**$ -**
Floor Patch and Repair			$ -			$ -			$ -			$ -
Cast-in-place / Misc			$ -			$ -			$ -			$ -
Division4 - Masonry			**$ -**			**$ -**			**$ -**			**$ -**
Non-bearing Infill			$ -			$ -			$ -			$ -
Load bearing - new wall construction			$ -			$ -			$ -			$ -
Division 5 - Metals			**$ 27,000**			**$ -**			**$ -**			**$ -**
Structural Steel / Misc. Fabrications Allowance	6	$ 4,500	27,000			-			-			-
Division 6 - Carpentry			**$ -**			**$ -**			**$ -**			**$ -**
Rough Carpentry			$ -			$ -			$ -			$ -
Casework Modifications			$ -			$ -			$ -			$ -
Division 7 - Thermal / Moisture Protection			**$ 15,000**			**$ -**			**$ -**			**$ -**
Roof Patch and Repair	6	$ 2,500	$ 15,000			$ -			$ -			$ -
Roof New Construction			$ -			$ -			$ -			$ -
Fire Stopping / Miscellaneous			$ -			$ -			$ -			$ -
Division 8 - Openings			**$ -**			**$ -**			**$ -**			**$ -**
Access Panels			-			-			-			-
Doors / Hardware			-			-			-			-
Windows			-			-			-			-
Louvers			-			-			-			-
Division - 9 Finishes			**$ 3,410**			**$ 1,124,970**			**$ 41,828**			**$ 22,165**
Soffits / Chases			$ -	187,495	$ 2.00	$ 374,990	6,435	$ 2.00	$ 12,870	3,410	$ 2.00	$ 6,820
Floor Patch and Repair			$ -			$ -			$ -			$ -
Acoustic Ceilings			$ -	187,495	$ 3.50	$ 656,233	6,435	$ 3.50	$ 22,523	3,410	$ 3.50	$ 11,935
Painting	3,410	$ 1.00	$ 3,410	187,495	$ 0.50	$ 93,748	6,435	$ 1.00	$ 6,435	3,410	$ 1.00	$ 3,410
Division 10 - Specialties			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous			-			-			-			-
Division 11 - Equipment			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous			$ -			$ -			$ -			$ -
Division 12 - Furnishings			**$ -**			**$ -**			**$ -**			**$ -**
Casework			$ -			$ -			$ -			$ -
Miscellaneous			$ -			$ -			$ -			$ -
Division 21 - Fire Protection			**$ 3,410**			**$ 468,738**			**$ 16,088**			**$ 8,525**
Demolition			$ -			$ -			$ -			$ -
New / Modify Existing	3,410	$ 1.00	$ 3,410	187,495	$ 2.50	$ 468,738	6,435	$ 2.50	$ 16,088	3,410	$ 2.50	$ 8,525
Division 22 - Plumbing			**$ -**			**$ -**			**$ -**			**$ -**
Demolition			$ -			$ -			$ -			$ -
Plumbing Fixtures			$ -			$ -			$ -			$ -
Micellaneous			$ -			$ -			$ -			$ -
Division 23 - HVAC			**$ 427,115**			**$ -**			**$ -**			**$ -**
Air Handling Equipment (VUV's / AHU's / RTU's)	6	$ 12,000	$ 72,000			$ -			$ -			$ -
Cooling Plant Equipment (Chiller / DX / Heat Pump)			$ -			$ -			$ -			$ -
Heating Plant Equipment (Boiler)			$ -			$ -			$ -			$ -
Demolition	3,410	$ 1.00	$ 3,410			$ -			$ -			$ -
AHU Equipment Installation / Start-up	6	$ 4,500	$ 27,000			$ -			$ -			$ -
Cooling Plant Equipment Installation			$ -			$ -			$ -			$ -
Heating Plant Installation			$ -			$ -			$ -			$ -
Chilled Water Distribution	1	$ 80,000.00	$ 80,000			$ -			$ -			$ -
Steam / Condensate Distribution	6	$ 4,500	$ 27,000			$ -			$ -			$ -
Hot Water Distribution			$ -			$ -			$ -			$ -
Ductwork Distribution Misc. (VAV's / Exhaust)	6	$ 18,000	$ 108,000			$ -			$ -			$ -
Controls	6	$ 18,000	$ 108,000			$ -			$ -			$ -
Test and Balance	3,410	$ 0.50	$ 1,705			$ -			$ -			$ -
Division 26 - Electrical			**$ 30,410**			**$ 1,124,970**			**$ 38,610**			**$ 20,460**
Demolition	3,410	$ 1.00	$ 3,410	187,495	$ 0.50	$ 93,748	6,435	$ 0.50	$ 3,218	3,410	$ 0.50	$ 1,705
Electrical Service			$ -			$ -			$ -			$ -
Power Connections	6	$ 4,500	$ 27,000			$ -			$ -			$ -
Lighting and Controls			$ -	187,495	$ 5.50	$ 1,031,223	6,435	$ 5.50	$ 35,393	3,410	$ 5.50	$ 18,755
Division 27 - Technology			**$ 3,410**			**$ -**			**$ -**			**$ -**
Demolition Allowance			$ -			$ -			$ -			$ -
Fire / Sound / Data Allowance	3,410	$ 1.00	$ 3,410			$ -			$ -			$ -
DIVISION SUB-TOTAL			**$ 513,165**			**$ 2,812,425**			**$ 99,743**			**$ 52,855**
Division 1 - General Conditions			**$ 89,804**			**$ 492,174**			**$ 17,455**			**$ 9,250**
OH & P			$ 51,317			$ 281,243			$ 9,974			$ 5,286
Liability Insurance			$ 5,132			$ 28,124			$ 997			$ 529
Performance Bond			$ 7,697			$ 42,186			$ 1,496			$ 793
General Contractor Misc.			$ 25,658			$ 140,621			$ 4,987			$ 2,643
CONSTRUCTION SUB-TOTAL			**$ 602,969**			**$ 3,304,599**			**$ 117,197**			**$ 62,105**
CONTINGENCY			**$ 90,445**			**$ 495,690**			**$ 17,580**			**$ 9,316**
CONSTRUCTION GRAND-TOTAL			**$ 693,414**			**$ 3,800,289**			**$ 134,777**			**$ 71,420**
COST per SQ FT			**$ 19.11**			**$ 20.27**			**$ 20.94**			**$ 20.94**