Minneapolis Public Schools
Special School District #1

Air Conditioning Cost Estimating Study Northrop Community School

MINNEAPOLIS PUBLIC SCHOOLS
Urban Education. Global Citizens.

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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 the Northrop Community 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: **Northrop Community School**
  Minneapolis Public Schools
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  Minneapolis, MN 55406
  Phone: (612) 668-4520
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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 Northrop Community 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:

Classrooms Building Areas #1 and #2 (35,550 Sq Ft): Replace the existing multi-zone units serving Area #1 with new variable air volume units. The units will be field constructed in the existing mechanical room and likely will be combined into a single system. Provide a remote DX condensing unit for cooling. Install a steam-to-hot water convertor in the boiler room to serve the hot water needs of the new systems. Install a high efficiency boiler for summer operation. New insulated ductwork with VAV boxes with hot water reheat will be installed in the existing duct pathways to each temperature control zone. The rooftop unit installed in 1999 that serves Building Area #2 was provided with a section for a future cooling coil. Provide a new DX cooling coil and remote condensing unit.

For consideration, an added scope option is included for providing a new lay-in ceiling and new LED lighting and controls in Building Area #1. 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
- Adequacy of the existing structure to support the new rooftop unit. Resolution of this risk requires a specific air handling unit selection and an analysis by a structural engineer.
- Integrity of the existing steam and condensate systems to accommodate necessary modifications for steam-to-hot water convertor.

Construction Cost Estimate:	**$ 2,739,000**
Add for Ceiling and Lights:	**$ 510,000**

Gymnasium Building Areas #3 (5,800 Sq Ft): Replace the existing air handling unit with a new constant volume air handling unit. Provide a remote DX condensing unit for cooling. Modify the existing steam system for heating. New insulated ductwork will be installed in the existing duct pathways. The existing ductwork is located above a hard ceiling with glue-on tile in the gymnasium requiring the ceiling to be removed and repaired for duct installation. For consideration, an added scope option is included to provide recessed LED lighting and controls and to locate the fire protection system above the ceiling. Each of these options requires additional ceiling removal and repair.

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.
- Structure and support of the existing ceiling. The estimate assumes that portions of the ceiling can be demoed to allow for new duct installation without taking the whole ceiling down.
-
- Integrity of the existing steam and condensate systems to accommodate necessary modifications.

Construction Cost Estimate:	**$ 450,000**
Recessed LED lights / FP	**$ 145,000**

EXISTING BUILDING INFORMATION

The original building was constructed in 1916. A major classroom addition was added in 1951. The cafeteria was relocated and expanded in 2017. The ventilation system installed in the original 1916 project consisted of a large constant volume fan that distributed air through individual ducts to each space vertically through the building. The original 1916 unit was replaced with two multi-zone units in 1980 or 1999 and reconnected to the original distribution ductwork. Horizontal unit ventilators originally served the addition project in 1951. In 1999, the unit ventilators were replaced with a roof mounted variable air volume air handling unit. A project in 2017 relocated and expanded the kitchen and cafeteria area.

There is not a centralized cooling plant. Areas including the main office and cafeteria are served by central systems with DX cooling. There are some areas cooled with mini-split systems and window AC units.

The building is heated with two large dual fuel fire tube steam boilers. A steam to hot water convertor was installed in 1980 to serve the variable air volume systems installed at that time.

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

Building Area Summary:

Year	Area (sq. ft.)
1916	32,132
1951	20,409
1980	5,333
2017	1,940
Total	**59,814**

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. Building Are #2 is excluded from the unit ventilator option because the project completed in that are has a central variable air volume system that has space for a future cooling coil.

Low Cost Option: Integral DX, Modify existing steam system

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

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

Vertical Unit Ventilators					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	24,300			
Total		**24,300**	**$862,000**	**$1,572,500**	**$3,559,700**

Central Variable Air Volume:

Replace the existing multi-zone units serving Area #1 with new variable air volume units. The units most likely will be field constructed in the existing mechanical rooms. New insulated ductwork will be installed in the existing duct pathways to each temperature control zone. The rooftop unit installed in 1999 that serves Building Area #2 was provided with a section for a future cooling coil.

Low Cost Option: Remote DX, Modify existing Steam System, Cooling only VAV's

Medium Cost Option: Remote DX, HW Convertor

High Cost Option: Air-cooled chiller, HW Convertor

Central Variable Air Volume					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	24,300	$2,058,000	$2,569,000	$3,433,700
#2	Classrooms	11,250	$84,000	$84,000	$84,000
Total		**35,550**	**$2,142,000**	**$2,739,000**	**$3,517,700**

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. To serve building area 2, the most likely location is in the storage room to the south of the gymnasium. There are considerable challenges to create new pathways for ductwork and piping because of the wood structure and because the existing vertical pathways in building are #1 have been removed. The construction budget includes an allowance as a placeholder for necessary structural work pending further investigation.

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, New HW plant for Area #1

Dedicated Outside Air / Displacement					
Building Area	**Serves**	**Area SF**	**Construction Budget**		
			Low	**Medium**	**High**
#1	Classrooms	24,300	N/A	N/A	
Total		**35,550**	N/A	N/A	**$3,939,400**

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, Convert existing boilers to HW

Additional Scope:

Additional work that may be considered with these options includes the following. The budget includes Building Area #1 only.

New Ceilings and LED Lights: **Construction Budget** **$ 510,000**

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 – 1916 Building (24,300 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 – 1916 Building	A - Mini-Split	B - Remote DX	A - None	1-ABA
	B - Vertical Unit Vents	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

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

Air Delivery: The original 1916 building construction included a large supply fan located on the ground floor of the building adjacent to the boiler room. Ventilation air is independently ducted to each ventilation zone vertically though multiple shafts from the ground floor. The supply fan was replaced in 1980 with two multi-zone units that connected to the original supply ductwork. The replacement units appear to be sized for a heating coil only. Further investigation is required to determine if the units could be retrofit with a cooling coil and the extent of insulation on the existing supply ductwork. 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 by the central system, there is a risk of creating high humidity conditions.

Vertical Unit Ventilators: Install new vertical unit ventilators to replace the existing central air handling system. An outside and relief air will be though a new louver installed in one of the existing windows. Modifications will be required to the perimeter steam finned tube radiation. The classrooms typically do not have perimeter casework.

Central Variable Air Volume (VAV): The basement fan room is a large area that will be utilized to the extent possible for new air handling equipment. It is anticipated that the current MN Energy Code will require energy recovery for systems serving the classrooms. It is possible that new heat recovery equipment will need to be located outside the building on grade to the east. It is anticipated that the new air handling systems will need to be field constructed in place due to limited access to the mechanical room. The existing supply ductwork will be replaced to allow for the ductwork to be insulated. The return air path is typically ducted to each room and is routed vertically up to the attic space and then back down to the mechanical room in a single riser. The return path can be reused with the new central system. Variable air volume boxes for each zone will be located typically within the classrooms. Soffits and ceilings should be considered as part of the final design to minimize sound and improve air distribution.

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 is an option for mini-split systems and vertical unit ventilators. The condensing units can be located directly above each space 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.

<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 two large dual fuel steam fire tube boilers. The steam options 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.

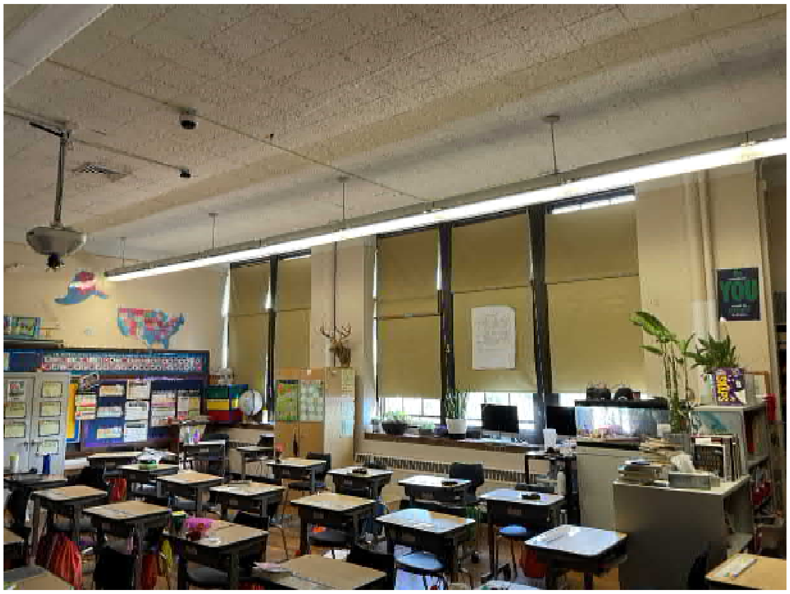
Project Risks: The following are design risks identified in implementing this project. The cost estimate includes a 15% design contingency to cover these risks. Further investigation into each of these could better define the solution and allow the design contingency to be reduced.

- Determine the optimal system configuration with the central air handling unit options. 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.
- 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.
- Determine structural constraints. Roof mounted remote condensing units will need to be reviewed for structural limitations. Further structural investigation is required.

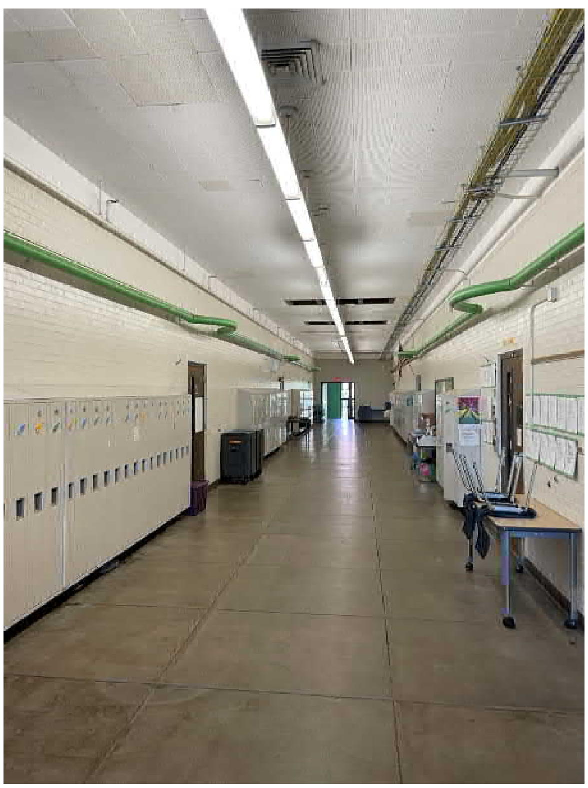
Additional Scope Considerations: The following items could be considered for inclusion in the project work scope. These items are not directly related to adding air conditioning but there would be cost efficiency by including them in the project scope and the have added value as noted.

- *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



First Floor Corridor – Looking East

Building Area 2 – 1951 Building (11,250 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
2 – 1951 Building	A - Mini-Split	B - Remote DX	A - None	2-ABA
	B - Vertical Unit Ventilators	A - Integral DX	B - Steam	2-BAB
			C - Hot Water*	2-BAC
		B - Remote DX	B - Steam	2-BBB
			C - Hot Water*	2-BBC
		C - Chilled Water*	B - Steam	2-BCB
			C - Hot Water*	2-BCC
	E - Add Cooling to Existing AHU	B - Remote DX	C - Steam	2-EBC
		C - Chilled Water*	C - Steam	2-ECB
	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: The 1951 building was originally constructed with horizontal unit ventilators along the outside wall. Steam and condensate return are fed from a tunnel below. A project in 1999 replaced the unit ventilators and installed a variable air volume rooftop air handling unit sized for 7,600 CFM. Air is distributed to each temperature control zone through supply and return located above the ceiling. The variable air volume boxes have hot water reheat coils. The rooftop unit was provided with a section to accommodate a future cooling coil. Further investigation is required to determine the extent that the existing supply ductwork is insulated. 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 central air handling system. An outside and relief air will be though a new louver installed in one of the existing windows. Modifications will be required to the perimeter steam finned tube radiation and casework.

Central Variable Air Volume (VAV): The existing variable air volume rooftop unit installed in 1999 was provided with space for a future cooling coil. Retrofit the existing AHU with a cooling coil. Further investigation is needed to determine if the supply duct is fully insulated.

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 is an option for mini-split systems, vertical unit ventilators, and retrofitting the existing rooftop air-handling unit. The condensing units can be located directly above each space 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 options includes modifying steam and condensate distribution piping to accommodate the new systems.

Hot Water HX: The area is currently served by with hot water from a steam to hot water heat exchanger installed in the 1999 construction. The heat exchanger is sized to accommodate the variable air volume system installed at that time. 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.
- Determine structural constraints. Roof mounted remote condensing units will need to be reviewed for structural limitations.
- Fully insulating the existing ductwork for options that reuse the existing distribution system will be extremely difficult. Uninsulated portions of the duct are at risk of sweating and being a source of microbial growth.

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 Photo:

Typical Classroom

Building Area 3 – Gymnasium (5,800 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 - Gymnasium	C - Central CV	A - Integral DX	A - No Heat	3-CAA
			B - Steam	3-CAB
			C - Hot Water*	3-CAC
		B - Remote DX	A - No Heat	3-CBA
			B - Steam	3-CBB
			C - Hot Water*	3-CBC
		C - Chilled Water*	B - Steam	3-CCB
			C - Hot Water*	3-CCC
	E – Add Cooling to Existing AHU	B - Remote DX	B - Steam	3-EBB
			C - Hot Water*	3-EBC
		C - Chilled Water*	B - Steam	3-ECB
			C - Hot Water*	3-ECC

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

Air Delivery: The gymnasium is ventilated by a single zone constant volume system installed in 1980 located on a mezzanine adjacent to the gymnasium. The space in which the unit is installed is very and difficult to access. The existing unit was not planned for a future cooling coil and will need to be field modified to expand the unit and make a new access section. The following outlines possible new air delivery methods:

> *Central Variable Air Volume (CV):* Install a new constant volume fan system on the roof adjacent to the gymnasium and connect to the existing ductwork for distribution. The structural capacity of the roof and the necessary structural modifications needs to be further investigated.

Cooling Plant: Viable options studied include 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): Install a package DX cooling unit with integral compressors and condensing systems. Integral DX is not an option for retrofitting the existing unit.*

> *Remote Direct Expansion (DX):* Install a remote DX condensing unit on the roof adjacent to the roof mounted air-handling unit.

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 options 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.
- Space constraints related to adding a cooling coil to the existing unit needs to be investigated to ensure there is still appropriate access.

- Determine structural constraints. Roof mounted equipment will need to be reviewed for structural limitations.

Typical Photos:

Gymnasium

Existing Gymnasium Unit

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 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. A 120-ton chiller capacity is assumed for cost estimation purposes based on a square foot estimate. Final load calculations are necessary to determine the final chiller size.

Air Cooled Chiller: The boiler room is on the north side of the building. Locating the chiller in the north parking lot will minimize the cost of installation, however, the close proximity of neighbors on the north side of the building will make it a challenge to install the chiller and meet sound criteria at the property line. The best option to reduce the sound risk is to locate the chiller to the south adjacent to the hard play surface. 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.

Ground Coupled Geo-thermal: A ground coupled geothermal solution has considerable advantages in eliminating the risk of a sound impact to the adjacent residential neighbors. The field to the south has ample room for a well field. Alternate geothermal technologies including Darcy Solutions closed loop systems should be considered to reduce the cost and size of the well field.

Heating Plant: Two dual fuel steam fire-tube boiler currently serves the entire 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 Geo Thermal Well Field – South 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. Building Area #1 areas included in the scope for new air conditioning systems 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 - 1916 Classrooms	24,300															
					Classrooms			Gymnasium								
Area - SQ FT	**24,300**	**24,300**	**59,814**		**Building Area #2**	**11,250 SQ FT**		**Building Area #3**	**5,800 SQ FT**							
Specification Division		**Building Area #1 - Central VAV, Remote DX, HW VAV's**			**Building Area #2 - Retrofit Ex Unit, Remote DX**			**Building Area #3 - Central CV, Remote DX, STM**			**Area #1 - Add for Ceilings and Lights**			**Area #3 - Add for Ceilings, Lights, Fire Protection**		
		Sq. Ft. / Qty	**Unit Cost**	**Cost**	**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)				**$ 24,300**			**$ -**			**$ 14,500**			**$ 12,150**			**$ 14,500**
Miscellaneous		24,300	$ 1.00	$ 24,300			$ -	5,800	$ 2.50	$ 14,500	24,300	$ 0.50	$ 12,150	5,800	$ 2.50	$ 14,500
Division 03 - Concrete				**$ 18,150**			**$ -**			**$ -**			**$ -**			**$ -**
Floor Patch and Repair		24,300	$ 0.50	$ 12,150			$ -			$ -			$ -			$ -
Cast-in-place / Misc		1	$ 6,000	$ 6,000			$ -			$ -			$ -			$ -
Division4 - Masonary				**$ 20,000**			**$ -**			**$ -**			**$ -**			**$ -**
Non-bearing Infill		1	$ 20,000	$ 20,000			$ -			$ -			$ -			$ -
Load bearing - new wall construction				$ -			$ -			$ -			$ -			$ -
Division 5 - Metals				**$ 12,150**			**$ 6,000**			**$ 6,000**			**$ -**			**$ -**
Structural Steel / Misc. Fabrications Allowance		24,300	$ 0.50	12,150	1	$ 6,000	6,000	1	$ 6,000	6,000			-			-
Division 6 - Carpentry				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Rough Carpentry				$ -			$ -			$ -			$ -			$ -
Casework Modifications													$ -			$ -
Division 7 - Thermal / Moisture Protection				**$ -**			**$ 2,500**			**$ 2,500**			**$ -**			**$ -**
Roof Patch and Repair				$ -	1	$ 2,500	$ 2,500	1	$ 2,500	$ 2,500			$ -			$ -
Roof New Construction				$ -			$ -			$ -			$ -			$ -
Fire Stopping / Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 8 - Openings				**$ 18,000**			**$ -**			**$ -**			**$ -**			**$ -**
Access Panels				-			-			-			-			-
Doors / Hardware				-			-			-			-			-
Windows				-			-			-			-			-
Louvers		4	$ 4,500	18,000			-			-			-			-
Division - 9 Finishes				**$ 157,950**			**$ -**			**$ 60,900**			**$ 157,950**			**$ 43,500**
Soffits / Chases		24,300	$ 3.50	$ 85,050			$ -	5,800	$ 7.50	$ 43,500	24,300	$ 2.00	$ 48,600	5,800	$ 7.50	$ 43,500
Floor Patch and Repair		24,300	$ 2.00	$ 48,600			$ -	5,800	$ 2.00	$ 11,600			$ -			$ -
Acoustic Ceilings				$ -			$ -			$ -	24,300	$ 3.50	$ 85,050			$ -
Painting		24,300	$ 1.00	$ 24,300			$ -	5,800	$ 1.00	$ 5,800	24,300	$ 1.00	$ 24,300			$ -
Division 10 - Specialties				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				-			-			-			-			-
Division 11 - Equipment				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 12 - Furnishings				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Casework				$ -			$ -			$ -			$ -			$ -
Miscellaneous				$ -			$ -			$ -			$ -			$ -
Division 21 - Fire Protection				**$ 24,300**			**$ -**			**$ 14,500**			**$ 60,750**			**$ 14,500**
Demolition		-		$ -			$ -			$ -			$ -			$ -
New / Modify Existing		24,300	$ 1.00	$ 24,300			$ -	5,800	$ 2.50	$ 14,500	24,300	$ 2.50	$ 60,750	5,800	$ 2.50	$ 14,500
Division 22 - Plumbing				**$ -**			**$ -**			**$ -**			**$ -**			**$ -**
Demolition				$ -			$ -			$ -			$ -			$ -
Plumbing Fixtures				$ -			$ -			$ -			$ -			$ -
Micellaneous				$ -			$ -			$ -			$ -			$ -
Division 23 - HVAC				**$ 1,573,925**			**$ 45,700**			**$ 198,800**			**$ -**			**$ -**
Air Handling Equipment (VUV's / AHU's / RTU's)		1	$ 80,000	$ 80,000			$ -	1	$ 20,000	$ 20,000			$ -			$ -
Cooling Plant Equipment (Chiller / DX / Heat Pump)		1	$ 40,000	$ 40,000	1	$ 13,500	$ 13,500	1	$ 10,000	$ 10,000			$ -			$ -
Heating Plant Equipment (Boiler)		1	$ 35,000	$ 35,000			$ -			$ -			$ -			$ -
Demolition		24,300	$ 0.75	$ 18,225			$ -	5,800	$ 1.50	$ 8,700			$ -			$ -
AHU Equipment Installation / Start-up		1	$ 20,000	$ 20,000	1	$ 7,500	$ 7,500	1	$ 15,000	$ 15,000			$ -			$ -
Cooling Plant Equipment Installation		1	$ 20,000	$ 20,000	1	$ 20,000	$ 20,000	1	$ 15,000	$ 15,000			$ -			$ -
Heating Plant Installation		1	$ 150,000	$ 150,000			$ -			$ -			$ -			$ -
Chilled Water Distribution				$ -			$ -			$ -			$ -			$ -
Steam / Condensate Distribution		1	$ 20,000	$ 20,000			$ -			$ -			$ -			$ -
Hot Water Distribution		24,300	$ 10.00	$ 243,000			$ -			$ -			$ -			$ -
Ductwork Distribution Misc. (VAV's / Exhaust)		24,300	$ 32.00	$ 777,600			$ -			$ -			$ -			$ -
Controls		24,300	$ 6.50	$ 157,950	1	$ 2,500	$ 2,500	5,800	$ 22.00	$ 127,600			$ -			$ -
Test and Balance		24,300	$ 0.50	$ 12,150	1	$ 2,200	$ 2,200	1	$ 2,500	$ 2,500			$ -			$ -
Division 26 - Electrical				**$ 104,300**			**$ 7,500**			**$ 7,500**			**$ 145,800**			**$ 34,800**
Demolition		24,300	$ 0.50	$ 12,150			$ -			$ -	24,300	$ 1	$ 12,150	5,800	$ 0.50	$ 2,900
Electrical Service		1	$ 50,000	$ 50,000			$ -			$ -			$ -			$ -
Power Connections		4	$ 7,500.00	$ 30,000	1	$ 7,500	$ 7,500	1	$ 7,500	$ 7,500			$ -			$ -
Lighting and Controls		24,300	$ 0.50	$ 12,150			$ -			$ -	24,300	$ 5.50	$ 133,650	5,800	$ 5.50	$ 31,900
Division 27 - Technology				**$ 12,150**			**$ -**			**$ -**			**$ -**			**$ -**
Demolition Allowance				$ -			$ -			$ -			$ -			$ -
Fire / Sound / Data Allowance		24,300	$ 0.50	$ 12,150			$ -			$ -			$ -			$ -
DIVISION SUB-TOTAL				**$ 1,965,225**			**$ 61,700**			**$ 304,700**			**$ 376,650**			**$ 107,300**
Division 1 - General Conditions				**$ 343,914**			**$ 10,798**			**$ 53,323**			**$ 65,914**			**$ 18,778**
OH & P	10%			$ 196,523			$ 6,170			$ 30,470			$ 37,665			$ 10,730
Liability Insurance	1%			$ 19,652			$ 617			$ 3,047			$ 3,767			$ 1,073
Performance Bond	2%			$ 29,478			$ 926			$ 4,571			$ 5,650			$ 1,610
General Contractor Misc.	5%			$ 98,261			$ 3,085			$ 15,235			$ 18,833			$ 5,365
CONSTRUCTION SUB-TOTAL				**$ 2,309,139**			**$ 72,498**			**$ 358,023**			**$ 442,564**			**$ 126,078**
CONTINGENCY	15%			**$ 346,371**			**$ 10,875**			**$ 53,703**			**$ 66,385**			**$ 18,912**
CONSTRUCTION GRAND-TOTAL				**$ 2,655,510**			**$ 83,372**			**$ 411,726**			**$ 508,948**			**$ 144,989**
COST per SQ FT				**$ 109.28**			**$ 7.41**			**$ 70.99**			**$ 8.51**			**$ 2.42**