AMERESCO

Airflow Testing Report

Prepared for

Portland Public Schools

August 2021

9700 SW Capitol Hwy, Suite 110
Portland, OR 97219
ameresco.com

PROJECT OVERVIEW

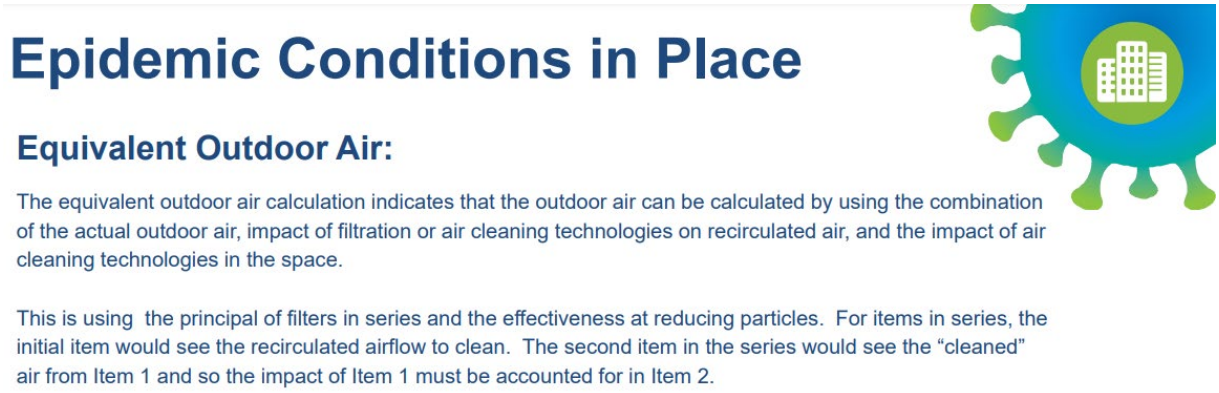
As part of the continuing process to ensure a safe return to in-person learning, Portland Public Schools has contracted with Ameresco to test the airflow and ventilation of all educational and office spaces in each school. The data is reviewed by both Ameresco and PPS personnel to identify any potential shortcomings in the airflow from the HVAC systems. To accomplish this task, Ameresco has partnered with a local NEBB certified Test-Adjust-Balance (TAB) firm, Neudorfer Engineers, who will measure the airflow to each zone with calibrated measurement equipment in accordance with current testing standards and procedures. As part of this effort, HVAC professionals will review the operation of the HVAC equipment serving every educational and office space in each school.

Ameresco is pleased to have partnered with PPS over the last decade as the district's Energy Services Company (ESCO) on six energy efficiency construction projects, four service projects, and numerous energy audits. Our partnership has resulted in reducing over 3,000 tons of CO_2 and other GHG emissions and over $1,000,000 in utility cost savings per year. Ameresco appreciates this opportunity to play a small role in the safe reopening of schools.

About Ameresco, Inc.
Founded in 2000, Ameresco, Inc. (NYSE:AMRC) is a leading cleantech integrator and renewable energy asset developer, owner and operator. Our comprehensive portfolio includes energy efficiency, infrastructure upgrades, asset sustainability and renewable energy solutions delivered to clients throughout North America and the United Kingdom. Ameresco's sustainability services in support of clients' pursuit of Net Zero include upgrades to a facility's energy infrastructure and the development, construction, and operation of distributed energy resources. Ameresco has successfully completed energy saving, environmentally responsible projects with Federal, state and local governments, healthcare and educational institutions, housing authorities, and commercial and industrial customers. With its corporate headquarters in Framingham, MA, Ameresco has more than 1,000 employees providing local expertise in the United States, Canada, and the United Kingdom. For more information, visit www.ameresco.com.

Explanation of ASHRAE Total Effective Air Changes per Hour (ACH_e) Calculation

ASHRAE has been updating their Building Readiness document to reflect the most current understanding in the engineering community for how to operate and maintain buildings during the pandemic. Their update on 4/27/2021 provided an explanation of the impact air filters and air cleaning devices have on the air in buildings. They provided the methodology, formulas, and an Excel-based tool for determining the equivalent outside air a space is receiving by having a mix of outside air, filtered recirculated air, and additional air filtration or cleaning devices in the room. Here is the explanation from ASHRAE:



As part of the airflow testing project that Portland Public Schools has partnered with Ameresco to complete, we are including the calculation of the Total Effective Air Changes per Hour (ACH_e) to show the impact of the air filtration that is active in nearly all spaces in the PPS schools. The formula for doing so is:

$$\mathrm{ACH_e} = \left(ACH_{oa} + ACH_f\right) * E_Z + ACH_ir$$

where:

- $\mathrm{ACH_{oa}}$ = air changes per hour of outside air = outside airflow in cubic feet per minute * 60 minutes per hour / room volume in cubic feet
- $\mathrm{ACH_f}$ = air changes per hour of clean air from filtered recirculated air with filters of the specified MERV rating as determined by ASHRAE
- E_z = Zone Air Distribution Effectiveness = how effective the HVAC system is at circulating and mixing the air to distribute the clean air throughout the room
- ACH_ir = the air changes per hour of clean air from portable air filters in the room = number of filters * CADR * 60 minutes per hour / room volume in cubic feet
    - CADR = Clear Air Delivery Rate = the CFM of clean air as specified by the manufacturer of the air filter

In order to include these calculations in the airflow testing reports, Ameresco and PPS have made the following assumptions as not all the variables are known:

1. PPS is in process of upgrading the air filters in their HVAC systems to MERV 13 and plans to be complete with that project for the start of the ’21-’22 school year. In this report and for the sake of the ACH_e calculation, we are using the filters that are in place at the time of the measurements, so some of them are still MERV 8.
2. ASHRAE has guidelines for what should be used for the Zone Air Distribution Effectiveness (E_z) based on the HVAC system configuration, but they do not provide a value for every HVAC system and room configuration. For the majority of PPS rooms, an E_z of 0.8 – 1.0 would be most appropriate, so we have made the conservative assumption of using 0.8 for every space as that yields the lower ACH_e.
3. The CADR for a given air filter is from manufacturer ratings and is based on certain conditions (fan speed, particulate size, filter cleanliness, etc.) that change with operating conditions.

NEUDORFER ENGINEERS INC.

TEST REPORT TYPE:
SURVEY REPORT

Portland Public Schools Airflow Testing
Abernethy ES
2421 SE Orange Ave, Portland, OR 97214

Job Number: 2021-0297

Project Completion Date: **September 2021**
Revision Date: - **Revision Number:** -





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PORTLAND

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Portland Public Schools Airflow Testing
Abernethy ES

TABLE OF CONTENTS

Title Sheet	3
Report Certification	4
Terms	5
Instrument Calibration	6
Report Summary	7
Airflow Survey Report	8
TAB Notes	10
Floor Layout	11

REPORT TITLE

CERTIFIED TEST: SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Abernethy ES

NEI Job#: 2021-0297

Mechanical Engineer: NA

Architect: NA

HVAC Contractor: NA

TAB Firm: Neudorfer Engineers Inc
Test Engineer: Zach Mayer





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CERTIFICATION

Portland Public Schools Airflow Testing

The data presented in this report is a record of system measurements and final adjustments that have been obtained in accordance with the current edition of the NEBB Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems. Any variances from design quantities, which exceed NEBB tolerances, are noted in the Test-Adjust-Balance Report Project Summary.

Significant / Noteworthy Remarks are noted on the General Remarks and General Field Notes pages. Other remarks are noted on individual test sheets.

Noted deficiencies are not the TAB firms responsibility to repair. Prior to issuance of this report, Deficiency Reports are forwarded to our contracted agent.

Warranty is limited to one year from date of this report. Within that time, any discrepancies, ambiguities, or omissions found in this report will be retested, adjusted, or balanced as needed. A written notification will be required.

Submitted and Certified by:

NEBB TAB Firm:	**Neudorfer Engineers Inc**
Certification No:	**3414**
Expiration Date:	**March 31, 2023**
Certification Date:	**March 31, 2021**
(Date completed)	*Signed and Sealed by:*
NEBB Supervisor:	**Mike Vawter P.E.**
NEBB Supervisor:	**Eric Stotts**





TERMS AND ABBREVIATIONS

Project: **Portland Public Schools Airflow Testing**

AC or ACU	Air Conditioner or Air Conditioning Unit
AH or AHU	Air Handler or Air Handling Unit
AVG	Average
BHP	Brake Horsepower
CAV	Constant Air Volume
CBV	Calbirated Balancing Valve (Circuit Setter)
CC	Cooling Coil
CD	Ceiling Diffuser
CFM	Cubic Feet per Minute
CH	Chiller
CHWS	Chilled Water Supply
CHWR	Chilled Water Return
CP	Circulating Pump
CR	Ceiling Register
CRAC	Computer Room Air Conditioner
CRU	Computer Room Unit
CT	Cooling Tower
CU	Condenser Unit
CUH	Cabinet Unit Heater
CWS	Condenser Water Supply
CWR	Condenser Water Return
DAT	Discharge Air Temperature
DB	Dyr Bulb
DD	Direct Drive
DDC	Direct Digital Controls: EMS Control System for the HVAC
Des.	Design
Dia.	Diameter
Disch.	Discharge
EA	Exhaust Air
EAT	Entering Air Temperature
Economizer	Controls and components that allow an air handler to logically utilize outdoor air for cooling as opposed to the use of mechanical cooling.
EF	Exhaust Fan
EG	Exhaust Grille
EMCS	Energy Management Control System
ERU	Energy Recovery Unit
E.S.P.	External Static Pressure
HRC	Heat Recovery Coil
EWT	Entering Water Temperature
FCU	Fan Coil Unit
FD	Fire Damper
FLA	Full Load Amperage: Maximum amperage a motor can draw.
Flow Hood	Instrument that captures air and converts the reading to CFM.
FHT	Fume Hood Test
FPB	Fan Powered Box
FPM	Feet per Minute
FR	Field Report
FT	Foot, Feet
FTU	Fan Terminal Unit
GPM	Gallons per Minute
HC	Heating Coil
TDH	Pressure Difference across the entering and leaving side of a pump.
HEPA	High Efficiency Particulate Arrestance
HP	Horsepower
HVAC	Heating Ventilation and Air Conditioning
HWS	Heating Water Supply
HWR	Heating Water Return
HX	Heat Exchanger
HZ	Hertz, cycle per second
in.	inches
in.w.g.	inches of water gauge
Kfactor	Correction factor to the free area need to calculate CFM.
KW	Kilowatts
LAT	Leaving Air Temperature
LWG	Low Wall Grille
LWR	Low Wall Register
LWT	Leaving Water Temperature
MAU	Make-up Air Hangling Unit
MBH	1,000 BTUH
N/A	Not Applicable
OSA	Outside Air
OBD	Opposed Blade Damper
∆P	Pressure Drop.
PH	Phase
PSI	Pounds per Square Inch
RA	Return Air
RAD	Radiator
RAT	Return Air Temperature
RF	Return Fan
RH	Relative Humidity
RHC	Reheat Coil
RPM	Revolutions per Minute
RTU	Roof Top Unit
SA	Supply Air
SAT	Supply Air Temerature
S.F.	Service Factor
SF	Supply Fan
SFD	Smoke/Fire Damper
SP	Static Pressure
sq.ft.	square feet
Suct.	Suction
SWG	Sidewall Grille
SWR	Sidewall Register
TAB	Test; Adjust; and Balance
TSP	Total Static Pressure: Difference between the entering and leaving static pressure of a fan.
UH	Unit Heater
VAV	Variable Air Volume; box that contains a motorized damper that modulates airflow.
VD	Volume Damper
VFD	Variable Frequency Drive
Velgrid	Instrument that reads used to read velocity in feet per minute.
VVT	Variable Volume Terminal
WC	Water Column
W.G.	Water Gauge
WB	Wet Bulb

INSTRUMENT CALIBRATIONS

Portland Public Schools Airflow Testing

Instrument Type	Air Data Meter with Flowhood	Instrument Serial #	**M00475**
Instrument Manufacturer	**Shortridge**	Calibration Date	**11/4/2020**
Instrument Model Number	**ADM 870**	Calibration Due	**11/4/2021**

Instrument Type	Differential Pressure Water Meter	Instrument Serial #	**W14090**
Instrument Manufacturer	**Shortridge**	Calibration Date	**10/16/2020**
Instrument Model Number	**HDM-250**	Calibration Due	**10/16/2021**

Instrument Type	Psychrometer	Instrument Serial #	**8084305**
Instrument Manufacturer	**Extech**	Calibration Date	**10/13/2020**
Instrument Model Number	**RH390**	Calibration Due	**10/13/2021**

Instrument Type	Tachometer	Instrument Serial #	**B185B5022P**
Instrument Manufacturer	**Nidec**	Calibration Date	**10/11/2020**
Instrument Model Number	**MT-200**	Calibration Due	**10/11/2021**

Instrument Type	Amp Probe	Instrument Serial #	**33380179WS**
Instrument Manufacturer	**Fluke**	Calibration Date	**10/9/2020**
Instrument Model Number	**323 Clamp Meter**	Calibration Due	**10/9/2021**

Instrument Type	Digital Thermometer	Instrument Serial #	**45400509WS**
Instrument Manufacturer	**Fluke**	Calibration Date	**10/9/2020**
Instrument Model Number	**52 II**	Calibration Due	**10/9/2021**

Instrument Type	Manometer	Instrument Serial #	**M00475**
Instrument Manufacturer	**Shortridge**	Calibration Date	**11/4/2020**
Instrument Model Number	**ADM 870**	Calibration Due	**11/4/2021**

Instrument Type	Thermal Anemometer	Instrument Serial #	**AVM440742003**
Instrument Manufacturer	**Alnor Instruments**	Calibration Date	**11/9/2020**
Instrument Model Number	**AVM 440**	Calibration Due	**11/9/2021**

Instrument Type	Ultrasonic Flow Meter	Instrument Serial #	**N5K1435T**
Instrument Manufacturer	**Fuji**	Calibration Date	**10/14/2020**
Instrument Model Number	**Portaflow-C**	Calibration Due	**10/14/2021**

PROJECT Portland Public Schools Airflow Testing
LOCATION Abernethy ES; 2421 SE Orange Ave, Portland, OR 97214

REPORT SUMMARY

This project has been surveyed per plans and specifications using the National Environmental Balancing Bureau (NEBB) standards and procedures.

The scope of work for this project was to assess the current airflows for each classroom, office, and special purpose space. Air changes per hour were calculated along with the % of OSA for the spaces and any deficiencies found for each piece of equipment has been noted in the following report.

All ventilation equipment was commanded to run by the BMS system. Ventilation units were measured with a flowhood on the supply outlets. Outside air was recorded with a flowhood on the OSA louvre where accessible. AK factors were calculated from flowhood readings. The remaining OSA values were recorded with a velgrid. AHU supply air was recorded by a summation of the outlets as recorded by flowhood or velgrid when appropriate. Outside air was recorded with a velgrid or airfoil and calculated by the free area method.

The measured airflows in this report represent the performance of the equipment at the time of measurement, which vary over time based on operating conditions. There are factors outside the control of Neudorfer that impact airflow, and variance in those factors is expected and normal. One significant factor is the MERV rating and condition of the air filters on the equipment. During the summer of 2021, PPS began upgrading the filters on all their fan systems to MERV 13. Those upgraded filters are more effective at capturing particles but also impact the amount of airflow from the equipment. These filter changes were occurring while the airflow measurement project was happening, so some schools had the new filters, and some had the old filters at the time of measurement. On the data page included this report, there is a line stating whether or not the upgraded filters were in place at the time of measurement.

Neudorfer Engineers. Inc.
Consulting Engineers Seattle Portland
www.NeudorferEngineers.com

AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Abernethy ES; 2421 SE Orange Ave, Portland, OR 97214
Filter Status: Upgraded

Room Floor Plan # (Actual #)	Equipment Info		Room Dimensions					Airflow Measurements			Calculated ACH					Notes
	Served By	Equipment Type	Room Length	Room Width	Room Area	Room Height	Room Volume	Total CFM Supply	OA CFM Supply	OA %	Air Changes per Hour (supply)	Air Changes per Hour (OA)	# of Portable Filters	Total Effective Air Changes per Hour (ACH_e) with Portable Filter	Total Effective Air Changes per Hour (ACH_e) without Portable Filter	
First Floor																
Rm 1	UV	UV	30.3	21.4	648	10	6,475	955	130	14%	8.8	1.2	1	8.9	6.5	
Rm 1A	UV	UV	37.4	30.5	1,141	11.9	13,574	505	50	10%	2.2	0.2	1	2.8	1.6	
Rm 2	UV	UV	49.2	21.5	1,058	12	12,694	885	135	15%	4.2	0.6	1	4.3	3.1	
Rm 2A	UV	UV	29.2	30.5	891	11.9	10,598	460	175	38%	2.6	1.0	1	3.4	2.0	Clogged OSA Louver.
Rm 3	UV	UV	29.7	21.4	636	10	6,356	905	45	5%	8.5	0.4	1	8.6	6.2	
Rm 3A	UV	UV	31.1	29.2	908	10.8	9,808	1,250	250	20%	7.6	1.5	1	7.2	5.6	Sloped roof, measured from the middle.
Rm 4	UV	UV	31.9	21.4	683	12	8,192	875	225	26%	6.4	1.6	1	6.6	4.7	
Rm 4A	UV	UV	31.2	29.2	911	10.8	6,910	880	135	15%	7.6	1.2	1	7.8	5.6	Sloped roof, measured from the middle.
Rm 5	UV	UV	29.9	21.4	640	12	8,699	935	0	0%	6.4	0.0	1	6.4	4.6	OSA damper may be closed.
Rm 6	UV	UV	33.1	21.9	725	12	8,699	820	300	37%	5.7	2.1	1	6.0	4.2	
Rm 7	UV	UV	29.8	22.4	668	12	8,010	705	200	28%	5.3	1.5	1	5.9	3.9	
Rm 8	UV	UV	29.7	21.8	647	12	7,770	920	305	33%	7.1	2.4	1	7.3	5.3	
Rm 9	UV	UV	40.6	21.0	853	12	10,231	905	210	23%	5.3	1.2	1	5.4	3.9	
Office 5A	-	-	-	-	119	11.8	1,403	-	-	-	0.0	0.0	1	11.1	0.0	**Note #1**. Ventilation is supplied from the hall.
Office 5A-1	-	-	8.7	4.9	43	8.8	375	-	-	-	0.0	0.0	1	41.6	0.0	Entry to counselors office, shared with hall.
Office 6A	-	-	16.9	23.0	389	12	4,664	-	-	-	0.0	0.0	1	3.3	0.0	Ventilation supplied from adjacent space.
Office 6B	-	-	14.0	14.4	202	12	2,419	-	-	-	0.0	0.0	1	6.4	0.0	Ventilation supplied from adjacent space.
Office 9A	-	-	10.5	8.2	86	10.5	904	-	-	-	0.0	0.0	1	17.3	0.0	Ventilation supplied from adjacent space.
Gym 2	-	-	17.9	12.1	217	12.3	2,664	-	-	-	0.0	0.0	0	N/A	0.0	Storage, ventilation supplied from adjacent space.
Auditorium	AHU-1	AHU	64.8	39.6	2,566	23.2	59,533	5,295	4,924	93%	4.8	4.4	1	4.0	3.8	**Note #2**. 13.146 sq ft area used with velgrid.
Balcony 16C	AHU-1	AHU	38.4	15.6	599	11.9	7,129	-	-	-						**Note #2**. Ventilation supplied by adjacent space.
Stage	-	-	25.5	16.1	411	26.1	10,715	-	-	-	0.0	0.0	1	1.5	0.0	Ventilation supplied from adjacent space.
Cafeteria	AHU-1	AHU	60.0	39.9	2,394	21.53	51,543	1,475	1,372	93%	1.7	1.6	1	1.7	1.4	**Note #2**
Gym	AHU-1	AHU	60.0	39.8	2,388	21.63	51,652	1,375	1,279	93%	1.6	1.5	1	1.6	1.3	**Note #2**

Date: 5/29/2021 Readings By: Zach Mayer, Justin Davis

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AIRFLOW SURVEY REPORT

Project: Portland Public Schools Airflow Testing
Location: Abernethy ES; 2421 SE Orange Ave, Portland, OR 97214
Filter Status: Upgraded

Room Floor Plan # (Actual #)	Equipment Info		Room Dimensions					Airflow Measurements			Calculated ACH					Notes
	Served By	Equipment Type	Room Length	Room Width	Room Area	Room Height	Room Volume	Total CFM Supply	OA CFM Supply	OA %	Air Changes per Hour (supply)	Air Changes per Hour (OA)	# of Portable Filters	Total Effective Air Changes per Hour (ACH_e) with Portable Filter	Total Effective Air Changes per Hour (ACH_e) without Portable Filter	
First Floor																
Gym 3	-	-	7.4	10.4	77	10.5	808	-	-	-	0.0	0.0	0	N/A	0.0	This is a shower.
Gym 4	-	-	-	-	-	-	-	-	-	-	0.0	0.0	0	N/A	0.0	No access. This is a small closet with no air supply.
5C	-	-	22.8	22.5	513	12.2	6,259	-	-	-	0.0	0.0	0	N/A	0.0	Kitchen ventilation supplied from adjacent space
5D	-	-	6.4	6.9	44	8	353	-	-	-	0.0	0.0	0	N/A	0.0	Kitchen walk-in cooler.
5G	-	-	8.2	10.8	89	10	886	-	-	-	0.0	0.0	0	N/A	0.0	This is a restroom.
Second Floor																
Rm 10	UV	UV	29.9	21.4	640	11.8	7,550	462	30	6%	3.7	0.2	1	4.7	2.7	
Rm 11	UV	UV	29.8	21.4	638	11.8	7,525	880	135	15%	7.0	1.1	1	7.2	5.1	
Rm 12	UV	UV	30.1	21.4	644	11.8	7,601	765	240	31%	6.0	1.9	1	6.5	4.5	
Rm 13	UV	UV	29.9	21.4	640	11.8	7,550	915	275	30%	7.3	2.2	1	7.5	5.4	
Rm 14	UV	UV	30.0	21.0	630	11.8	7,434	765	250	33%	6.2	2.0	1	6.7	4.6	
Rm 15	UV	UV	29.8	21.7	647	11.8	7,631	895	445	50%	7.0	3.5	1	7.4	5.3	
Rm 16	UV	UV	29.8	21.8	650	11.8	7,666	755	80	11%	5.9	0.6	1	6.3	4.3	
Rm 17	UV	UV	29.9	21.5	643	11.8	7,586	840	235	28%	6.6	1.9	1	7.0	4.9	
Rm 18	UV	UV	29.8	21.4	638	11.8	7,525	865	200	23%	6.9	1.6	1	7.2	5.1	
Rm 19	UV	UV	29.9	21.3	637	11.8	7,515	685	145	21%	5.5	1.2	1	6.1	4.0	
Library	-	-	77.3	15.1	1,167	10.5	12,256	-	-	-	0.0	0.0	1	1.3	0.0	Ventilation supplied by adjacent spaces.
13A	-	-	24.1	13.9	335	11.6	3,886	-	-	-	0.0	0.0	1	4.0	0.0	Ventilation supplied by adjacent spaces.

Date: 5/29/2021 Readings By: Zach Mayer, Justin Davis

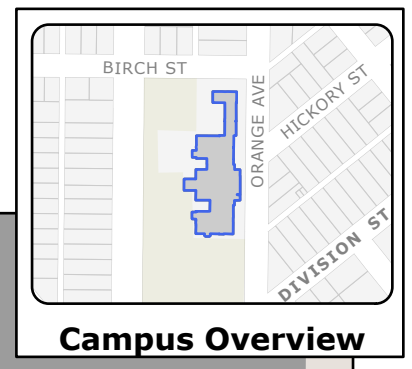
Project: Portland Public Schools Airflow Testing
Location: Abernethy ES; 2421 SE Orange Ave, Portland, OR 97214

NOTE #	NOTE DESCRIPTION
1	Counselor office, room 5A, is not square. Sq ft = 118.89 and 11.9 ft ceilings.
2	AHU-1 7,612cfm OSA.

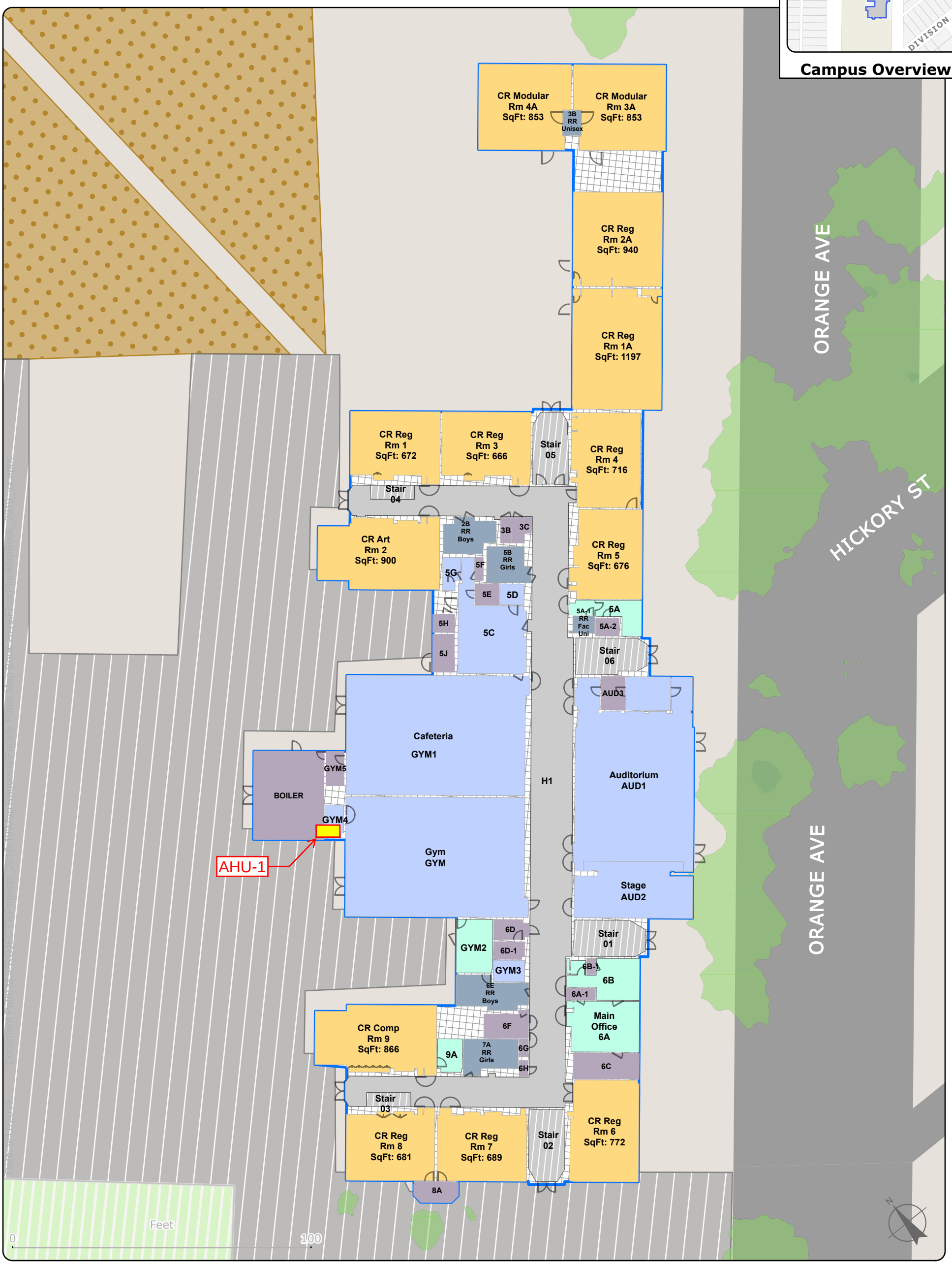
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ABERNETHY: First Floor



Campus Overview



Space Use

- Classroom
- Office
- Rest Room
- Special Purpose
- Corridor
- Other
- Stairs/Elevator

School Grounds

- Campus Footprints
- Athletic Field
- Playground: Paved
- Playground: Unpaved
- Streets
- Doors

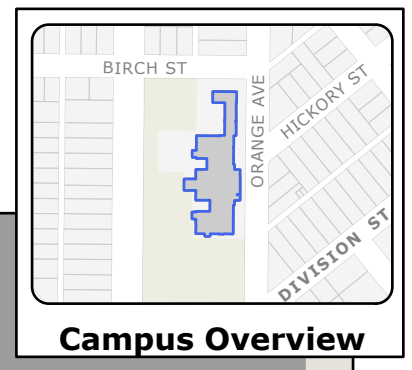
Total Number Of Rooms By Classification

Classrooms: 13	Special Purpose: 10
Office Spaces: 5	Storage: 16

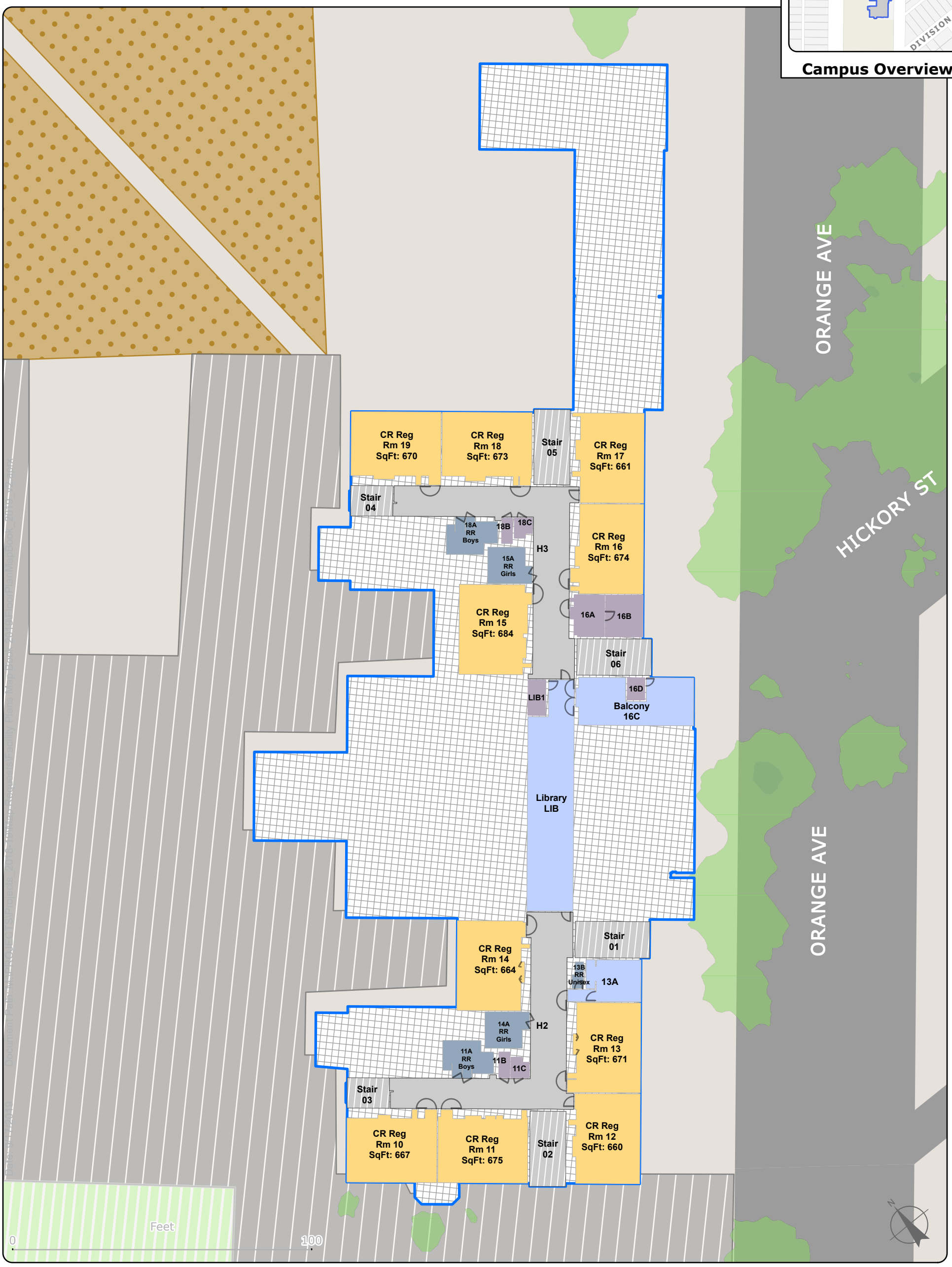
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ABERNETHY: Second Floor



Campus Overview



Space Use

- Classroom
- Office
- Rest Room
- Special Purpose
- Corridor
- Other
- Stairs/Elevator

School Grounds

- Campus Footprints
- Athletic Field
- Playground: Paved
- Playground: Unpaved
- Streets
- Doors

Total Number Of Rooms By Classification

Classrooms: 10	Special Purpose: 3
Office Spaces: 0	Storage: 7