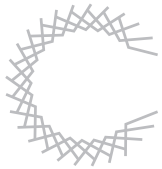
PASSIVE HOUSE CASE STUDIES:

RESIDENTIAL, COMMERCIAL, AND MANUFACTURING BUILDINGS IN DULUTH

Carly Coulson, AIA, LEED AP, CPHC

COULSON
ARCHITECTURE



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COMMON PASSIVE HOUSE FEATURES:

90% REDUCTION IN SPACE HEATING DEMAND

80-90% REDUCTION IN PRIMARY ENERGY DEMAND (w/o PV)

IDEAL INTERIOR COMFORT, NO DRAFTS, NO TEMPERATURE SWINGS

CONTINUOUS AIR-TIGHT SYSTEM

CONTINUOUS VENTILATION

ELIMINATION OF TRADITIONAL HEATING & COOLING SYSTEMS

NO REQUIREMENT FOR HIGH-TECH OR UNCOMMON MATERIALS

THESE CASE STUDIES WILL SHOW DESIGN DETAILS ARE FLEXIBLE EVEN IN THIS COLD CLIMATE:

LOW COST AND VERY SMALL BUILDINGS ARE POSSIBLE

LARGER, MULTI-FAMILY BUILDINGS DON'T HAVE TO BE COMPACT IN FORM

VARIETY OF CONSTRUCTION MATERIALS AND DETAILS CAN BE USED

BUILDINGS WITH LARGE EQUIPMENT INTERNAL HEAT GAINS CAN BE UTILIZED IN WINTER AND CONTROLLED IN SUMMER

Specific Space Heat Demand

3.6 **kBTU/(ft²yr)**

Pressurization Test Result

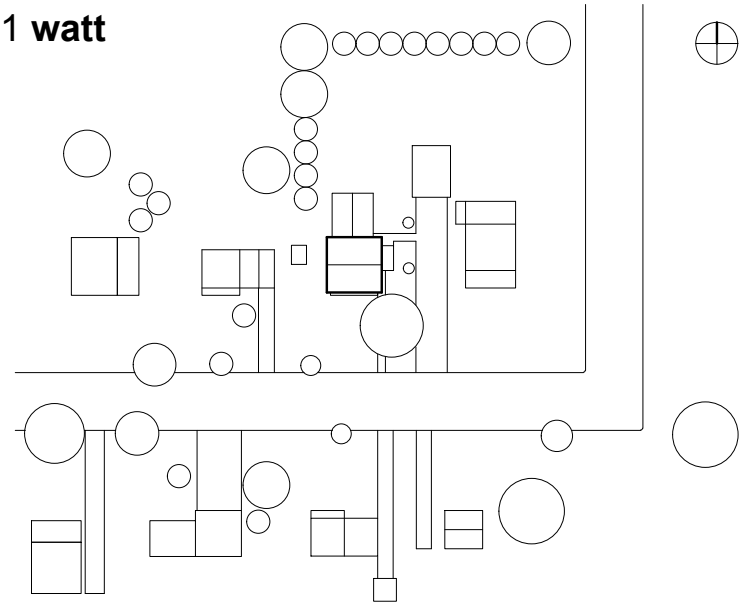
0.5 **ACH50**

Specific Primary Energy Demand (w/o PV)

33 **kBTU/(ft²yr)**

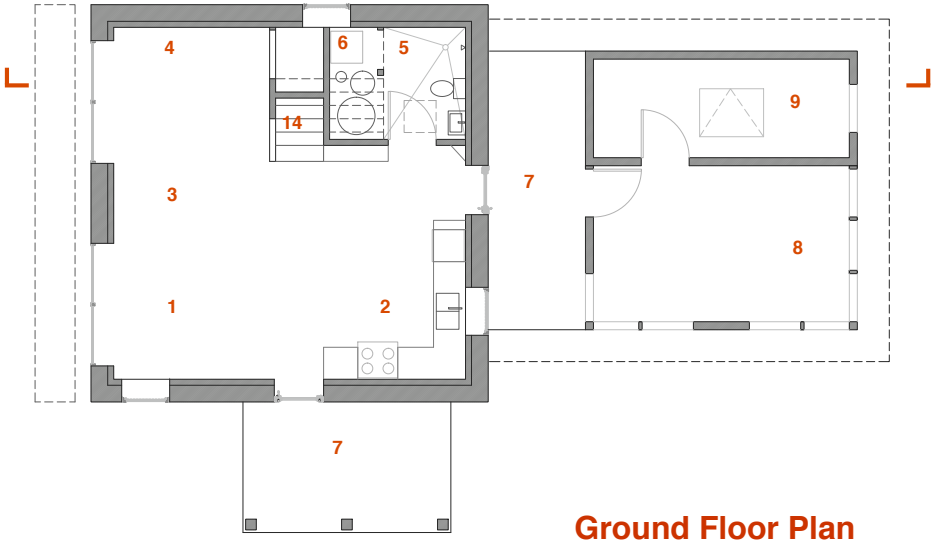
Peak Heating Load

1341 **watt**



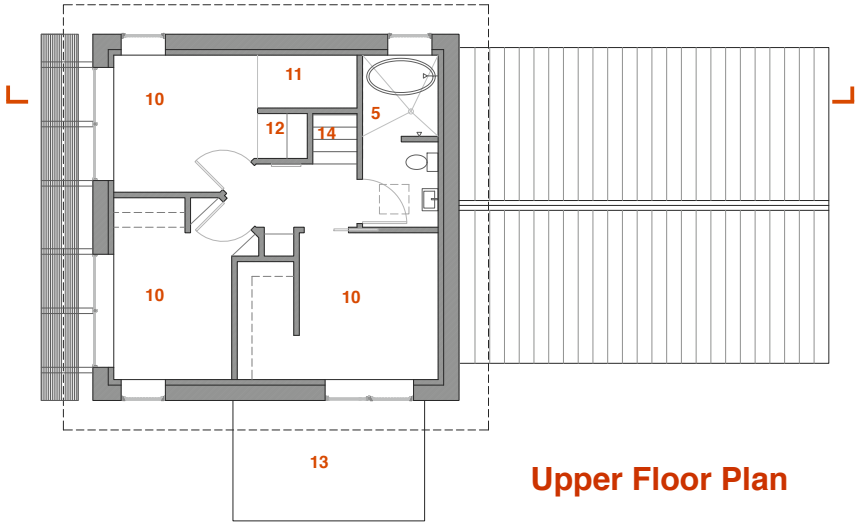
CASE STUDY 1: NEWENHOUSE

Single-family Home, New Construction



Ground Floor Plan

N



Upper Floor Plan

Project Features:

-affordable construction cost

-kit design, easy to execute

-designed for deconstruction

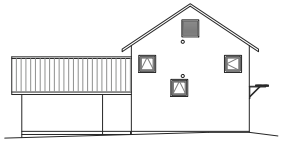
-very compact form

-no basement or attic

1 Dining room
2 Kitchen
3 Living room
4 Study
5 Bathroom
6 Laundry
7 Detached entry deck
8 Screen porch (unconditioned)
9 Storage room (unconditioned)
10 Bedroom
11 Sleeping loft
12 HRV
13 Vegetative roof
14 Stair
15 Root cellar (unconditioned)
16 Attic (unconditioned)
17 Photovoltaic panels
18 Solar hot water panels

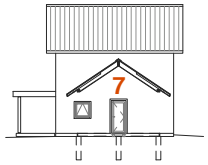
CASE STUDY 1 : NEWENHOUSE

East Elevation

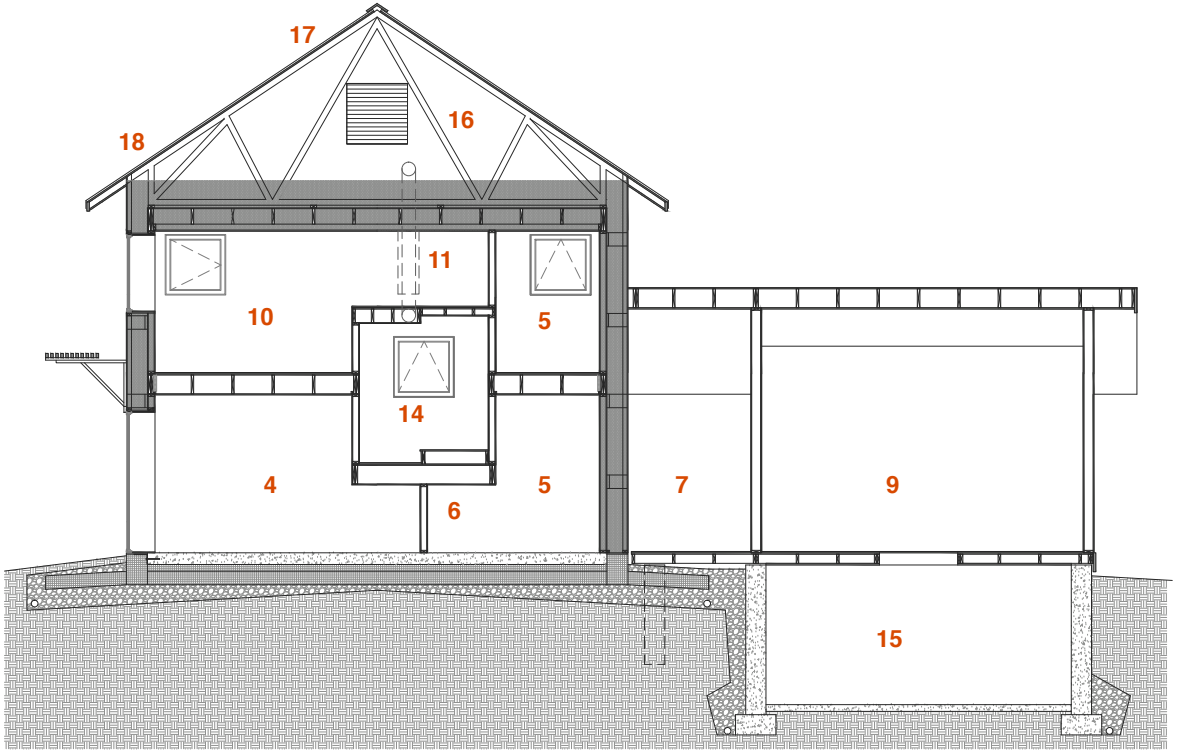


West Elevation

South Elevation



North Elevation



Building Section

1 Dining room
2 Kitchen
3 Living room
4 Study
5 Bathroom
6 Laundry
7 Detached entry deck
8 Screen porch (unconditioned)
9 Storage room (unconditioned)
10 Bedroom
11 Sleeping loft
12 HRV
13 Vegetative roof
14 Stair
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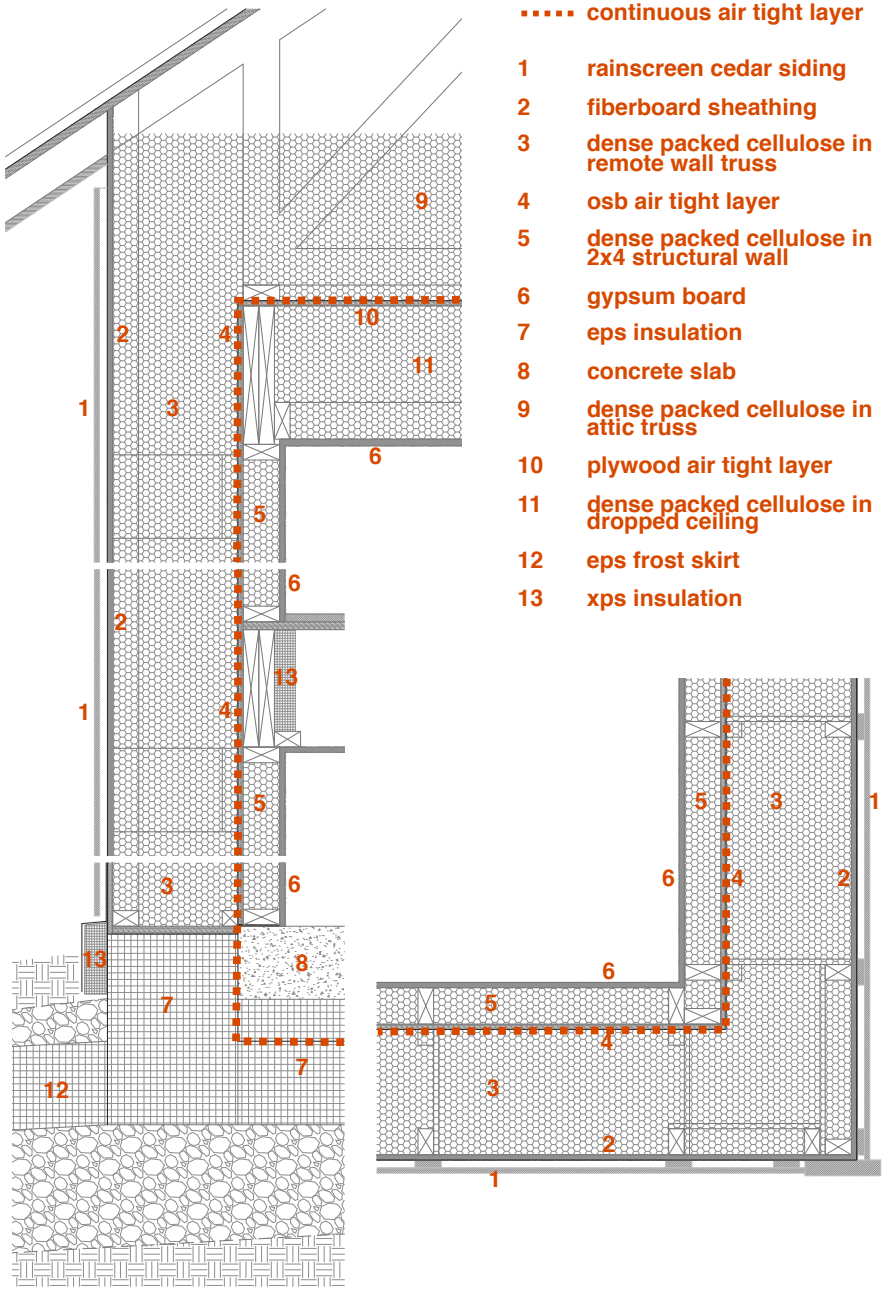
Thermal & Air-Tight Details



	continuous air tight layer	
1	rainscreen cedar siding	
2	fiberboard sheathing	13mm
3	dense packed cellulose in remote wall truss	305mm
4	osb air tight layer	13mm
5	dense packed cellulose in 2x4 structural wall	89mm
6	gypsum board	13mm
7	eps insulation	305mm
8	concrete slab	178mm
9	dense packed cellulose in attic truss	406mm
10	plywood air tight layer	13mm
11	dense packed cellulose in dropped ceiling	324mm
12	eps frost skirt	
13	xps insulation	

Continuous Air-Tight System

No Thermal Bridges

Traditional platform framed 2x4 wa

Modified Larsen Truss Design

Structural slab-on-grade

Roof R-value
94 **hr.ft².F/BTU**

Wall R-value
63 **hr.ft².F/BTU**

Slab R-value

57 **hr.ft².F/BTU**

CASE STUDY 1 : NEWENHOUSE

Thermal & Air-Tight Details

12” EPS foam under and around 9” thick cast-in-place concrete slab

Thermal & Air-Tight Details

Plywood roof air-tight layer, OSB wall air-tight layer, seams taped

Thermal & Air-Tight Details

Modified Larsen Truss installed over OSB air-tight layer

Structural window boxes installed

Thermal & Air-Tight Details

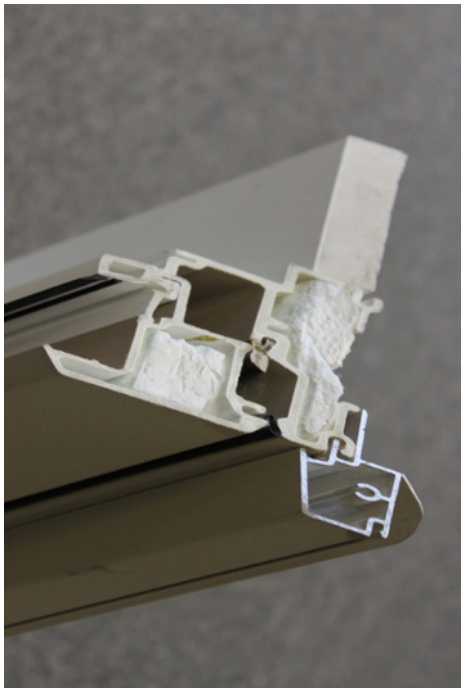
Dense-packed cellulose in all wall and roof cavities

Glazing Details

Door Frame U-value
0.16 BTU/hr.ft².F

Door Glass U-value
0.09 BTU/hr.ft².F

Door Glass SHGC
50%



Window Frame U-value
0.22 **BTU/hr.ft².F**

Window Glass U-value
0.13 **BTU/hr.ft².F**

Window Glass SHGC
56%

Passive House Certified wood with aluminum cladding door frames

Low-profile fiberglass window frames with core insulation

Triple-pane glass with high SHGC for passive solar in winter

Over-insulated window frame on interior with polyiso insulation

No drafts or need for heating source at windows and doors

Super air-tight door construction

HVAC Systems

Peak Heating Load
1341 watt

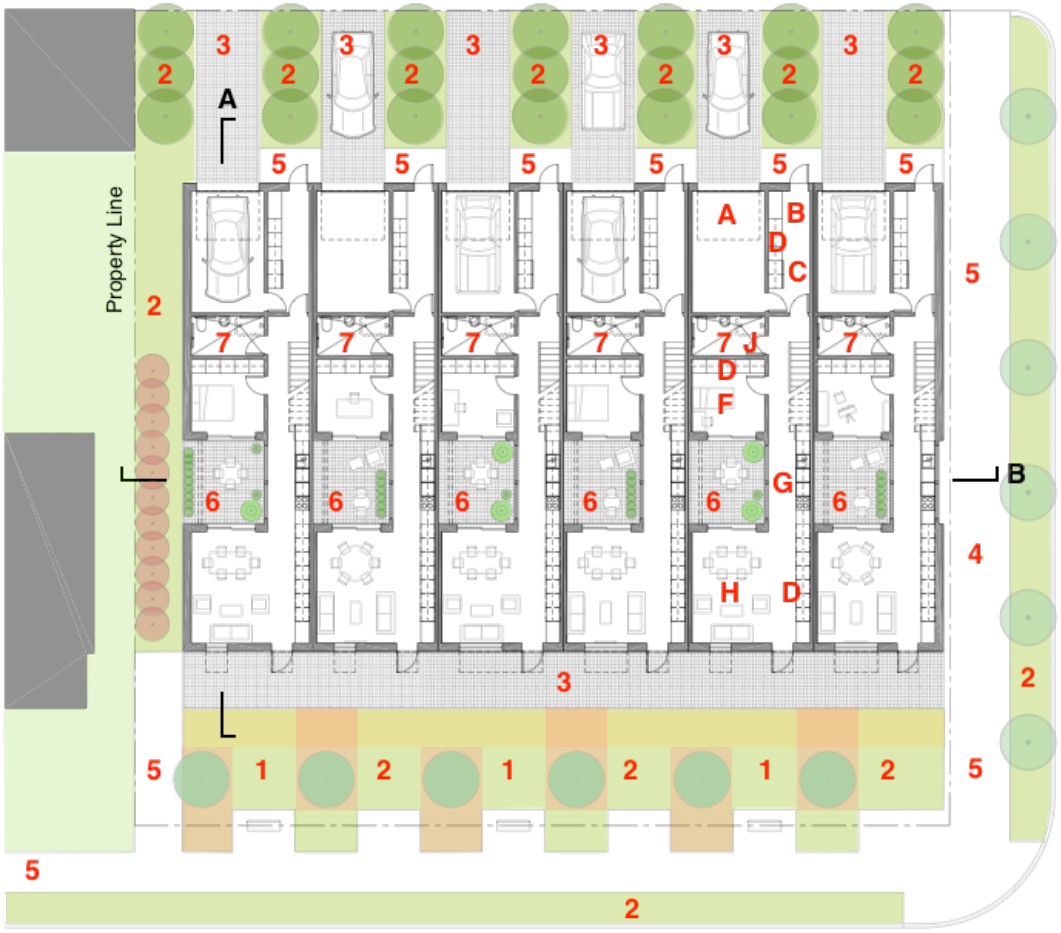
Low cost electric radiant panels in bathrooms and hallway provide heat

92% efficient HRV with internal defroster and summer by-pass mode

Active Solar Systems

3300 kWh/yr grid-connected, photovoltaic system, net zero site energy

284 liter solar hot water system with electric back-up



Specific Space Heat Demand

3.5 kBTU/(ft²yr)

Pressurization Test

0.6 ACH50

Peak Heating Load

5.4 BTU/sf/hr

Peak Cooling Load

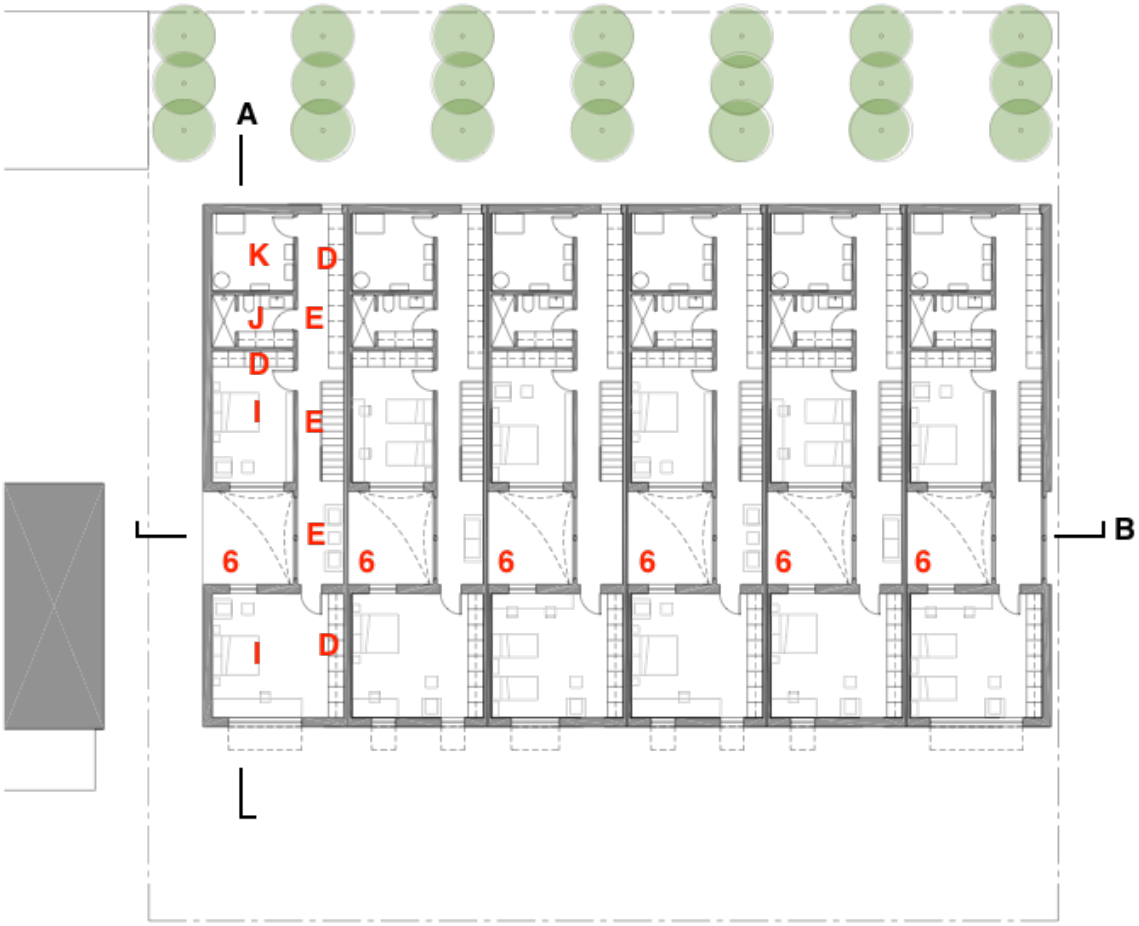
2.8 BTU/sf/hr

A	Single-car garage (bicycle storage)	G	Kitchen
B	Vestibule with walk-off mat	H	Open Dining/Living Room.
C	Built-in Washer Dryer	I	Bedroom
D	Built-in Storage Cabinets	J	Bathroom
E	Gallery Space	K	Mechanical Room
F	Flex Space. Office, Bedroom, Workshop, Playroom.		

1. **Public Art & Community Green Space**
2. **Vegetated Areas**
3. **Permeable Paver Hardscape Area**
4. **Setback Variance required at Sheridan Ave**
5. **Concrete sidewalk.**
6. **Private Courtyards increase access to passive heating, natural light, natural ventilation, and exterior views**

CASE STUDY 2 : BEARDEN PLACE

Multi-family Townhomes, New Construction



A Single-car garage (bicycle storage)
B Vestibule with walk-off mat
C Built-in Washer Dryer
D Built-in Storage Cabinets
E Gallery Space
F Flex Space. Office, Bedroom, Workshop, Playroom.
G Kitchen
H Open Dining/Living Room.
I Bedroom
J Bathroom
K Mechanical Room

Project Features:

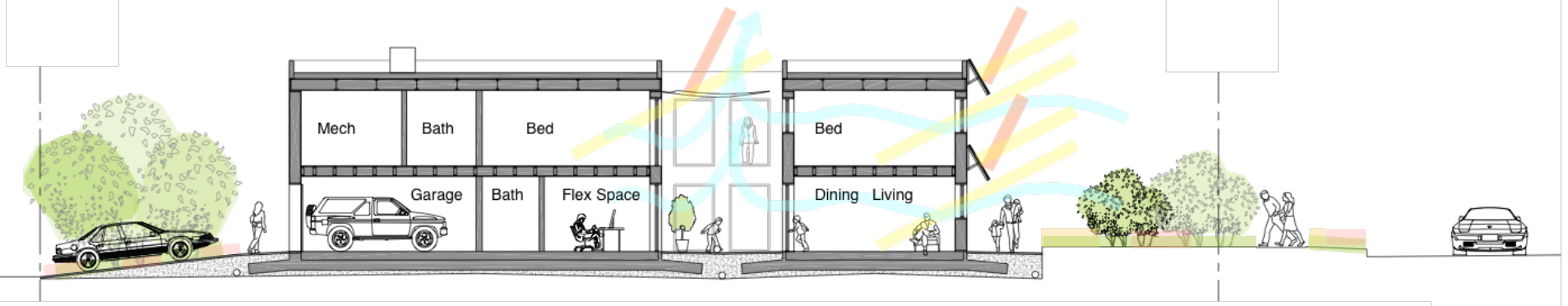
-passive solar and natural lighting to inner townhomes via courtyards

-secure and private courtyard green space

-larger building mass has less heat loss, thus, allows for courtyard cutouts without increasing insulation levels

CASE STUDY 2 : BEARDEN PLACE

Thermal & Air-Tight Details



Section A Looking East 1/8" = 1'-0"

10" structural slab-on-grade with 12" structural EPS foam underneath and around perimeter

14" SIP roof with 5" tapered foam insulation above.

14" SIP exterior walls

Windows and chimney effect of courtyard provides passive cooling

Photovoltaic awnings provide summer shade

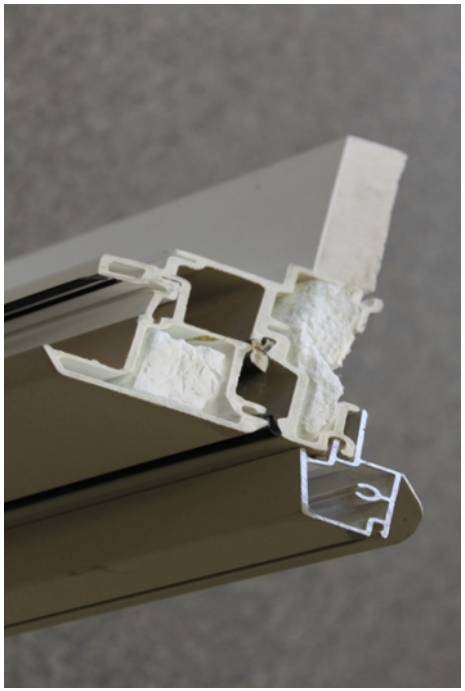
Roof R-value
78 **hr.ft^2.F/BTU**

Wall R-value
52 **hr.ft^2.F/BTU**

Slab R-value

48 **hr.ft^2.F/BTU**

Glazing Details



Window & Door Frame U-value
0.22 BTU/hr.ft^2.F

Window & Door Glass U-value
0.13 BTU/hr.ft^2.F

Window & Door Glass SHGC
56%

Low-profile fiberglass window and door frames with core insulation

Triple-pane glass with high SHGC for passive solar in winter

Over-insulated window frame on interior with polyiso insulation

No drafts or need for heating source at windows and doors

Super air-tight door construction

HVAC System

Peak Heating Load

5.4 BTU/sf/hr

Peak Cooling Load

2.8 BTU/sf/hr

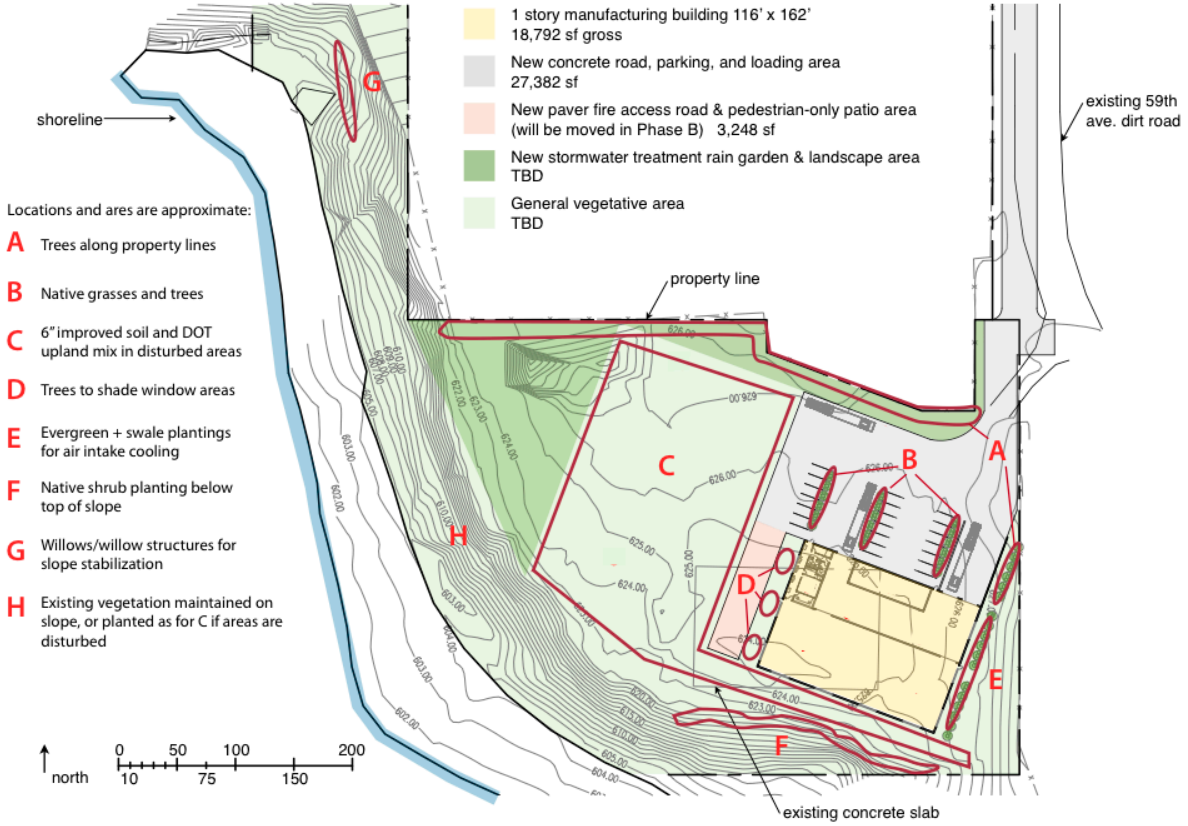
Small HRV in each townhome provides continuous ventilation with electric post-heater to provide all space heating. HRV is 92% efficient, passive house certified, with internal defrost, and summer by-pass mode.

No other heating system.

Cooling provided by one ductless mini-split unit

Active Solar Systems

3000 kWh/yr photovoltaic panel system per townhome to be Net Zero Source Energy. Mounted as awnings over windows and doors on south street elevation, integrated into the playful design aesthetic.



Specific Space Heat Demand

3.3 **kBTU/(ft²yr)**

Pressurization Test Result

0.6 **ACH50**

Peak Heating Load

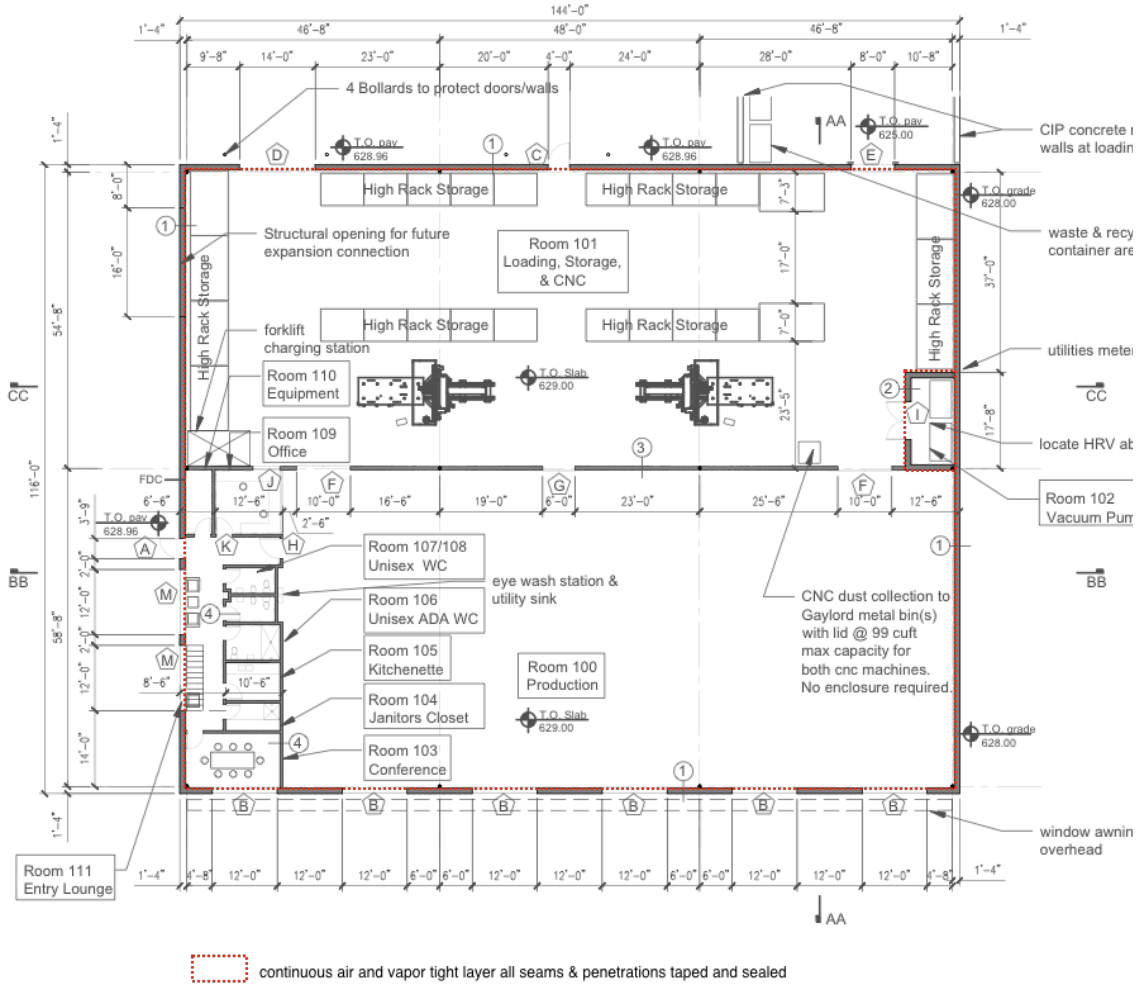
6.6 **BTU/sf/hr** 116,000 **BTU/hr**

Peak Cooling Load

3.6 **BTU/sf/hr** 62,800 **BTU/hr**

CASE STUDY 3 : STRYKER BAY FACTORY

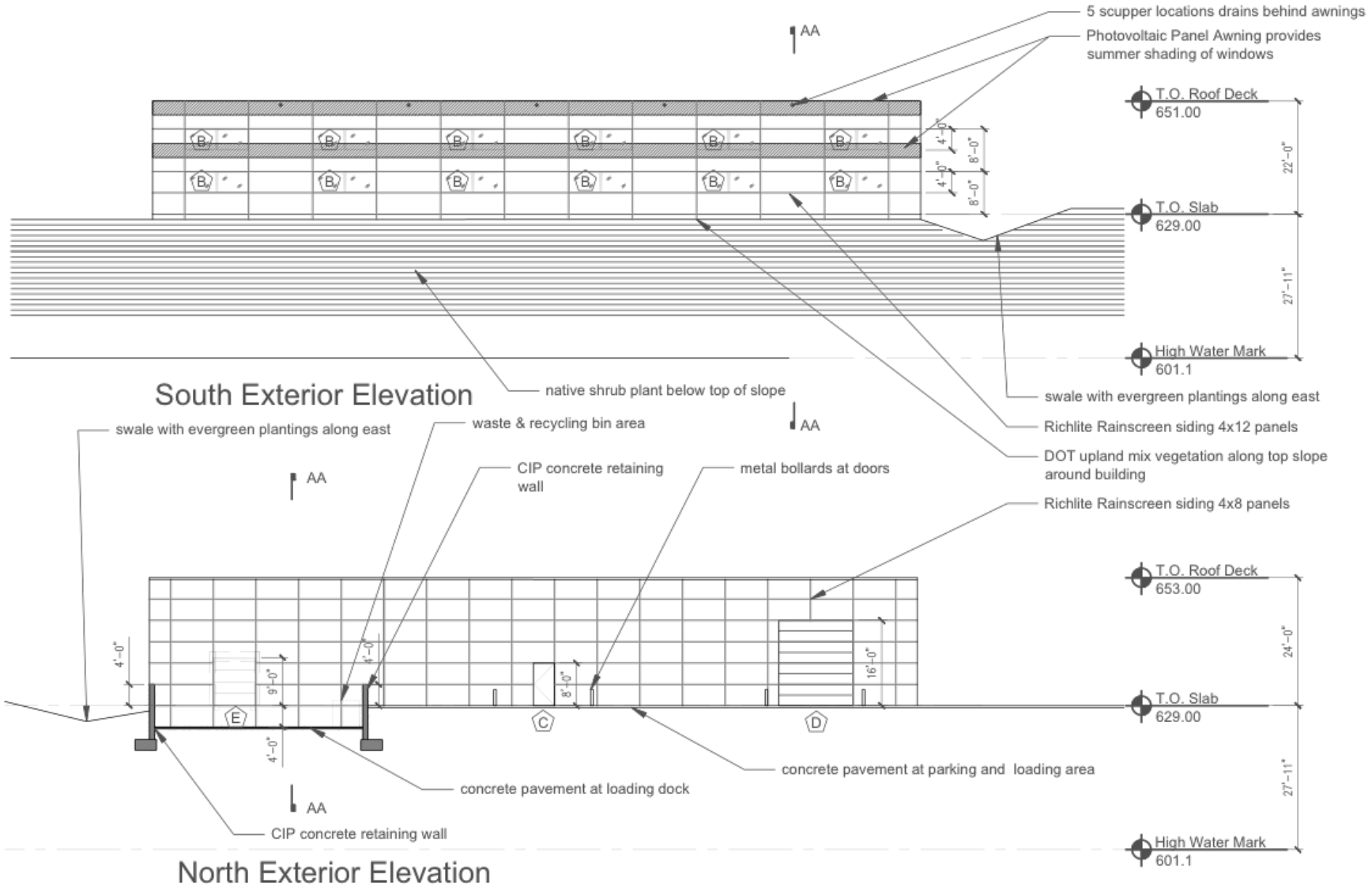
Manufacturing Facility, New Construction



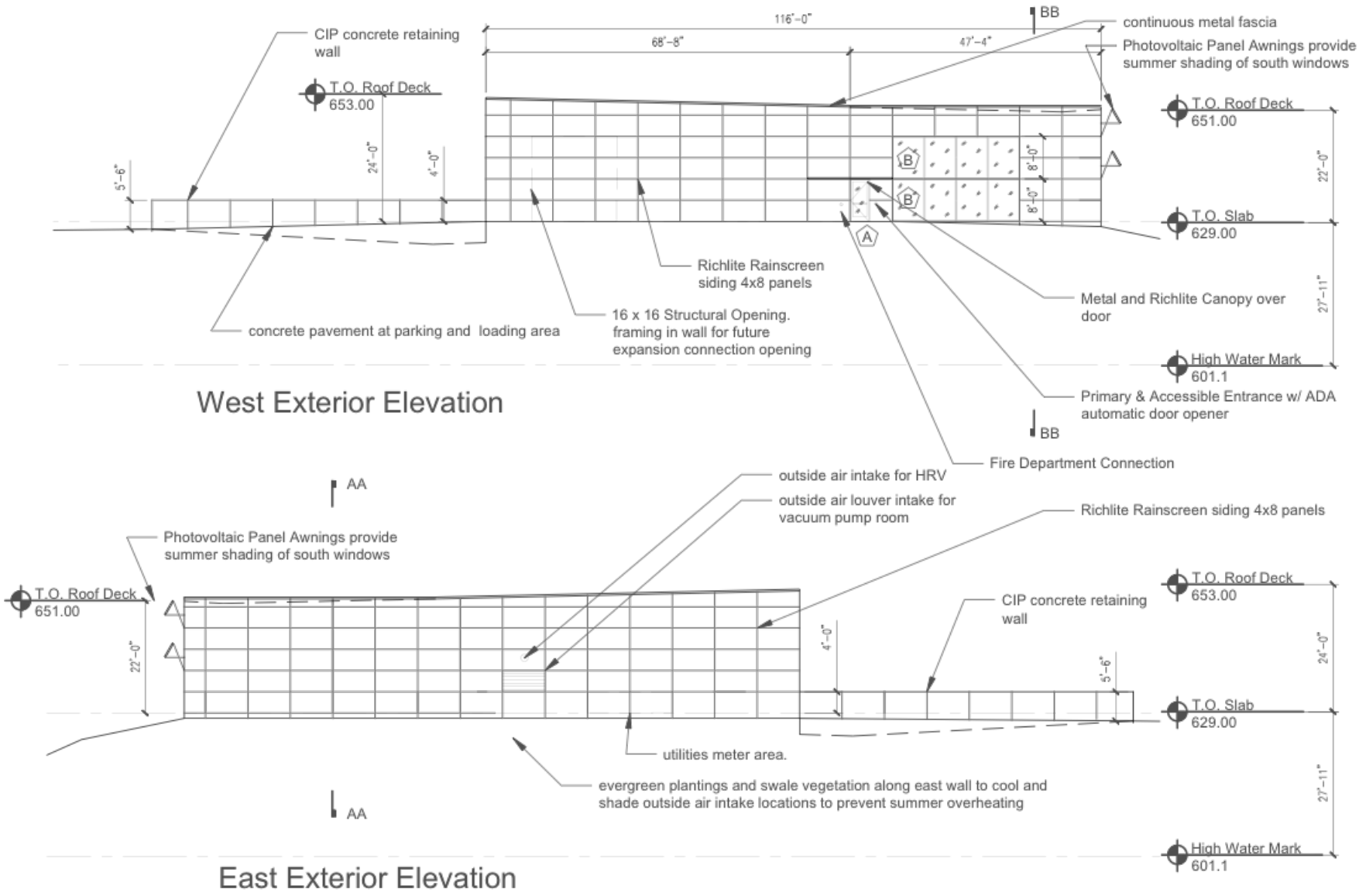
Project Features:

-isolating equipment internal heat gains, using for space heating in winter and exhausting in summer

-dramatically reducing electrical loads where possible: lighting, hot water, office and kitchen equipment, because CNC equipment energy use cannot be reduced significantly. Use more PV to offset CNC use.

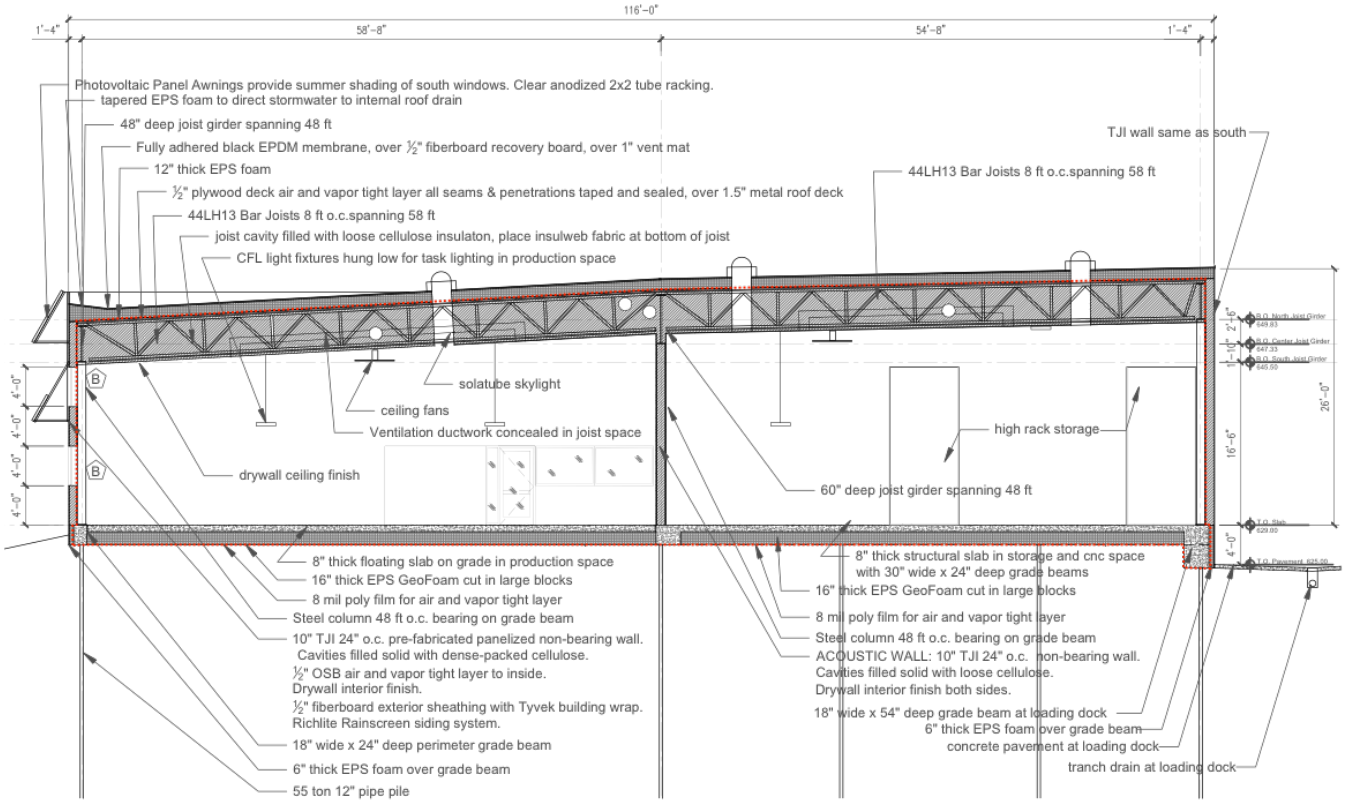


CASE STUDY 3 : STRYKER BAY FACTORY



CASE STUDY 3 : STRYKER BAY FACTORY

Thermal & Air-tight Details



Roof R-value
120 hr.ft^2.F/BTU

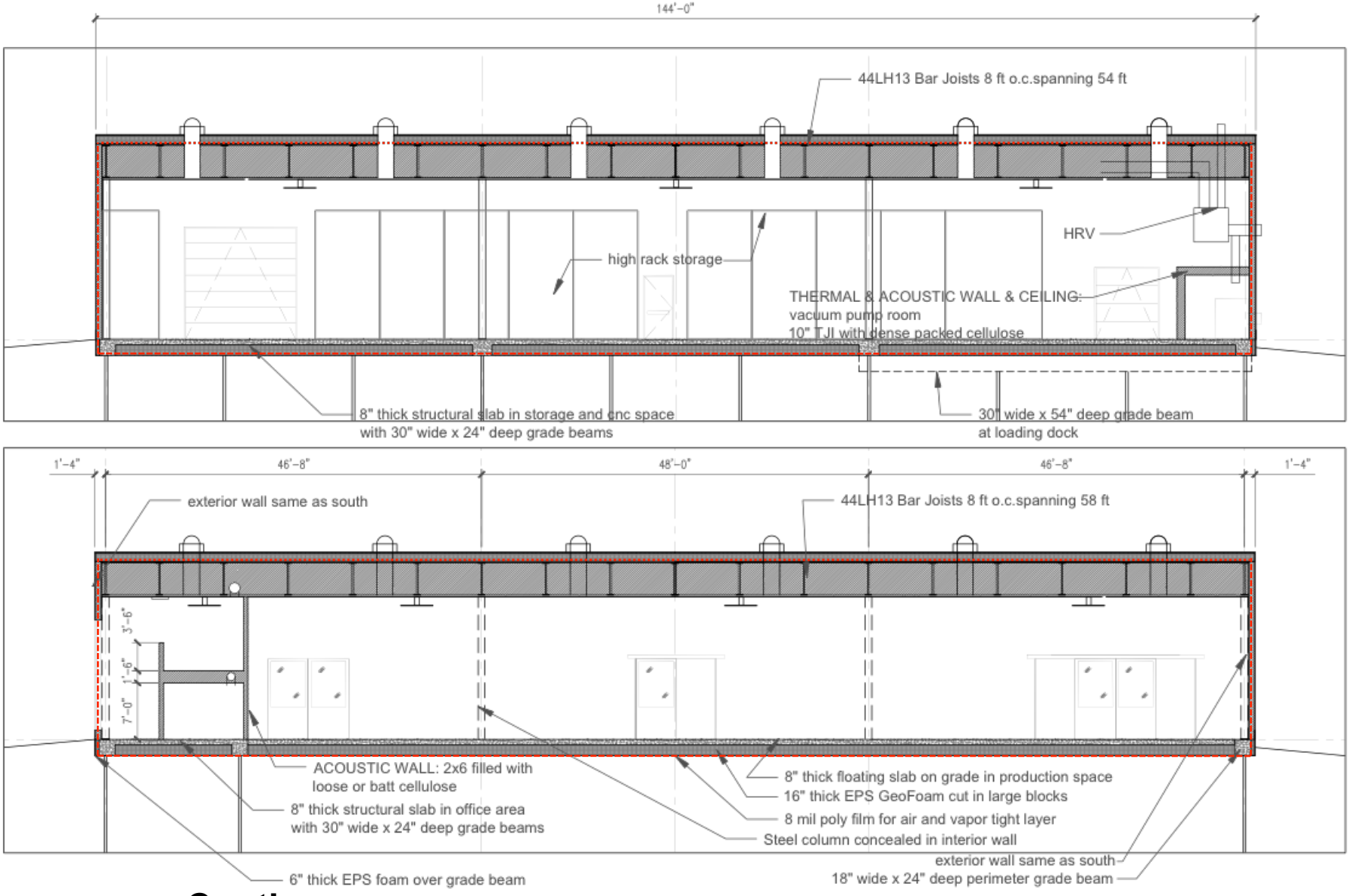
Wall R-value
49 hr.ft^2.F/BTU

Slab R-value

49 hr.ft^2.F/BTU

Continuous
Air-Tight System

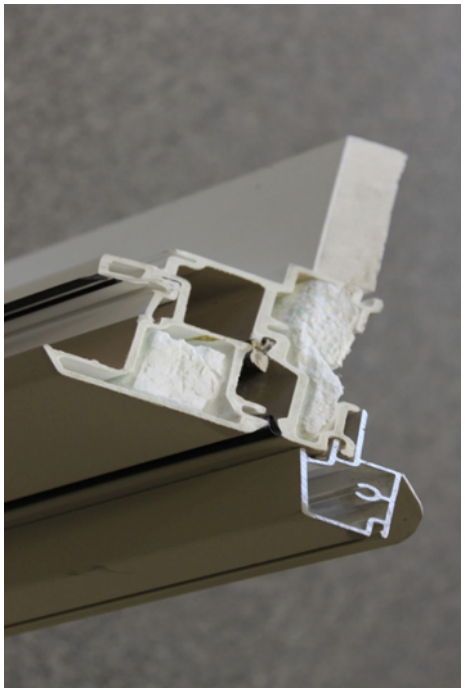
Thermal & Air-tight Details



Continuous Air-Tight System

CASE STUDY 3 : STRYKER BAY FACTORY

Glazing Details



Window Frame U-value
0.22 BTU/hr.ft^2.F

Window Glass U-value
0.13 BTU/hr.ft^2.F

Window Glass SHGC
56%

Low-profile fiberglass window frames with core insulation

Triple-pane glass with high SHGC for passive solar in winter

Over-insulated window frame on interior with polyiso insulation

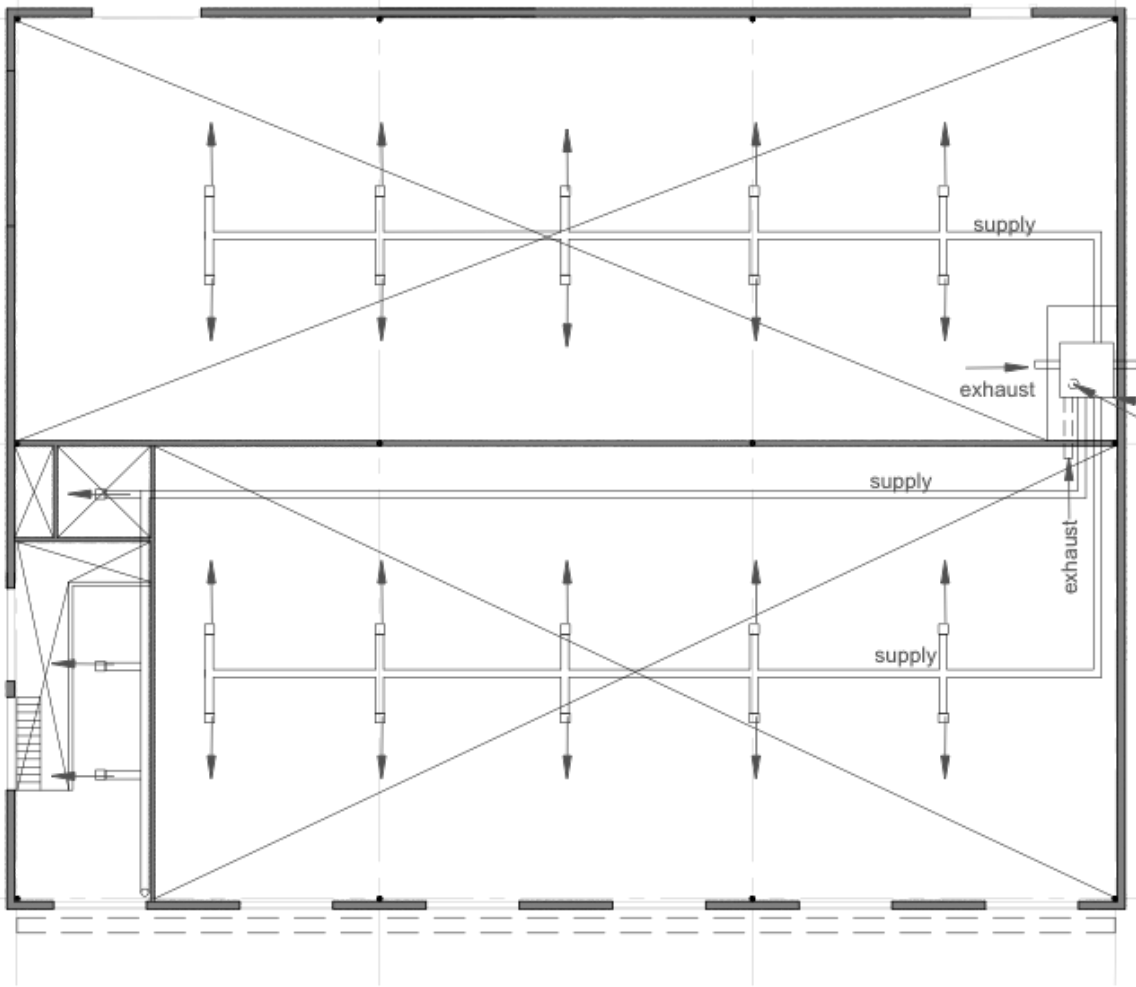
No drafts or need for heating source at windows

Super air-tight and high-insulation value overhead door construction

HVAC System

Peak Heating Load

6.6 BTU/sf/hr 116,000 BTU/hr



HVAC General Notes:

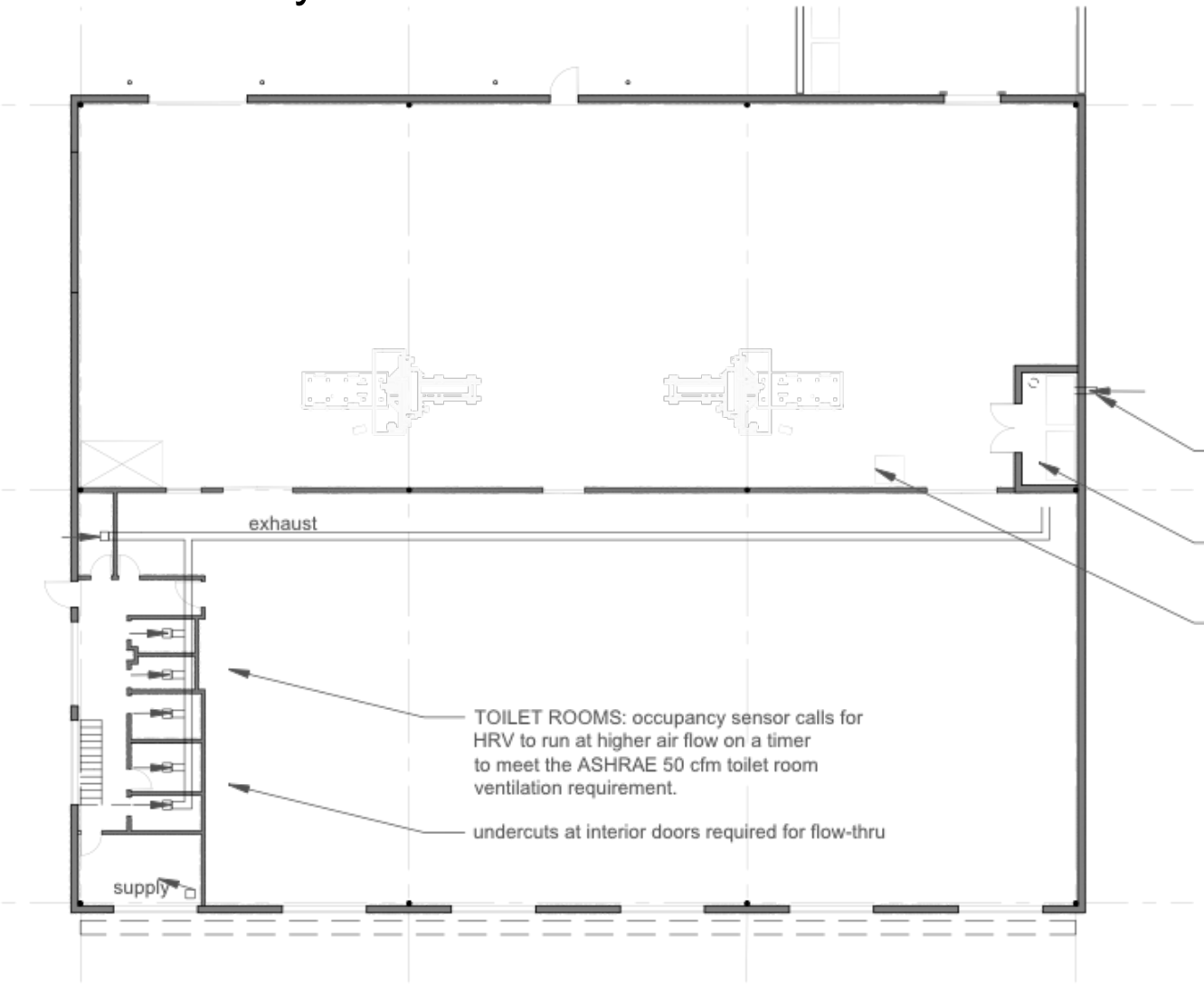
1. Ventilation: Variable Speed Heat Recovery Ventilation Unit. 90% heat recovery efficient. 700 normal air flow, 1300 maximum air flow. Winter operation at normal air flow 24 hours per day using heat from vacuum pump room as a pre-heat source, defrost option still required in case vacuum pumps are not operating. Summer operation at normal air flow during day with summer hx by-pass and at maximum air flow at night for night cooling of thermal mass. Acoustic mufflers provided between rooms. No fire dampers required. Merv 13 filter at supply air and Merv 7 filter at exhaust air of unit.

2. Space Heating. 40kw peak heat load. Supplied thru ventilation system with 40kw heat gain from vacuum pump room as primary heat source used as a pre-heat at the HRV intake and zoned electric duct coil post heater units as backup (3 zones)

HRV outside air intake through east wall
HRV unit over room below

HRV outside air exhaust through roof

HVAC System

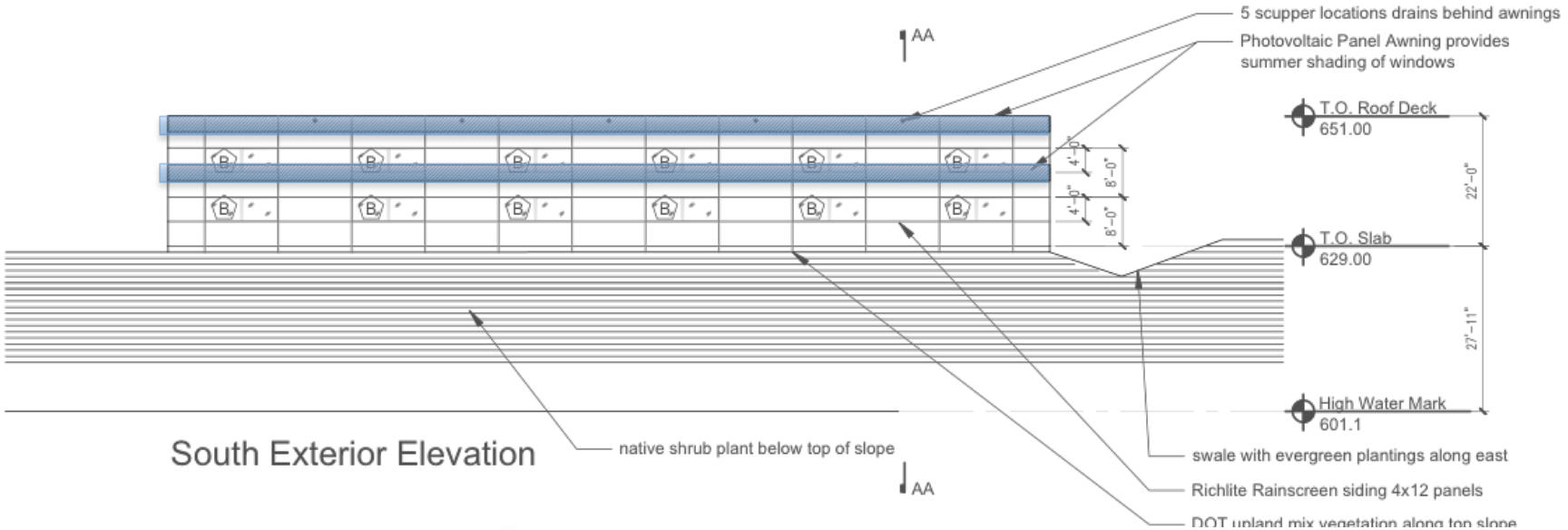


vacuum pump room outside air intake through east wall. Shaded landscaping will keep microclimate below 95 deg F summer outside air temp

exhaust vacuum pump room heat into intake air of HRV as a pre-heat

dust collection of cnc machines is not direct vented outside. The system is internal and does not require an enclosure. The dust can be collected in metal gaylord bins with lid @ 99 cuft max capacity for both cnc machines.

Active Solar System



South Exterior Elevation

Grid-connected photovoltaic panels applied to south elevation of building above windows and used for summer shading

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