DOCKETED	
Docket Number:	21-SPPE-01
Project Title:	CA3 Backup Generating Facility-Vantage
TN #:	238216
Document Title:	VDC CA3BGF Responses to CEC Data Requests Set 1 - Part II
Description:	N/A
Filer:	Scott Galati
Organization:	DayZenLLC
Submitter Role:	Applicant Representative
Submission Date:	6/15/2021 2:11:30 PM
Docketed Date:	6/15/2021

PLANT NOTES:

1. THE CONTRACTOR SHALL VERIFY PLANT QUANTITIES FROM THE PLANTING PLAN. QUANTITIES SHOWN IN THE LEGEND ARE FOR CONVENIENCE ONLY.
2. NOTIFY THE LANDSCAPE ARCHITECT IMMEDIATELY IN THE EVENT OF ANY DISCREPANCIES BETWEEN ACTUAL SITE CONDITIONS AND THE PLANTING PLAN.
3. PLANT GROUNDCOVER IN SHRUB AREAS AS NOTED, USE TRIANGULAR SPACING.
4. SEE DETAIL AND SPECIFICATION SHEETS FOR ADDITIONAL INFORMATION.
5. THERE WILL BE NO MATERIALS OR PLANT MATERIALS SUBSTITUTIONS WITHOUT APPROVAL OF THE OWNER OR THE LANDSCAPE ARCHITECT.
6. ALL SLOPES PLANTED WITH GROUND COVER NOT TO EXCEED A 2:1 SLOPE.
7. PROVIDE POSITIVE DRAINAGE AWAY FROM ALL BUILDINGS (2% MIN.)
8. IN THE EVENT OF ANY DISCREPANCIES BETWEEN THIS PLAN AND ACTUAL SITE CONDITIONS, THE LANDSCAPE ARCHITECT IS TO BE NOTIFIED IMMEDIATELY.
9. ENTIRE SITE IS TO BE ROUGH GRADED BY THE GRADING CONTRACTOR TO WITHIN 3/10TH FOOT OF FINISH GRADE. LANDSCAPE CONTRACTOR IS TO FINE GRADE ALL LANDSCAPE AREAS.
10. ALL SITE UTILITIES ARE TO BE PROTECTED DURING CONSTRUCTION. IN THE EVENT OF CONFLICT BETWEEN THE PLANS AND UTILITIES, THE CONTRACTOR SHALL NOTIFY THE LANDSCAPE ARCHITECT. ANY DAMAGE TO UTILITIES, STRUCTURES, OR OTHER FEATURES TO REMAIN, AND CAUSED BY THE LANDSCAPE CONTRACTOR SHALL BE REPLACED OR REPAIRED BY THE CONTRACTOR AT NO EXPENSE TO THE OWNER.
11. THE WORK IN THESE DRAWINGS AND SPECIFICATIONS MAY RUN CONCURRENTLY WITH WORK BY OTHERS. THE LANDSCAPE CONTRACTOR SHALL COORDINATE THE WORK WITH OTHER CONTRACTORS.
12. PRIOR TO ANY DIGGING OR TRENCHING, CALL UNDERGROUND SERVICE ALERT -1.800.227.2600

PLANT LIST:

KEY	BOTANICAL NAME	COMMON NAME	QTY.	SIZE	REMARKS	WUCOLS	APBDCV 'D' COMPLIANT-CI
	TREES						
T1	LOPHESTEMON CONFERTUS	QUEENSLAND BOX		24" BOX	STANDARD	MEDIUM	
T2	---	---					
T3	JUNIPERUS S. 'SKYROCKET'	SKYROCKET JUNIPER	---	24" BOX	COLUMNAR	LOW	
T4	ARBUTUS 'MARINA'	MARINA STRAWBERRY TREE	---	24" BOX	STANDARD	LOW	COMPLIANT
T5	PLATANUS A. 'COLUMBIA'	LONDON PLANE TREE	---	24" BOX	STANDARD	MEDIUM	COMPLIANT
T6	PLATANUS R. 'ROBERTS'	CALIFORNIA SYCAMORE	---	24" BOX	LOW-BRANCH	MEDIUM	COMPLIANT
T7	TRISTANIA LAURINA	WATER GUM	---	24" BOX	MULTI-TRUNK	LOW	COMPLIANT
	SHRUBS						
S1	CALLISTEMON C. 'LITTLE JOHN'	LITTLE JOHN DWARF BOTTLEBRUSH	---	5 GAL		LOW	
S2	PITTOSPORUM T. 'MARJORIE CHANNON'	VARIEGATED KOHUHU	---	15 GAL		LOW	
S3	PHORMIUM 'MAORI MAIDEN'	NEW ZEALAND FLAX	---	5 GAL		LOW	
S4	TULBAGHIA V. 'TRICOLOR'	TRI-COLOR SOCIETY GARLIC	---	1 GAL		LOW	COMPLIANT
S5	DIETES G. 'VARIEGATA'	STRIPED FORTNIGHT LILY	---	5 GAL		LOW	
S6	PITTOSPORUM T. 'VARIEGATA'	VARIEGATED PITTOSPORUM	---	5 GAL		LOW	
S7	RHAPHIOLEPIS U. 'MINOR'	DWARF YEDDO HAWTHORN	---	5 GAL		LOW	
S8	CHONDROPETALUM TECTORUM	SMALL CAPE RUSH	---	5 GAL		LOW	COMPLIANT
S9	JUNCUS PATENS	CALIFORNIA GRAY RUSH	---	5 GAL		LOW	COMPLIANT
S10	MUHLENBERGIA RIGENS	DEER GRASS	---	5 GAL		LOW	COMPLIANT
S11	PHORMIUM T. 'MAORI CHIEF'	NEW ZEALAND FLAX	---	5 GAL		LOW	
	GROUND COVERS						
G1	BULBINE FRUTESCENS	STALKED BULBINE	---	1 GAL	18" O.C.	LOW	
G2	ROSMARINUS O. 'HUNTINGTON CARPET'	CARPET ROSEMARY	---	1 GAL	36" O.C.	LOW	
G3	PENNISETUM A. 'LITTLE BUNNY'	LITTLE BUNNY DWARF FOUNTAIN GRASS	---	1 GAL	24" O.C.	LOW	
G4	MAHONIA REPENS	CREEPING MAHONIA	---	1 GAL	24" O.C.	LOW	COMPLIANT
G5	STONE MULCH	1/2" DIA. RIVER WASHED	--	---	3" DEPTH	--	
G6	SARCEJA DOUGLASII	YERBA BUENA	--	1 GAL	24" O.C.	LOW	
G7	OSTEOSPERMUM F. 'WHITE'	FREEWAY DAISY	--	1 GAL	24" O.C.	LOW	

PLANT SYMBOLS

SXX — INDICATES PLANT KEY
XX — INDICATES PLANT QUANTITY

2590 WALSH AVENUE

ADMIN BLDG

SVP SUBSTATION

WALSH AVENUE

Scale 1" = 20 ft
sheet size = 42"x30"

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PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

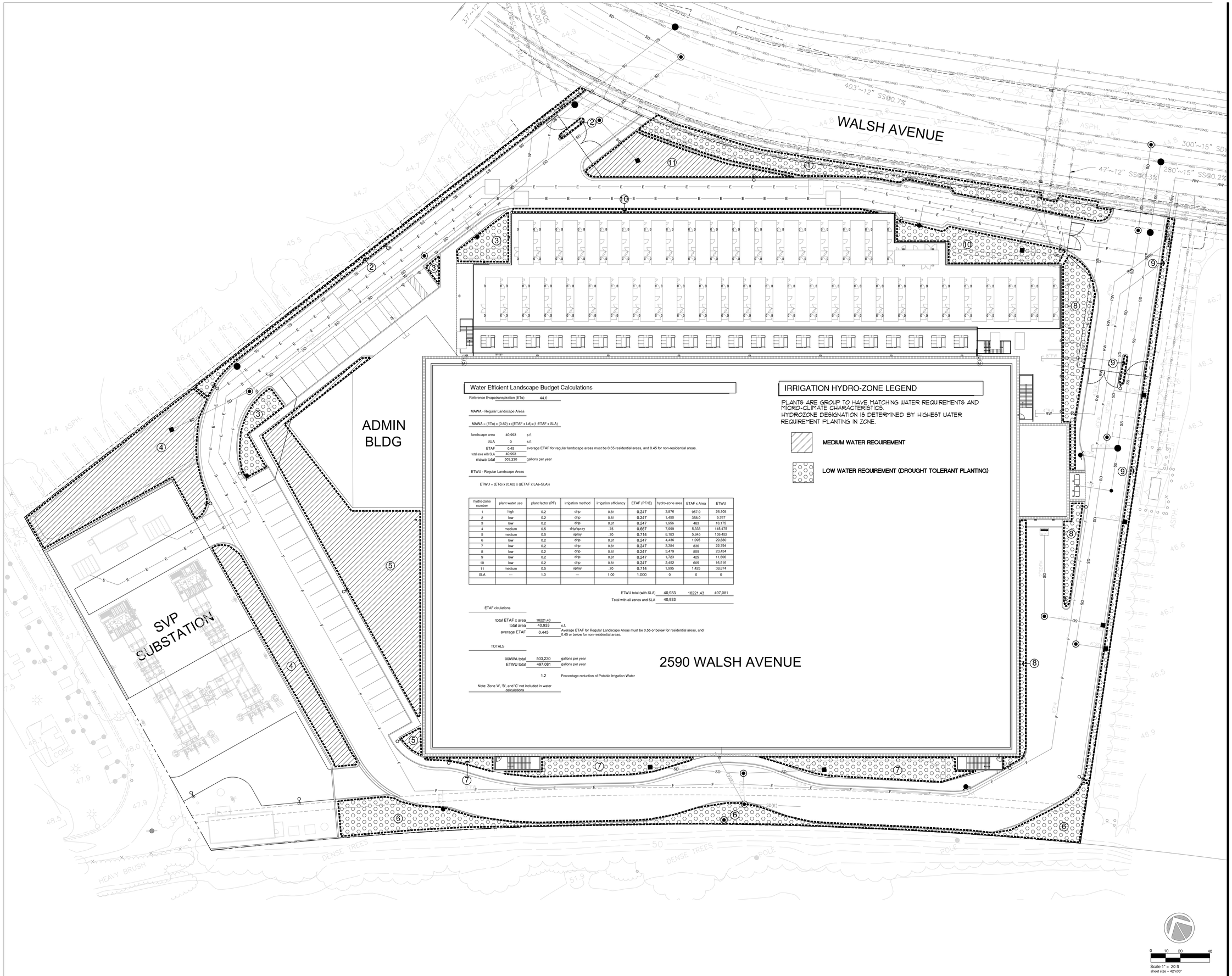
2590 WALSH AVENUE
SANTA CLARA, CA 95051

MASTERPLAN

PRELIMINARY
PLANTING PLAN

L1.0

SCALE: AS NOTED



Water Efficient Landscape Budget Calculations

Reference Evapotranspiration (ETo) 44.0

MAWA - Regular Landscape Areas

MAWA = (ETo) x (0.62) x ((ETAF x LA)+(1-ETAF x SLA)

landscape area	40,993	s.f.
SLA	0	s.f.
ETAF	0.45	average ETAF for regular landscape areas must be 0.55 residential areas, and 0.45 for non-residential areas.
total area with SLA	40,993	
mawa total	503,230	gallons per year

ETWU - Regular Landscape Areas

ETWU = (ETo) x (0.62) x ((ETAF x LA)+SLA))

hydro-zone number	plant water use	plant factor (PF)	irrigation method	irrigation efficiency	ETAF (PF/IE)	hydro-zone area	ETAF x Area	ETWU
1	high	0.2	drip	0.81	0.247	3,876	957.0	26,108
2	low	0.2	drip	0.81	0.247	1,450	358.0	9,767
3	low	0.2	drip	0.81	0.247	1,956	483	13,175
4	medium	0.5	drip/spray	.75	0.667	7,999	5,333	145,475
5	medium	0.5	spray	.70	0.714	8,183	5,845	159,452
6	low	0.2	drip	0.81	0.247	4,436	1,095	29,880
7	low	0.2	drip	0.81	0.247	3,384	836	22,794
8	low	0.2	drip	0.81	0.247	3,479	859	23,434
9	low	0.2	drip	0.81	0.247	1,723	425	11,606
10	low	0.2	drip	0.81	0.247	2,452	605	16,516
11	medium	0.5	spray	.70	0.714	1,995	1,425	38,874
SLA	---	1.0	---	1.00	1.000	0	0	0
					ETWU total (with SLA)	40,933	18221.43	497,081
					Total with all zones and SLA	40,933		

ETAF ciculations

total ETAF x area	18221.43	
total area	40,933	s.f.
average ETAF	0.445	Average ETAF for Regular Landscape Areas must be 0.55 or below for residential areas, and 0.45 or below for non-residential areas.

TOTALS

MAWA total	503,230	gallons per year
ETWU total	497,081	gallons per year
	1.2	Percentage reduction of Potable Irrigation Water

Note: Zone 'A', 'B', and 'C' not included in water calculations

IRRIGATION HYDRO-ZONE LEGEND

PLANTS ARE GROUP TO HAVE MATCHING WATER REQUIREMENTS AND MICRO-CLIMATE CHARACTERISTICS.
HYDROZONE DESIGNATION IS DETERMINED BY HIGHEST WATER REQUIREMENT PLANTING IN ZONE.

MEDIUM WATER REQUIREMENT

LOW WATER REQUIREMENT (DROUGHT TOLERANT PLANTING)

0 10 20 40
Scale 1" = 20 ft
sheet size = 42"x30"

OWNER

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PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

2590 WALSH AVENUE
SANTA CLARA, CA 95051

MASTERPLAN

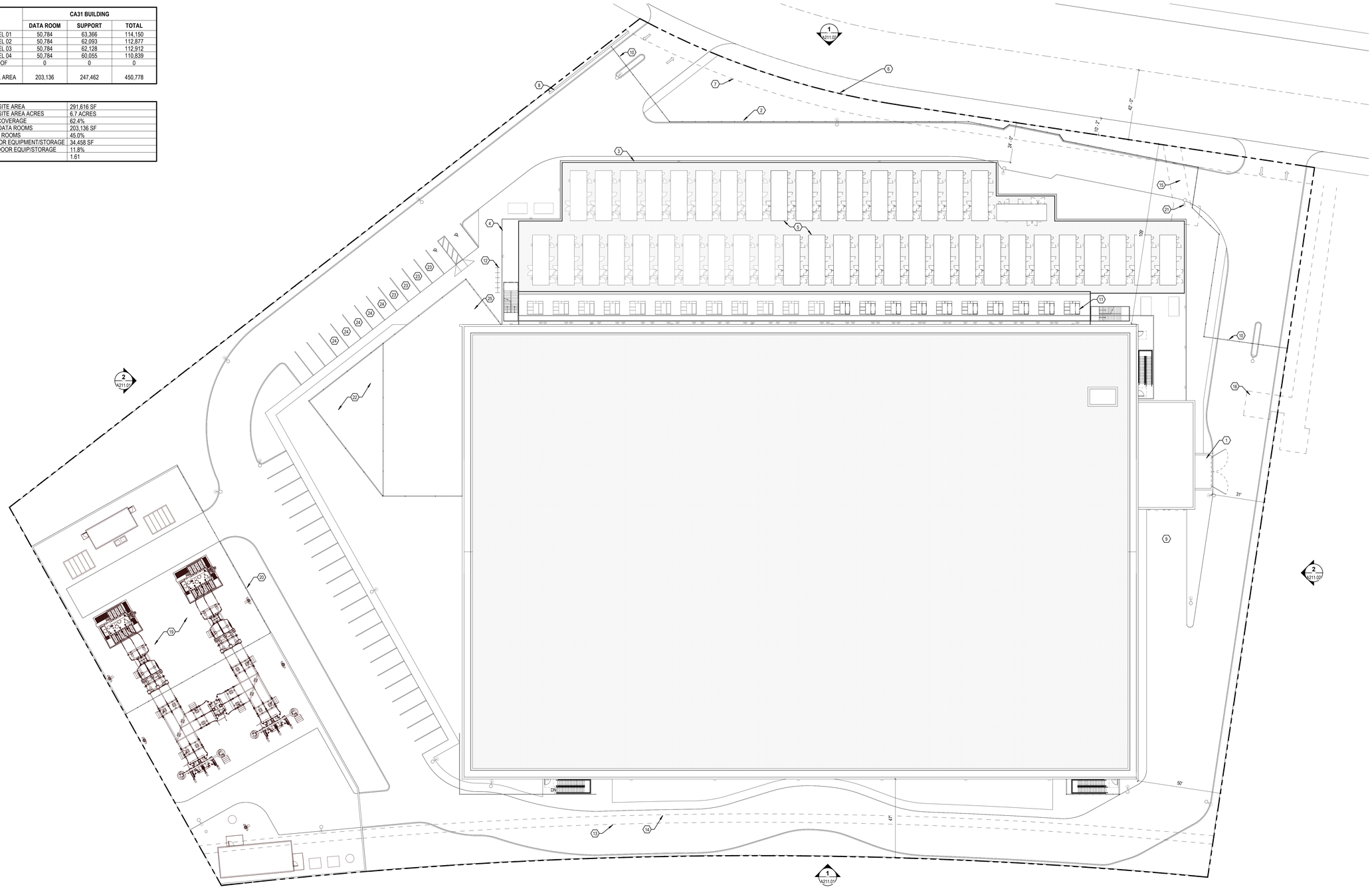
Landscape
Hydrozone Plan

L2.0

SCALE: AS NOTED

	CA31 BUILDING		
	DATA ROOM	SUPPORT	TOTAL
LEVEL 01	50,784	63,366	114,150
LEVEL 02	50,784	62,093	112,877
LEVEL 03	50,784	62,128	112,912
LEVEL 04	50,784	60,655	110,839
ROOF	0	0	0
TOTAL AREA	203,136	247,462	450,778

TOTAL SITE AREA	291,616 SF
TOTAL SITE AREA ACRES	6.7 ACRES
% LOT COVERAGE	62.4%
TOTAL DATA ROOMS	203,136 SF
% DATA ROOMS	45.0%
OUTDOOR EQUIPMENT/STORAGE	34,458 SF
% OUTDOOR EQUIP/STORAGE	11.8%
F.A.R.	1.61



1 SITE PLAN
3/64" = 1'-0"

GENERAL NOTES

PARKING

PER CITY OF SANTA CLARA TITLE 18 ZONING SECTION 18.74.020.D.2 DATA CENTERS. ONE SPACE PER FOUR THOUSAND (4,000) SQUARE FEET OF GROSS FLOOR AREA RESULTING IN A MINIMUM OF 114 PARKING SPACES. THE PROJECT APPLICANT IS REQUESTING A ZONING ADMINISTRATOR MODIFICATION TO ALLOW FOR SHARED PARKING WITH THE EXISTING EXCESS PARKING OF THE CA2 CAMPUS ACROSS WALSH AVE. WHEN COMBINED THE TOTAL PARKING FAR EXCEEDS THE REQUIRED PARKING REQUIREMENT.

BIKE PARKING

THE NUMBER AND TYPE OF BIKE SPACES WILL BE PROVIDED AS REQUIRED BY THE CITY OF SANTA CLARA.
PER THE CALIFORNIA BUILDING CODE - 5.106.4.1 BICYCLE PARKING:
LONG-TERM PARKING (CLASS 1) = 6 (5% OF VEHICULAR PARKING)
SHORT-TERM PARKING (CLASS 2) = 6 (5% OF VEHICULAR PARKING)

BUILDING HEIGHT

THE PROJECT SITE IS ZONED AS MH. THE MAXIMUM BUILDING HEIGHT UNDER THE MH ZONING DESIGNATION IS 70 FEET WITH A PREVIOUSLY APPROVED MODIFICATION ALLOWING AN INCREASE IN HEIGHT UP TO 25 PERCENT. BUILDINGS UNDER THIS DESIGNATION ARE REQUIRED TO HAVE AT LEAST 15-FOOT SETBACK DISTANCE FROM THE STREET. THIS ZONING DESIGNATION ACCOMMODATES INDUSTRIES OPERATING SUBSTANTIALLY WITHIN AN ENCLOSED BUILDING. THE PREVIOUSLY APPROVED ALLOWABLE HEIGHT OF THE PROPOSED BUILDINGS TO THE TOP OF THE ROOF WOULD BE APPROXIMATELY 87.5 FEET ABOVE GROUND SURFACE (102.25 FEET ABOVE GROUND SURFACE TO THE TOP OF THE ROOF SCREEN). THE PROPOSED BUILDINGS WOULD BE SET BACK FROM THE STREET BY MORE THAN 15 FEET.

AIRPORT OPERATION

THE PROJECT SITE IS LOCATED APPROXIMATELY 0.3 MILE WEST OF THE NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT, AND IS NOT WITHIN THE NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT INFLUENCE AREA. THE HEIGHT OF THE PROPOSED BUILDINGS TO THE TOP OF THE METAL SCREEN WOULD BE APPROXIMATELY 102.25 FEET ABOVE GROUND SURFACE. AIRPORT SAFETY HAZARDS ASSOCIATED WITH THE NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT WERE EVALUATED ACCORDING TO AIRPORT SAFETY ZONES AND FEDERAL AVIATION REGULATIONS PART 77 AIRSPACE SURFACES. THE PROJECT SITE IS OUTSIDE OF ALL AIRPORT SAFETY ZONES. ADDITIONALLY, THE PROPOSED PROJECT WOULD NOT INTRUDE UPON THE PART 77 AIRSPACE SURFACE FOR THE NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT, WHICH ESTABLISHES A MAXIMUM STRUCTURE HEIGHT OF 212 FEET (ABOVE MEAN SEA LEVEL) FOR THE PROJECT SITE. IN ACCORDANCE WITH FAA REQUIREMENTS, THE PROJECT APPLICANT WOULD COMPLETE AND SUBMIT ALL NECESSARY NOTICES AND DOCUMENTATION TO THE FAA TO OBTAIN THE NECESSARY APPROVALS FOR CONSTRUCTION IN COMPLIANCE WITH FAA'S NOTICE OF PROPOSED CONSTRUCTION REQUIREMENTS. DUE TO COMPLIANCE WITH APPLICABLE REGULATIONS SET FORTH BY THE NORMAN Y. MINETA SAN JOSE INTERNATIONAL AIRPORT AND THE FAA, THE PROJECT WOULD NOT RESULT IN A CHANGE IN AIR TRAFFIC PATTERNS OR OBSTRUCT AIRPORT OPERATIONS.

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

1	TRASH ENCLOSURE
2	FENCING TO BE PROVIDED AS REQUIRED BY PLANNING APPROVAL
3	25' TALL GENERATOR YARD SCREEN
4	15' TALL GENERATOR YARD SCREEN
5	GENERATOR YARD
6	PROPERTY LINE
7	10' GENERAL PURPOSE EASEMENT
8	8' TALL NOISE BARRIER WALL
9	LOADING DOCK
10	SECURITY GATE
11	ELECTRICAL GEAR
12	SHORT-TERM BICYCLE PARKING
13	20' GENERAL PURPOSE EASEMENT
14	5' WIRE CLEARANCE EASEMENT
15	UNDERGROUND ELECTRIC EASEMENT
16	ELECTRIC UTILITY EASEMENT
19	SUBSTATION
20	MECHANICAL EQUIPMENT
21	SITE LIGHTING, SEE ELECTRICAL DRAWINGS
22	4TH FLOOR TERRACE
23	EV CHARGING SPACE
24	EV CHARGING SPACE
25	MAIN ENTRANCE

OWNER

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PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

ARCHITECTURAL SITE PLAN

AS100.01

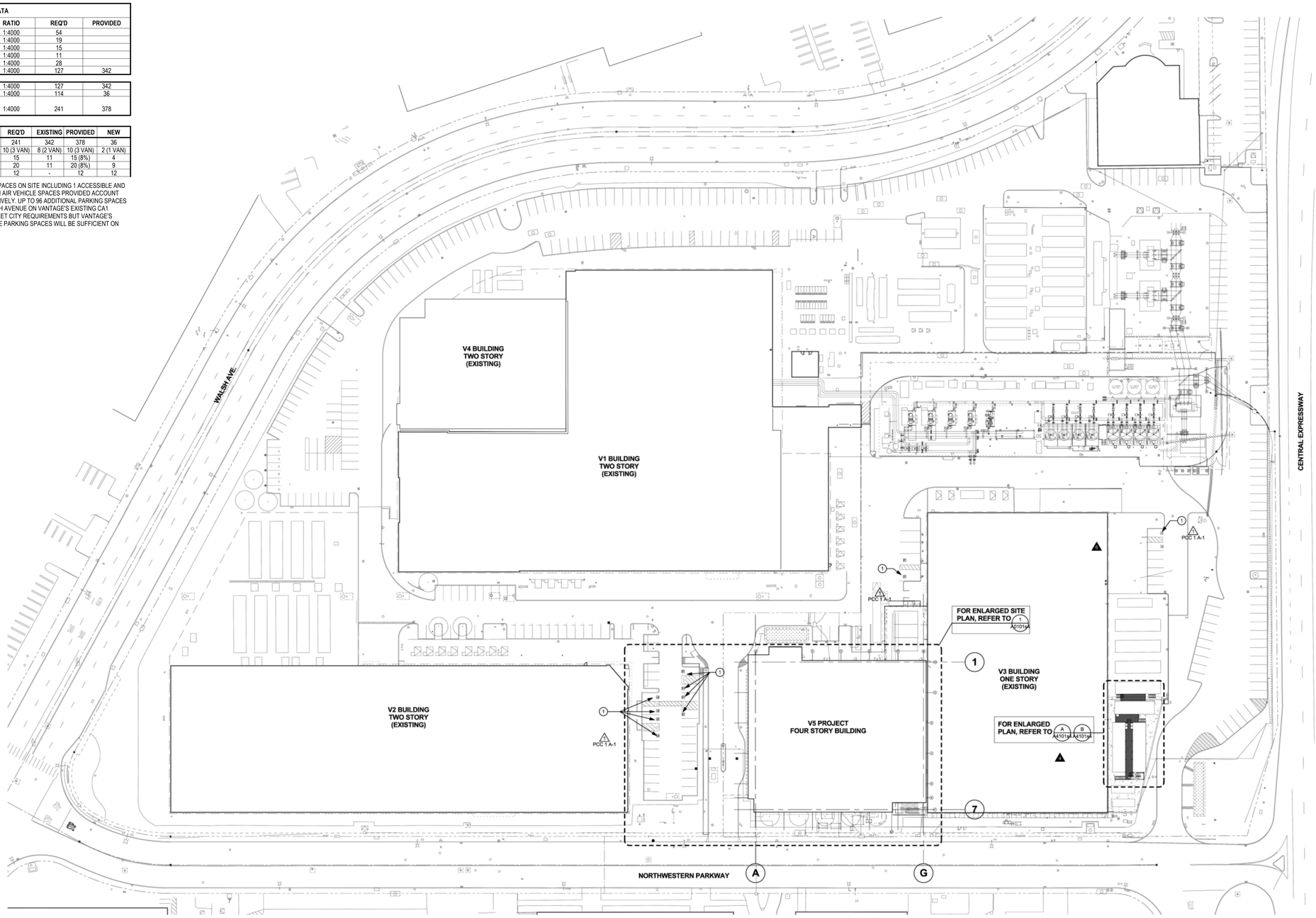
SCALE: AS NOTED

PARKING DATA					
BUILDING	AREA	ZONE	RATIO	REQ'D	PROVIDED
V1	215,935 SF	ML	1:4000	54	
V2	74,935 SF	ML	1:4000	19	
V3	60,040 SF	ML	1:4000	15	
V4	42,800 SF	ML	1:4000	11	
V5	109,510 SF	ML	1:4000	28	
TOTAL EXISTING	503,220 SF	ML	1:4000	127	342

TOTAL EXISTING	503,220 SF	ML	1:4000	127	342
CA31	454,620 SF	ML	1:4000	114	36
TOTALS	957,840 SF	ML	1:4000	241	378

	REQ'D	EXISTING	PROVIDED	NEW
TOTAL STALLS	241	342	378	36
ACCESSIBLE STALLS PROVIDED	10 (3 VAN)	8 (2 VAN)	10 (3 VAN)	2 (1 VAN)
EV CHARGING STATIONS PROVIDED	15	11	15 (8%)	4
CLEAN AIR VEHICLE SPACES PROVIDED	20	11	20 (8%)	9
BICYCLE PARKING (10% TOTAL CA31 VEHICLE PARKING)	12	-	12	12

THE PROJECT WILL PROVIDE A TOTAL OF 36 PARKING SPACES ON SITE INCLUDING 1 ACCESSIBLE AND 1 VAN ACCESSIBLE PARKING SPACE. THE EV AND CLEAN AIR VEHICLE SPACES PROVIDED ACCOUNT FOR 8% AND 6% OF TOTAL PARKING SPACES, RESPECTIVELY. UP TO 96 ADDITIONAL PARKING SPACES WILL BE PROVIDED FOR THE CA31 SITE ACCROSS WALSH AVENUE ON VANTAGE'S EXISTING CA1 CAMPUS. THE ADDITIONAL PARKING IS PROVIDED TO MEET CITY REQUIREMENTS BUT VANTAGE'S EXPERIENCE HAS DEMONSTRATED THAT THE 36 ON-SITE PARKING SPACES WILL BE SUFFICIENT ON THEIR OWN TO SUPPORT CA31 OPERATIONS.



1 Campus Parking Plan
1" = 40'-0"

GENERAL NOTES

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

SHEET LEGEND

OWNER

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REED ASSOCIATES
LANDSCAPE ARCHITECTURE

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

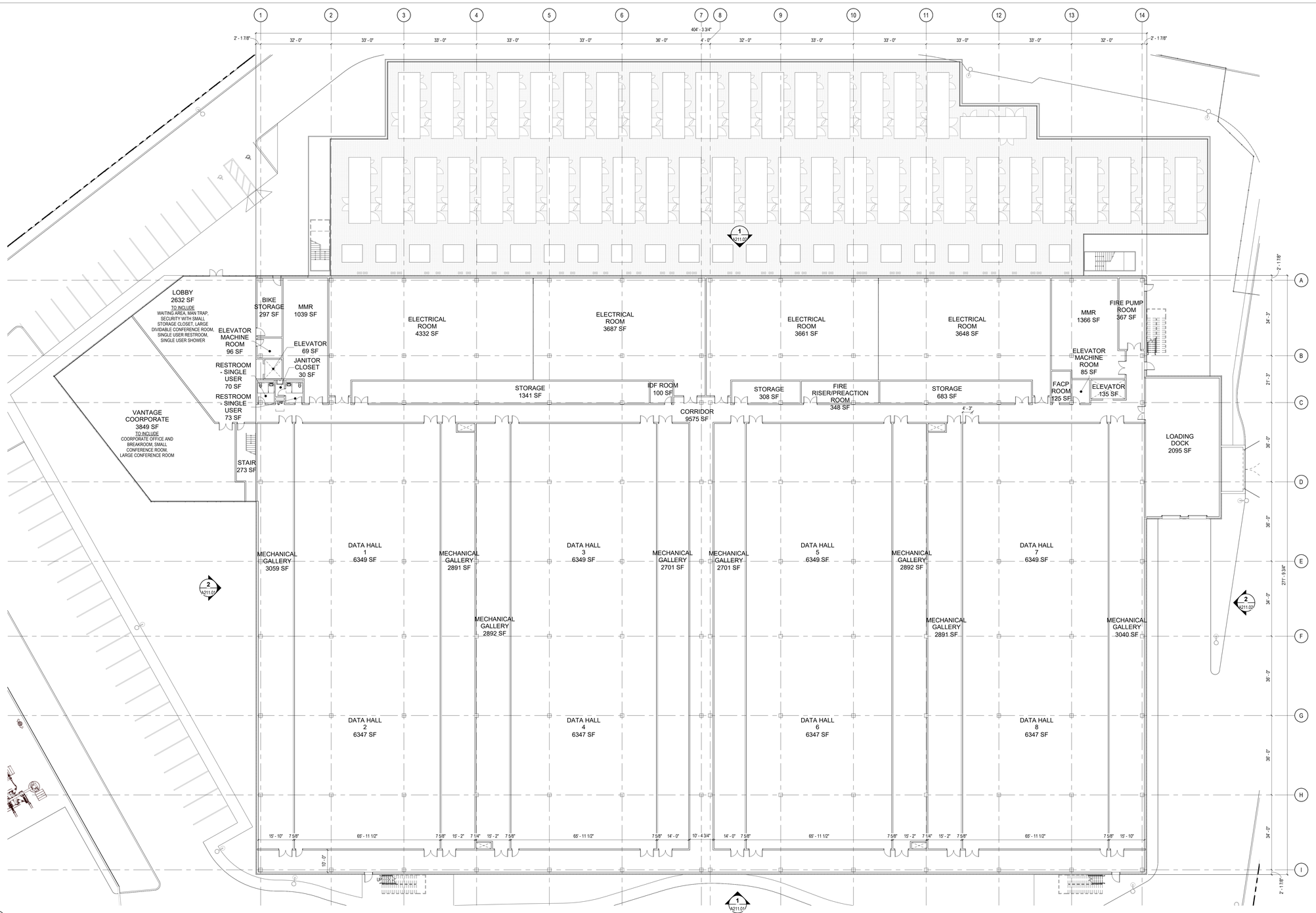
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

CAMPUS PARKING PLAN

AS100.02

SCALE: AS NOTED



1 FLOOR PLAN - LEVEL 1
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

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SHEET LEGEND

OWNER

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SAN JOSE, CALIFORNIA

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

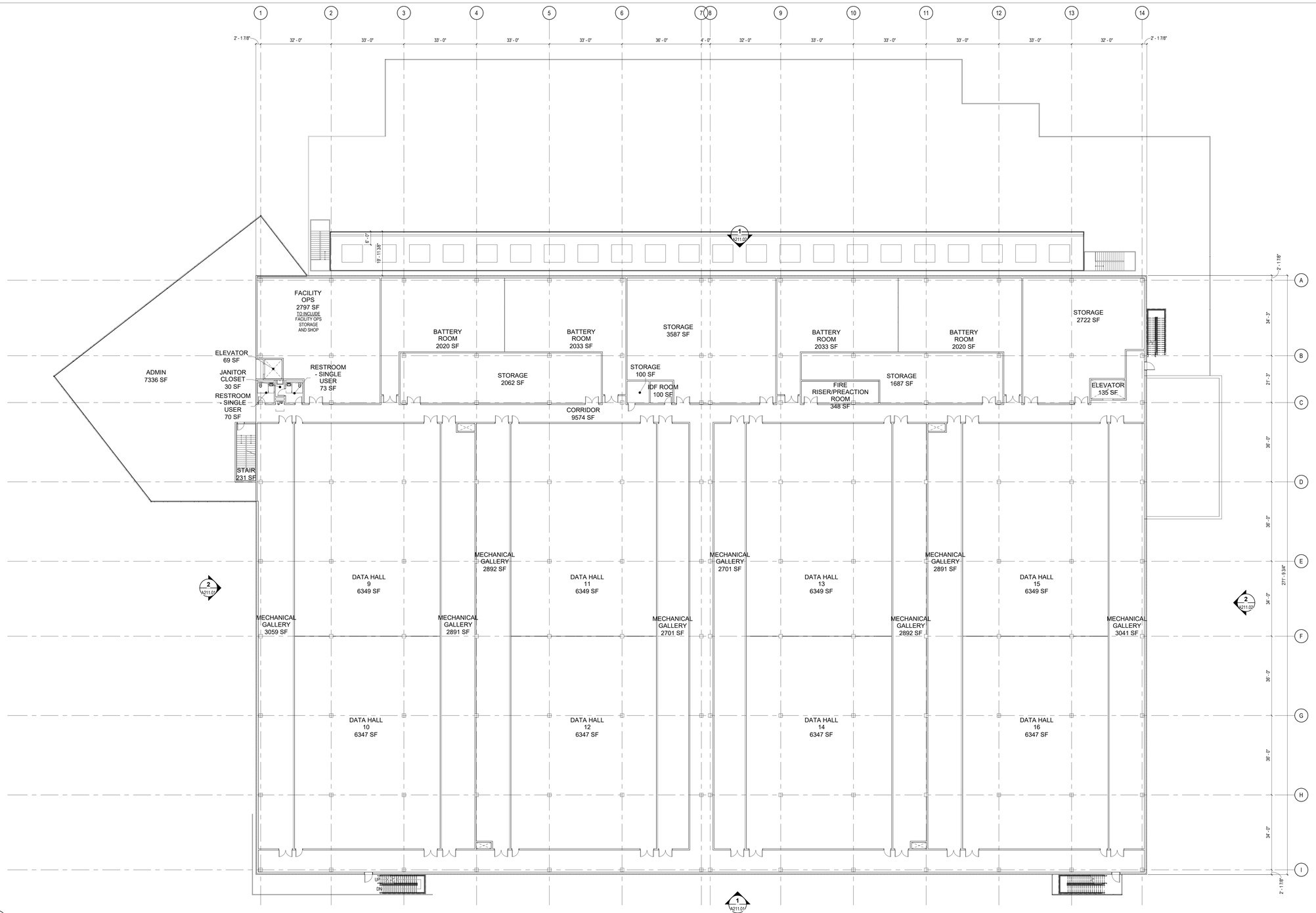
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

FLOOR PLAN - LEVEL 1

A110.01

SCALE: AS NOTED



1 FLOOR PLAN - LEVEL 2
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

SHEET LEGEND

OWNER

VANTAGE DATA CENTERS

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No.	Description	Date

VANTAGE CA31

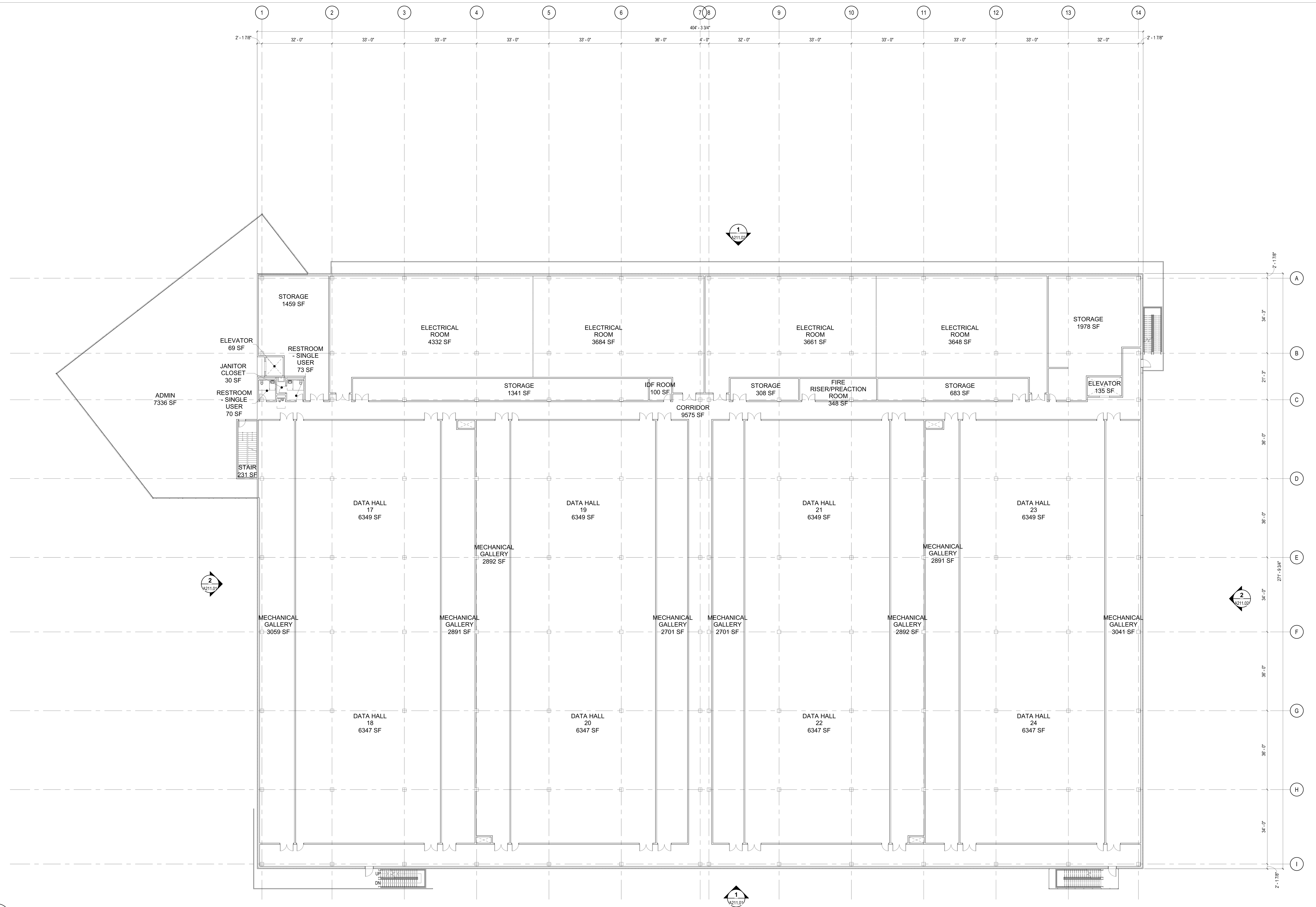
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

FLOOR PLAN - LEVEL 2

A110.02

SCALE: AS NOTED



1 FLOOR PLAN - LEVEL 3
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

SHEET LEGEND

OWNER

VANTAGE DATA CENTERS

ARCHITECT

SHEEHAN NAGLE HARTRAY ARCHITECTS

SHEEHAN NAGLE HARTRAY ARCHITECTS
30 WEST MONROE, SUITE 900
CHICAGO, IL 60603

MEP ENGINEER

KW
Mission Critical Engineering
40 E. Rio Salado Parkway, 4th Floor
602.568.3144

CUPERTINO ELECTRIC
1132 NORTH 7TH STREET
SAN JOSE, CA 95112
(408) 808-8000
C-10 LIC. NO. 174637

STRUCTURAL ENGINEER

PEOPLES ASSOCIATES
STRUCTURAL ENGINEERS
408-957-9220 San Jose, California
www.pase.com Pleasanton, California

CIVIL ENGINEER

HMH
1570 Oakland Road
San Jose, CA 95131
(408) 487-2200
HMHca.com

REED ASSOCIATES
LANDSCAPE ARCHITECTURE

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

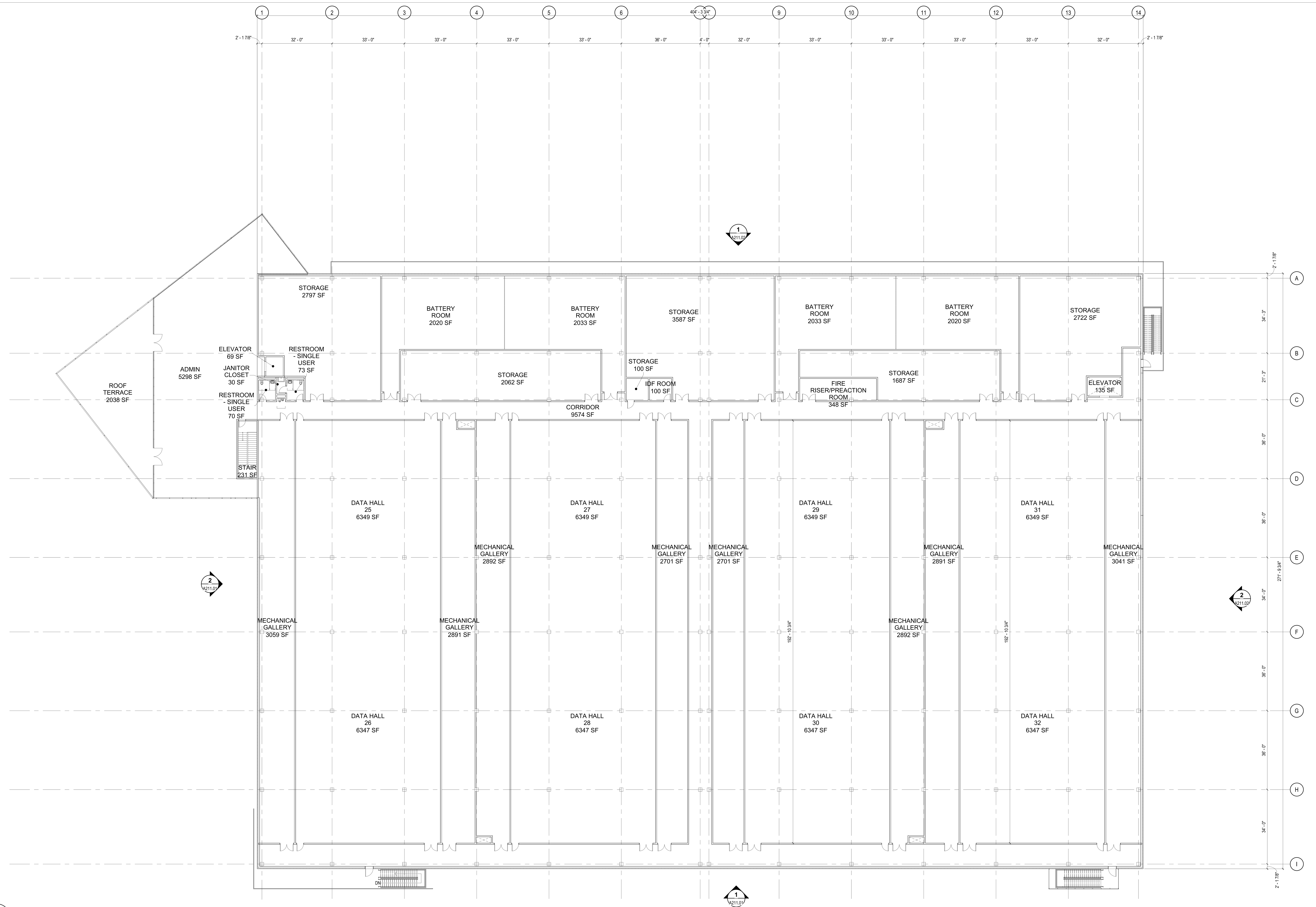
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

FLOOR PLAN - LEVEL 3

A110.03

SCALE: AS NOTED



1 FLOOR PLAN - LEVEL 4
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

SHEET LEGEND

OWNER

VANTAGE DATA CENTERS

ARCHITECT

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No.	Description	Date

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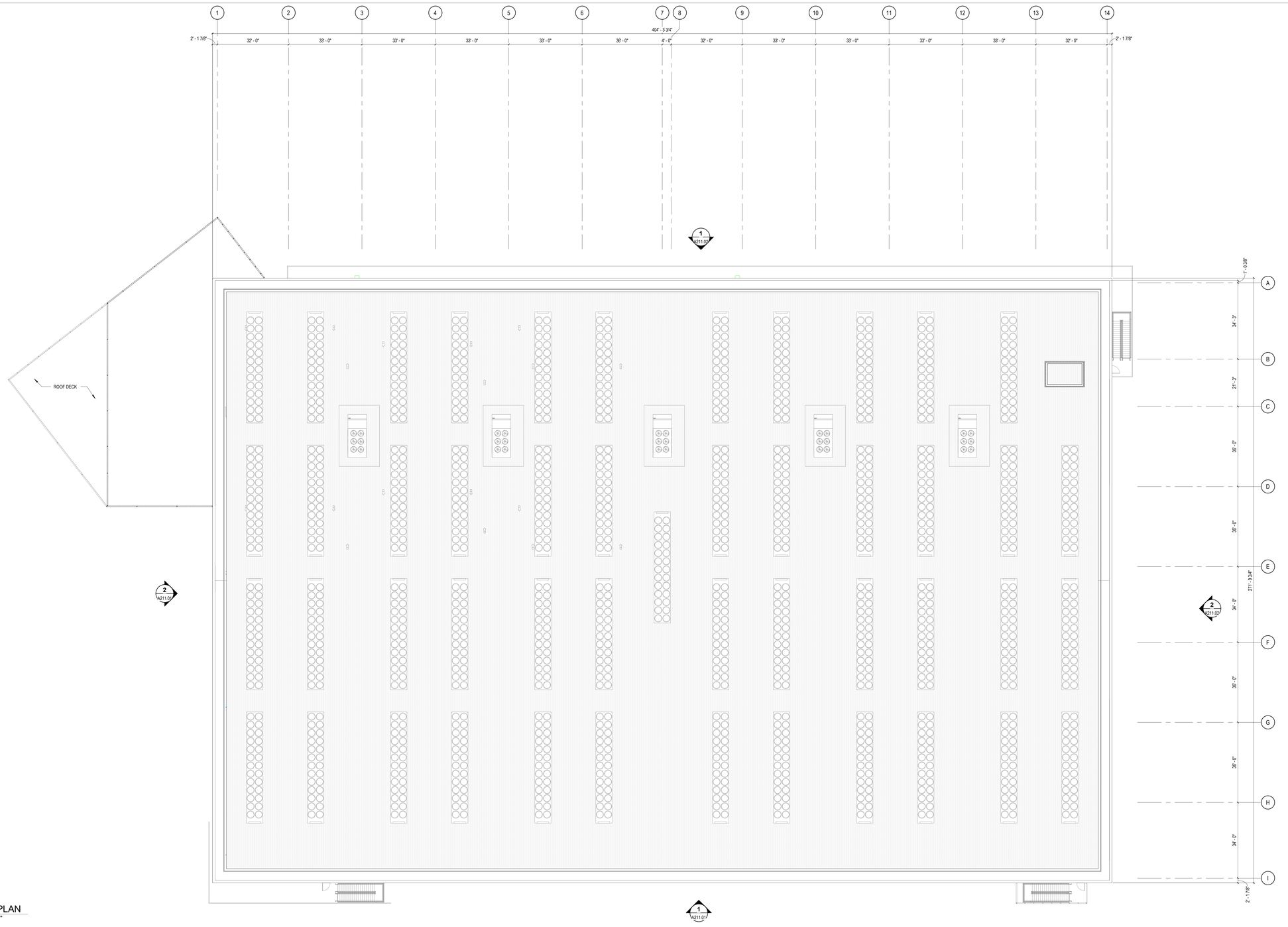
FLOOR PLAN - LEVEL 4

A110.04

SCALE: AS NOTED



1 ROOF PLAN
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

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SHEET LEGEND

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LANDSCAPE ARCHITECTURE

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

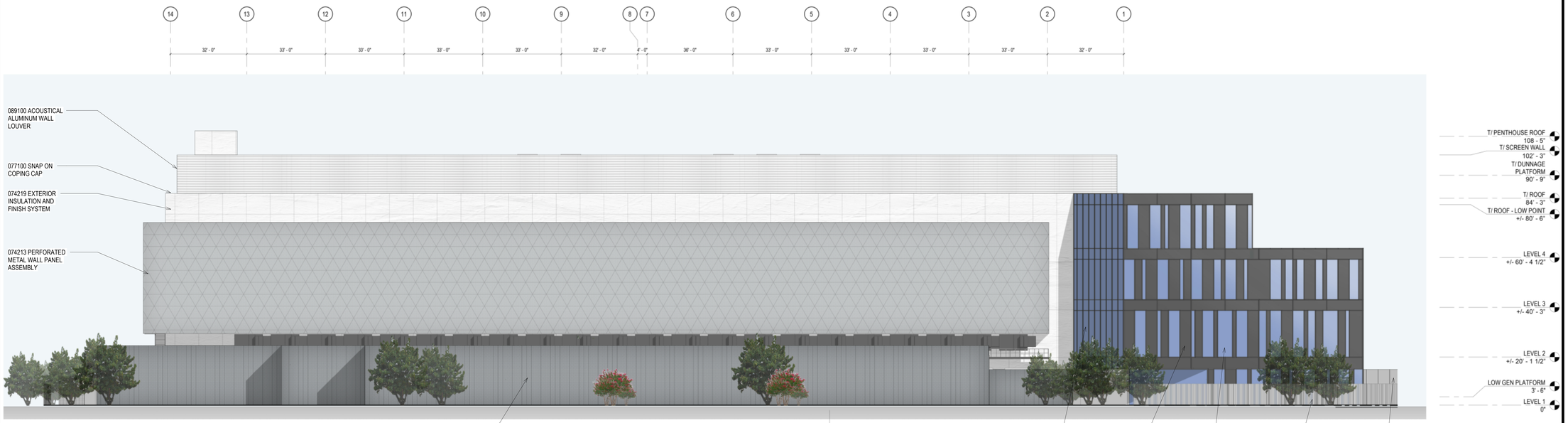
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

DUNNAGE PLATFORM PLAN

A110.05

SCALE: AS NOTED



1 NORTH ELEVATION
1/16" = 1'-0"

2 WEST ELEVATION
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

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LANDSCAPE ARCHITECTURE

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

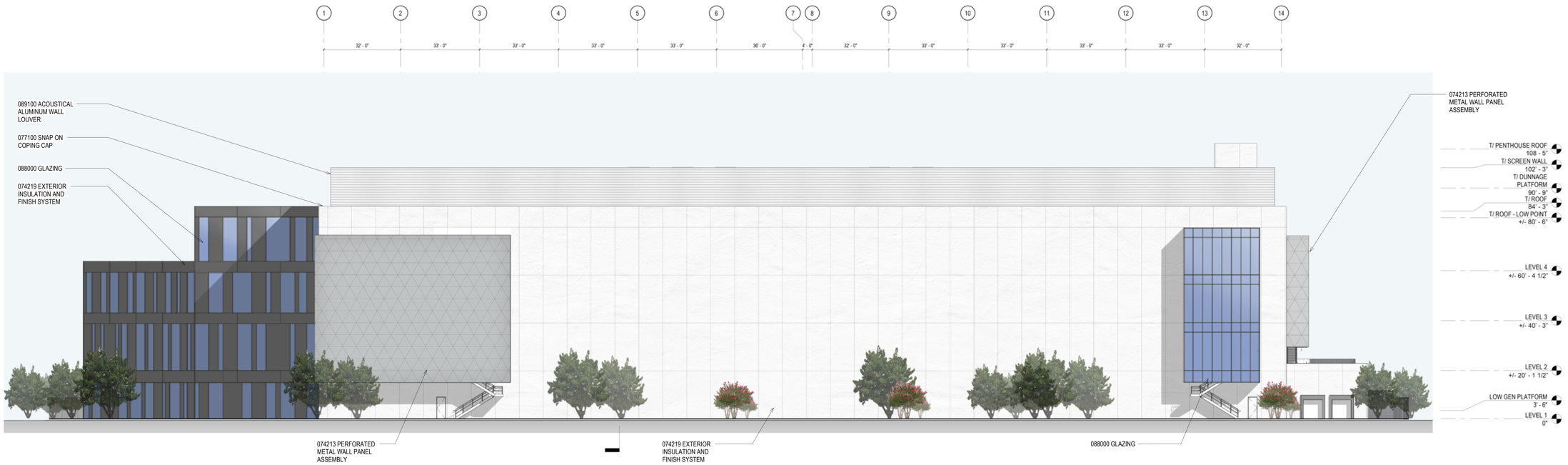
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

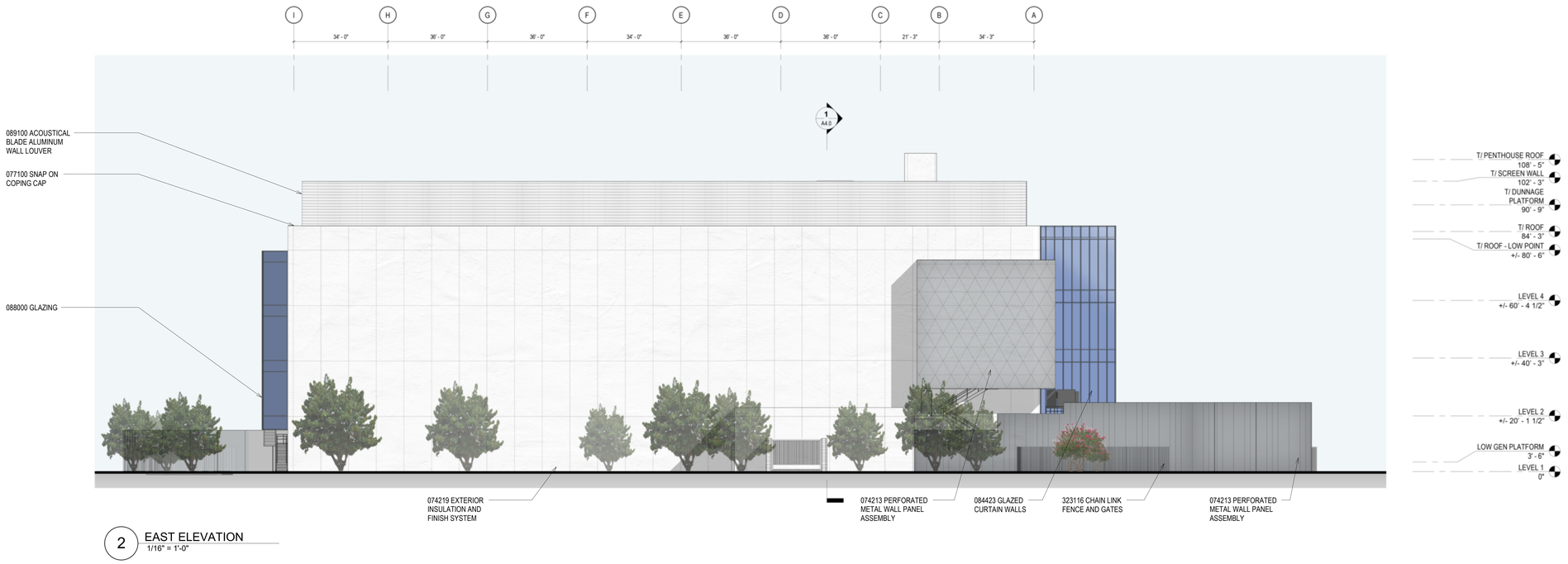
EXTERIOR ELEVATIONS

A211.01

SCALE: AS NOTED



1 SOUTH ELEVATION
1/16" = 1'-0"



2 EAST ELEVATION
1/16" = 1'-0"

GENERAL NOTES

SHEET NOTES

NOTE: NOT ALL SHEET NOTES BELOW MAY BE USED ON THIS SHEET

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(408) 487-2200 HMHca.com

REED ASSOCIATES LANDSCAPE ARCHITECTURE

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NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

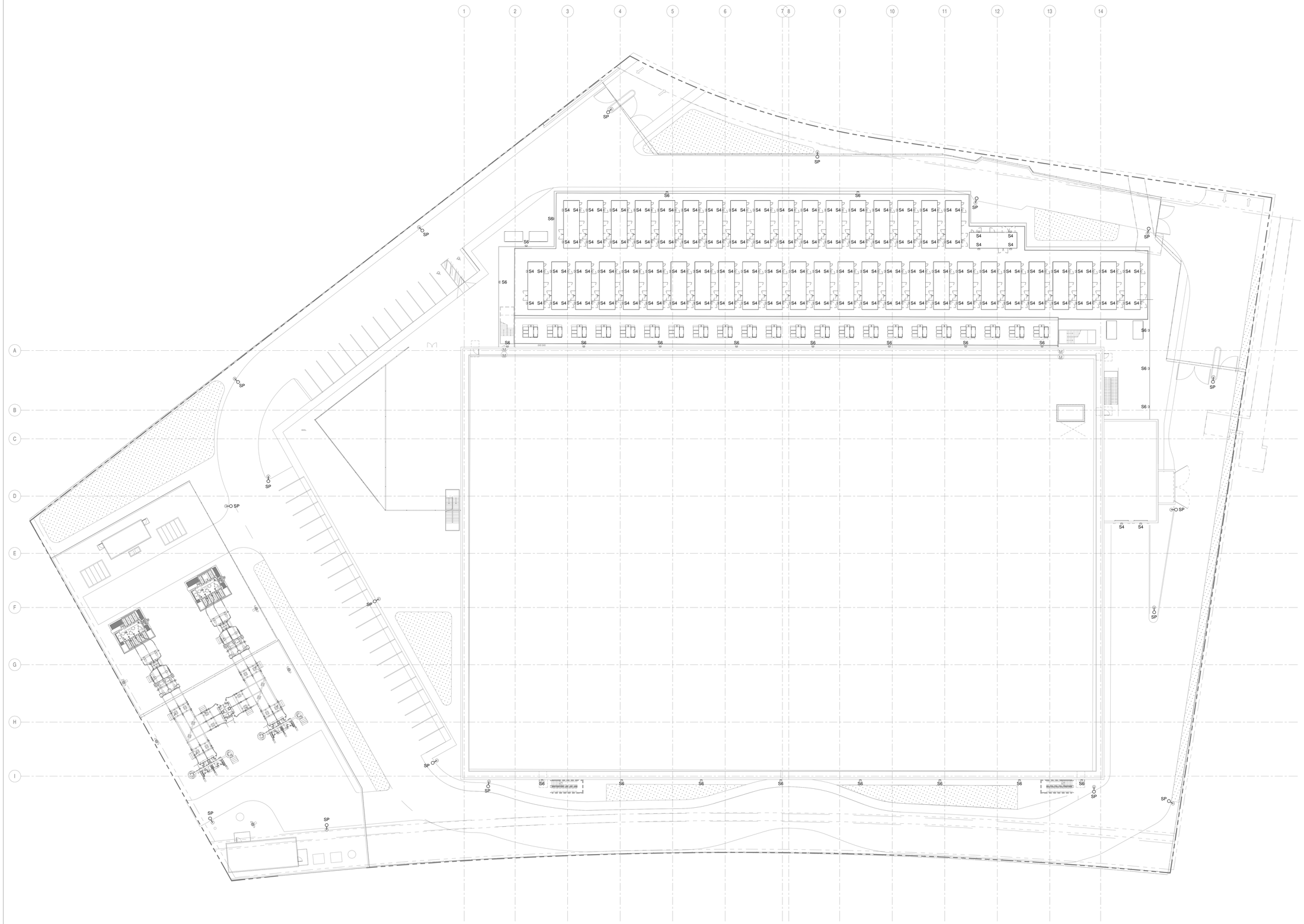
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

EXTERIOR ELEVATIONS

A211.02

SCALE: AS NOTED



1 SITE LIGHTING PLAN
1" = 20'-0"

OWNER

VANTAGE DATA CENTERS

ARCHITECT

SHEEHAN NAGLE HARTRAY ARCHITECTS

SHEEHAN NAGLE HARTRAY ARCHITECTS
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TECHNOLOGY ENGINEER

CIVIL ENGINEER

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(408) 487-2200
HMHca.com

REED ASSOCIATES
LANDSCAPE ARCHITECTURE

PROGRESS SET
NOT FOR CONSTRUCTION

No.	Description	Date

VANTAGE CA31

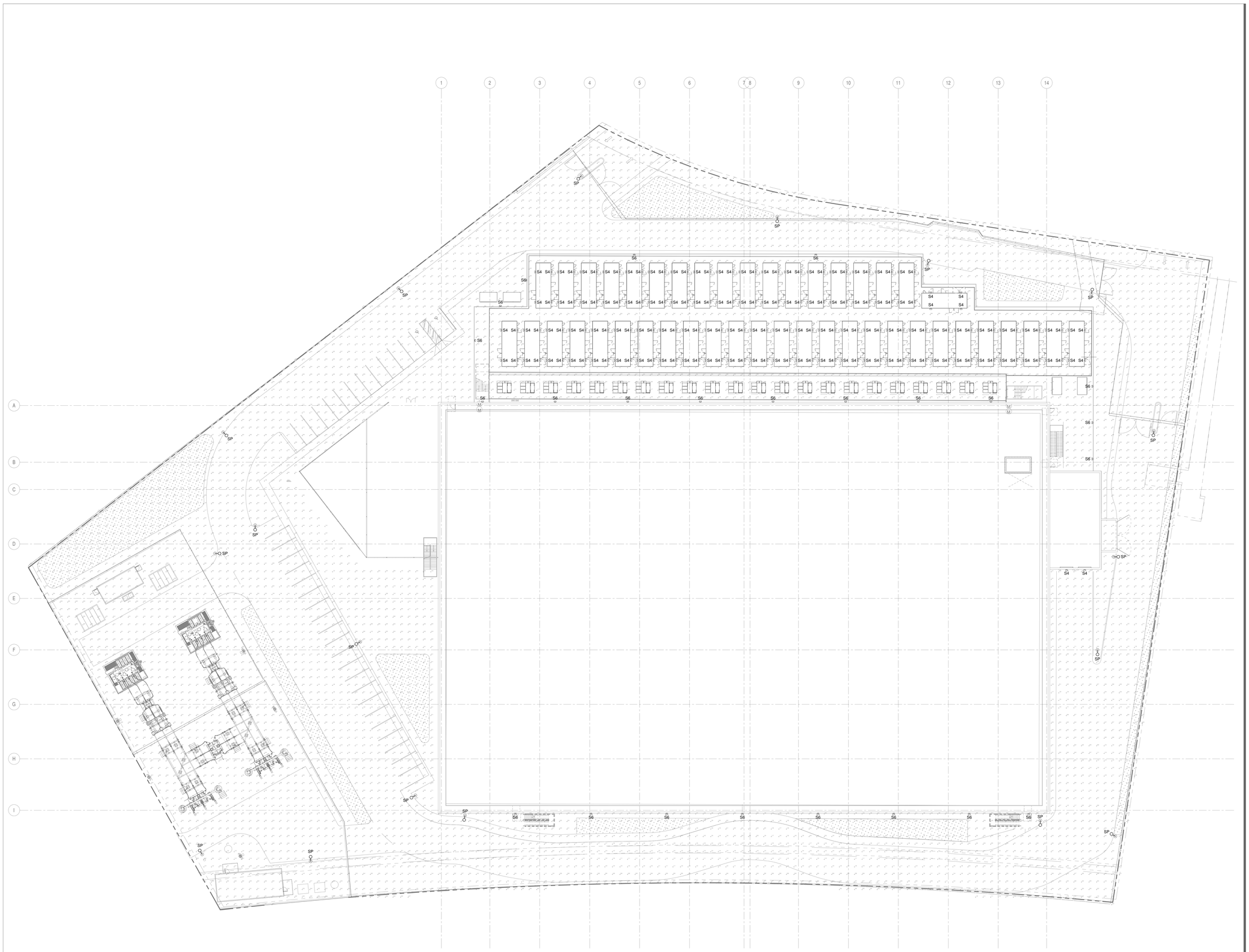
2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

ELECTRICAL SITE LIGHTING PLAN

E100.01

SCALE: AS NOTED



1 SITE LIGHTING PHOTOMETRICS PLAN
1" = 20'-0"

OWNER

VANTAGE DATA CENTERS

ARCHITECT

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REED ASSOCIATES
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PROGRESS SET
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No.	Description	Date

VANTAGE CA31

2590 WALSH AVENUE
SANTA CLARA, CA 95051

ISSUE FOR PCC REVIEW

ELECTRICAL SITE PHOTOMETRICS PLAN

E100.02

SCALE: AS NOTED

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

Date Form Completed: 04/08/21

Provision C.3 Data Form

Completed by: HMH

Which Projects Must Comply with Stormwater Requirements?

All projects that create and/or replace **10,000 sq. ft.** or more of impervious surface on the project site must fill out this worksheet and submit it with the development project application.

All restaurants, auto service facilities, retail gasoline outlets, and uncovered parking lot projects (stand-alone or part of another development project, including the top uncovered portion of parking structures) that create and/or replace **5,000 sq. ft.** or more of impervious surface on the project site must also fill out this worksheet.

Interior remodeling projects, routine maintenance or repair projects such as re-roofing and re-paving, and single family homes that are not part of a larger plan of development are **NOT** required to complete this worksheet.

What is an Impervious Surface?

An impervious surface is a surface covering or pavement that prevents the land's natural ability to absorb and infiltrate rainfall/stormwater. Impervious surfaces include, but are not limited to rooftops, walkways, paved patios, driveways, parking lots, storage areas, impervious concrete and asphalt, and any other continuous watertight pavement or covering. Pervious pavement, underlain with pervious soil or pervious storage material (e.g., drain rock), that infiltrates rainfall at a rate equal to or greater than surrounding unpaved areas OR that stores and infiltrates the water quality design volume specified in Provision C.3.d of the Municipal Regional Stormwater Permit (MRP), is not considered an impervious surface.

For More Information

For more information regarding selection of Best Management Practices for stormwater pollution prevention or stormwater treatment contact: the Environmental Programs Division at environment@santaclara.gov or 408-615-3080

1. Project Information

Project Name: Vantage CA31 **APN #** 216-28-112

Project Address: 2590 Walsh Avenue, Santa Clara, CA 95051

Cross Streets: Walsh Avenue & Northwestern Parkway

Applicant/Developer Name: Vantage

Project Phase(s): 1 **of** 1 **Engineer:** HMH

Project Type (Check all that apply): ☐ New Development ☑ Redevelopment

☑ Private ☐ Public

☐ Residential ☐ Commercial ☑ Industrial ☐ Mixed Use ☐ Institutional

☐ Restaurant ☑ Uncovered Parking ☐ Retail Gas Outlet ☐ Auto Service (SIC code) _____
(5013-5014, 5541, 7532-7534, 7536-7539)

☑ Other Data Center

Project Description: Multi-story data center and power substation along with associated site improvements, landscaping and surface parking

Project Watershed/Receiving Water (creek, river or bay): Guadalupe Creek

2. Project Size

a. Total Site Area: 6.69 acre	**b. Total Site Area Disturbed:** 6.69 **acre** (including clearing, grading, or excavating)				
Impervious Area[1] (IA)	**Pre-project (Existing) IA (ft^2)**	**Existing IA Retained As-is (ft^2) (x)**	**Existing IA Replaced with IA (ft^2) (y)**	**New IA Created (ft^2) (z)**	**Total Post-Project IA (ft^2) (x+y+z)**
Roof	115,000	0	115,000	5,658	120,658
Surface Parking	57,960	0	5,925	0	5,925
Sidewalks, streets, etc.	78,046	0	78,046	44,753	122,799
c. Total Impervious Area	251,006	0	198,971	50,411	249,382
d. Total new and replaced impervious area			249,382		
Pervious Area (PA)	**Pre-project (Existing) PA (ft^2)**				**Total Post-Project PA (ft^2)**
Landscaping[2]	40,610				42,234
Pervious Paving	0				0
Other (e.g. Green Roof)	0				0
e. Total Pervious Area	40,610				42,234
f. Total Area (IA+PA)	291,616				291,616
g. Percent Replacement of IA in Redevelopment Projects (Total Existing IA Replaced with IA ÷ Total Existing IA) x 100% = 79.27 %					

3. State Construction General Permit Applicability:

a. Is #2.b. equal to 1 acre or more?

- ☑ Yes, applicant must obtain coverage under the State Construction General Permit (see www.swrcb.ca.gov/water_issues/programs/stormwater/construction.shtml for details).
- ☐ No, applicant does not need coverage under the State Construction General Permit.

4. MRP Provision C.3 Applicability:

a. Is #2.d. equal to **10,000** sq. ft. or more, or **5,000** sq. ft. or more for restaurants, auto service facilities, retail gas outlets, and stand-alone uncovered parking?

- ☑ Yes, C.3. source control, site design and treatment requirements apply
- ☐ No, C.3. source control and site design requirements may apply – check with local agency

b. For redevelopment projects, is #2.g. equal to 50% or more?

- ☑ Yes, C.3. requirements (site design and source control, as appropriate, and stormwater treatment) apply to the entire site
- ☐ No, C.3. requirements only apply to the impervious area created and/or replaced

5. Hydromodification Management (HM) Applicability:

a. Does the project create and/or replace one acre or more of impervious surface AND is the total post-project impervious area greater than the pre-project (existing) impervious area?

- ☑ Yes (continue)
- ☐ No – exempt from HM, go to page 3

b. Is the project located in an area of HM applicability (green area) on the HM Applicability Map? (www.scvurppp-w2k.com/hmp_maps.htm)

- ☐ Yes, the project must implement HM requirements
- ☑ No, the project is exempt from HM requirements

---

[1] The "new" and "replaced" IA are based on the total area of the site and not specific locations on site. "Retained" means to leave existing IA in place. "Replaced" means to reconstruct IA where existing IA is removed. "New" IA is the quantity of IA that exceeds "Existing" IA at the site.

[2] Include bioretention and infiltration areas in landscaping.

6. Selection of Specific Stormwater Control Measures:

Site Design Measures

- ☐ Minimize land disturbed (e.g., protect trees and soil)
- ☐ Minimize impervious surfaces (e.g., reduction in post-project impervious surface)
- ☐ Minimum-impact street or parking lot design (e.g., parking on top of or under buildings)
- ☑ Cluster structures/ pavement
- ☐ Disconnected downspouts (direct runoff from roofs, sidewalks, patios to landscaped areas)
- ☐ Pervious pavement
- ☐ Green roof
- ☑ Other self-treating[3] area (e.g., landscaped areas)
- ☐ Self-retaining[3] area
- ☐ Interceptor trees[3]
- ☐ Rainwater harvesting and use (e.g., rain barrel, cistern for designated use) [4]
- ☐ Preserved open space: _____ ac. or sq. ft. (circle one)
- ☐ Protected riparian and wetland areas/buffers (Setback from top of bank: _____ft.)
- ☐ Other _____

Source Control Measures

- ☐ Wash area/racks, drain to sanitary sewer[5]
- ☑ Covered dumpster area, drain to sanitary sewer[5]
- ☐ Sanitary sewer connection or accessible cleanout for swimming pool/spa/fountain[5]
- ☑ Beneficial landscaping (minimize irrigation, runoff, pesticides and fertilizers; promotes treatment)
- ☐ Outdoor material storage protection
- ☑ Covers, drains for loading docks, maintenance bays, fueling areas
- ☑ Maintenance (pavement sweeping, catch basin cleaning, good housekeeping)
- ☑ Storm drain labeling
- ☐ Other _____

Treatment Measures

- ☐ None (all impervious surface drains to self-retaining areas)

LID Treatment

- ☑ Bioretention area
- ☐ Flow-through planter
- ☐ Tree Well Filter or Trench with bioretention soils
- ☐ Rainwater harvest/use (e.g., cistern or rain barrel for designated use, sized for C.3.d treatment)
- ☐ Infiltration trench
- ☐ Infiltration well/dry well
- ☐ Subsurface Infiltration System (e.g. vault or large diameter conduit over drain rock)
- ☐ Other _____

Non-LID Treatment Methods

- ☐ Proprietary high flow rate tree box filter[6]
- ☐ Proprietary high flow media filter (sand, compost, or proprietary media)[6]
- ☐ Vegetated filter strip[7]
- ☐ Extended detention basin[7]
- ☐ Vegetated swale[7]
- ☐ Other _____

Flow Duration Controls for Hydromodification Management (HM)

- ☐ Extended Detention basin
- ☐ Underground tank or vault
- ☐ Bioretention with outlet control
- ☐ Other _____

[3] See SCVURPPP C3 Handbook for definitions.
[4] Optional site design measure; does not have to be sized to comply with Provision C.3.d treatment requirements.
[5] Subject to sanitary sewer authority requirements.
[6] These treatment measures are only allowed if the project qualifies as a "Special Project".
[7] These treatment measures are only allowed as part of a multi-step treatment process (i.e., for pretreatment).

7. Stormwater Treatment Measure (STM) Sizing for Projects with Treatment Requirements

Stormwater Treatment Measure (STM)	Hydraulic Sizing Criteria Used*
Bioretention	3
	Choose from list
	Choose from list
	Choose from list

*Key: 1a: Volume – WEF Method
1b: Volume – CASQA BMP Handbook Method
2a: Flow – Factored Flood Flow Method
2b: Flow – CASQA BMP Handbook Method
2c: Flow – Uniform Intensity Method
3: Combination Flow and Volume Design Basis

8. Alternative Certification: Was the treatment system sizing and design reviewed by a qualified third-party professional that is not a member of the project team or agency staff?

☑ Yes ☐ No Name of Third-party Reviewer Schaaf & Wheeler

9. Operation & Maintenance Information

A. Property Owner's Name Vantage Data Centers

B. Responsible Party for Stormwater Treatment/Hydromodification Control O&M:

a. Name: Simon Casey

b. Address: 2820 Northwestern Parkway, Santa Clara, CA 95051

c. Phone/E-mail: scasey@vantage-dc.com

This section to be completed by Municipal staff.

O&M Responsibility Mechanism

Indicate how responsibility for O&M is assured. Check all that apply:

☐ O&M Agreement

☐ Other mechanism that assigns responsibility (describe below):

_____

This section to be completed by Municipal staff (Note: This is an optional section that agencies should modify per their internal review and tracking process.)

Reviewed By:

Community Development Department

Planning Division: _____

Building Division: _____

Public Works Department

Engineering: _____

Other (Specify): _____

Return form to: _____

Data entry performed by: _____

SHEEHAN
NAGLE
HARTRAY
ARCHITECTS

June 4, 2021

Zoning Administrator
Planning Division
1500 Warburton Avenue
Santa Clara, California 95050

Re: 2590 Walsh Avenue (CA31) Proposed Project – Minor Modification Request

Dear Zoning Administrator,

This letter is in support of our request for a minor modification to the building height of the proposed project located at 2590 Walsh Avenue. The project is located in the Light Industrial Zoning District, which allows a maximum building height of 70 feet. The height of the proposed buildings to the top of the roof would be approximately 87.5 feet above ground surface (102.3 feet above ground surface to the top of the roof top mechanical equipment screen wall). Buildings under this zoning designation are required to have a minimum 15-foot setback distance from the street. The proposed building would be set back from the street by more than 100 feet and set back from the side and rear of the property line by more than 47'.

We are requesting a zoning administrator modification to allow for a height increase of up to 25 percent, and as such is consistent with the minor modification conditions. With approval of a zoning administrator modification, the project would be consistent with the development standards for the Light Industrial zoning designation and the proposed data center uses would be consistent with allowed uses for the Light Industrial zoning designation

Thank you for your consideration.

Sincerely,

Duane Hill, AIA
Associate Principal

ATTACHMENT TRANS DR-25

Thermal Plume Analysis

Prepared for
Vantage Data Centers
Santa Clara, California

Prepared by
Ramboll US Consulting, Inc.
San Francisco, California

Project Number
1690020771

Date
June 2021

PLUME ASSESSMENT
VANTAGE CA3 DATA CENTER
SANTA CLARA, CALIFORNIA

RAMBOLL

CONTENTS

TABLES

FIGURES

ACRONYMS AND ABBREVIATIONS

ACFM	Actual cubic feet per minute
CASA	Civil Aviation Safety Authority
CEC	California Energy Commission
F	Fahrenheit
ft	feet
ft/s	feet per second
K	Kelvin
m	meter
m/s	meters per second
s	second

1. INTRODUCTION

1.1 Background

Vantage Data Centers has proposed to develop a data center in Santa Clara, California, at 2590 Walsh Ave. The data center will involve forty-four (44) backup emergency diesel generators and forty-eight (48) roof-mounted air chillers.

The California Energy Commission (CEC) has asked Vantage Data Centers to evaluate the potential implications of the thermal plumes from the proposed stacks on aviation safety. Ramboll has been engaged by Vantage to undertake this assessment and has completed a screening assessment. The assessment of vertical plume velocity was conducted in accordance with CEC methodology, invoking the Spillane methodology to analytically solve for plume height. The effect of merged plumes are taken into account.

The acceptable plume vertical velocity threshold is specified in supplemental testimony of James Adams and Appendix TT-2 of a CEC project titled "Palmdale Energy Project" (PEP) docketed on December 29, 2016. This project defines the significance level of 5.3 m/s at all heights above 1,500 feet AGL (above ground level). The threshold of 5.3 m/s average velocity is used in this assessment.

The vertical velocity of the emissions from the emergency standby generators and the air-cooled chillers will be greater than 5.3 m/s at the point of discharge and therefore an assessment of the vertical velocity is required to be undertaken.

2. SCREENING ASSESSMENT

2.1 Vertical plume velocity guidelines

The assessment will conservatively determine the potential for turbulence generated by the plume-averaged vertical velocity of the emergency standby generator and chiller exhaust plumes. The method uses worst-case assumptions of calm winds and neutral atmospheric conditions for the entire vertical extent of the plume to determine the worst-case impacts.

Since the development of a simple-cycle gas turbine power station at the end of a runway in Australia in the mid-1990s,[1] the Australian Civil Aviation Safety Authority (CASA) has taken an active role in the review of the siting of facilities with the potential to affect aviation activities.

Potential hazards that could affect the safety of aircraft include tall visible or invisible obstructions. Visible obstructions include structures such as tall stacks or communication towers. Invisible obstructions include industrial exhausts that generate significant turbulence due to high velocity and buoyancy. CASA has issued an Advisory Circular, (CASA 2004) that specifies the requirements and methodologies to be used to assess whether a new industrial plume is likely to have adverse implications for aviation safety.

The general CASA requirement is to determine the height at which the plume (or plumes) could generate atmospheric turbulence and to determine the dimensions of the plume in these circumstances. The frequency of in-plume vertical velocities at the lowest height an aircraft may travel over the site, and at other heights are also required. For large plumes that are remote from airports, CASA requires an assessment that determines the size of a hazard zone to alert pilots to the potential hazard. Normally this analysis uses a sophisticated air dispersion model that determines plume vertical velocities and lateral/vertical extents based on wind fields generated from actual meteorological data. Rather than use such a refined technique, a conservative screening analysis based on calm wind field assumptions was used for this project.

For this assessment, the plume-averaged vertical velocities were calculated as a function of height under calm conditions. The established CEC significance criteria is for an averaged plume velocity to equal or exceed 5.3 m/s at altitudes where aircraft can operate. This significance criteria was adopted in the CEC Palmdale Energy Project.

[1] Note that this project consists of internal combustion engines (ICEs) and air-cooled chillers that have plume exhausts with much smaller volumetric flows and buoyancy fluxes than the turbine projects that elicited the initial interest of CASA.

3. MODEL INPUT DATA

3.1 Emissions information

The proposed data center will have a number of atmospheric emission sources including:

1. Emergency standby diesel generators; and
2. Air-cooled "free cooling" chillers;

The highest exit velocity and emissions volume is associated with the emergency generators and therefore the screening assessment has primarily focused on these sources. An additional scenario associated with the cooling towers was also included. The emission parameters used within the screening assessment for the three scenarios considered for emergency generators and one scenario considered for the chillers are presented in Table 1.

Table 1. Stack Parameters

	Emergency generators		
	Scenario 1 - Worst-case	**Scenario 2**	**Scenario 3**
Ambient Potential Temp (F)	30	59	76
Stack Height (feet)	33.0	33.0	33.0
Stack Diameter (feet)	1.8	1.8	1.8
Stack Velocity at exit (m/s)	42.2	42.2	42.2
Stack Potential Temp (F)	893	893	893
	Air-cooled chillers		
	Scenario 1 - Worst-case		
Ambient Potential Temp (F)	30		
Stack Height (feet)	109.7		
Stack Diameter (feet)	3		
Stack Velocity at exit (m/s)	9.8		
Stack Potential Temp (F)	125.0		

The 44 generator stacks and 48 chiller stacks are arranged in the configuration displayed in Figure 1. Although the project consists of 40 3-MW generators and four 4-MW generators, the 4-MW generators were assumed to have the same stack parameters as a 3-MW generator for ease of calculation. The chillers are located on the roofs of the buildings. Buildings are approximately 104 feet in height. The chillers are placed on acoustical stacks which are 66" tall. The top of the chillers would be nearly 110 feet above ground level (including the 5' 6" for the platforms).

3.2 Methodology

This assessment analyses vertical plume rise using the Spillane methodology, developed by Dr. Kevin Spillane, to analytically solve for plume heights above the jet phase in calm conditions. Three methods were evaluated: Method 1 assumes conservation of buoyancy and a Gaussian distribution of the vertical velocities, Method 2 is based on the Best et al., 2003 paper's analytical solution, and Method 3 considers the enhancement of vertical velocities that may occur if the plumes from multiple stacks merge and form a higher buoyancy combined/merged plume. Method 3, developed by the CEC, is based on the single stack plume velocity multiplied by the number of stacks raised to the 0.25 power.

Table 2. Model Results

Assumptions							Maximum Height Above Ground with Vertical Velocity above Threshold (5.3 m/s)		
Source (Number of Units)	**Ambient Temperature**	**Stack Height (h_s)**	**Stack Diameter (D)**	**Stack Velocity (V_{exit})**	**Volumetric Flow**	**Stack Potential Temperature (θ_S)**	**Method 1**	**Method 2**	**Merged Plumes**
Emergency Diesel Generators (44)	272 K (30°F)	10.06 m (33.0 ft)	0.56 m (1.8 ft)	42.22 m/s (138.5 ft/s)	21,189 ACFM	752 K (893.1°F)	25.30 m (83 ft)	21.03 m (69 ft)	21.03 m (69 ft)
Chillers[1] (48)	272 K (30°F)	33.43 m (110 ft)	0.91 m (3.0 ft)	9.79 m/s (32.1 ft/s)	13,627 ACFM	325 K (125.0°F)	39.01 m (128 ft)	38.41 m (126 ft)	39.93 m (131 ft)

Notes:

[1] These values apply for a single fan; for a turbine array, a volumetric flow was utilized for 26 adjacent fans, as is the case for the facility chillers.

4. MODEL RESULTS

4.1 Worst-case calm wind scenario

Plumes that may have a vertical velocity of greater than 5.3 m/s are of primary interest to the airport safety authorities. While the vertical velocity of the plumes at the point of discharge are in excess of 5.3 m/s, the vertical velocity is quickly dissipated following discharge as the plume mixes with ambient air.

Ramboll evaluated all three scenarios described in Table 1, and determined that the worst-case scenario was assuming an ambient temperature of 30 F. Accordingly, an assessment assuming calm winds for the entire height of the plume and an ambient temperature of 30 F is presented here to represent the worst-case. Results of the plume vertical velocities at various heights are presented in Appendix A and summarized in Table 2 based both the Spillane methodology and the CEC methodology (merged plumes).

For this conservative analysis, both single plume and merged plume velocities were evaluated. Using the Spillane methodology Method 1, the plume-averaged vertical velocity drops below the CEC screening threshold of 5.3 m/s at 83 feet above ground level for one emergency generator and at 128 feet above ground level for one chiller. Method 2 yielded slightly lower heights than Method 1. Using the CEC methodology of merged plumes, the vertical velocity drops below 5.3 m/s for the 44 generators at 69 feet above ground level and for the 48 chillers at 131 feet above ground level.

5. SUMMARY AND CONCLUSION

Modelling of the characteristics of the plumes from the diesel emergency generators and roof-mounted air chillers at the Vantage McLaren data center has been completed and indicates:

1. Under worst-case ambient conditions and calculation methodology, predicted vertical velocities are below 5.3 m/s for emergency generators at a height of 83 feet above ground; and
2. Under worst-case ambient conditions and calculation methodology, predicted vertical velocities are below 5.3 m/s for roof-mounted air chillers at a height of 131 feet above ground.

6. REFERENCES

Best, P., Jackson, L., Killip, C., Kanowski, M., Spillane, K. (2003) "Aviation Safety and Buoyant Plumes." Clean Air Conference, Newcastle, New South Wale, Australia.

FIGURES

- Emergency Generator Stacks
- Chillers
- Buildings & Structures
- Facility Boundary

0 50 100 Meters

STACK AND CHILLER LOCATIONS
VANTAGE CA3 CAMPUS

Vantage CA3
2590 Walsh Avenue
Santa Clara, California

FIGURE 01

RAMBOLL US CORPORATION
A RAMBOLL COMPANY

RAMBOLL

	Assumptions						Maximum Height Above Ground with Vertical Velocity above Threshold (5.3 m/s)		
Source (Number of Units)	**Ambient Temperature**	**Stack Height (h_s)**	**Stack Diameter (D)**	**Stack Velocity (V_{exit})**	**Volumetric Flow**	**Stack Potential Temperature (θ_s)**	**Method 1**	**Method 2**	**Merged Plumes**
Emergency Diesel Generators (44)	272 K (30°F)	10.06 m (33 ft)	0.56 m (1.8 ft)	42.22 m/s (138.5 ft/s)	21,189 ACFM	752 K (893.1°F)	25.30 m (83 ft)	21.03 m (69 ft)	21.03 m (69 ft)
Chillers (48)	272 K (30°F)	33.43 m (109.7 ft)	0.91 m (3.0 ft)	9.79 m/s (32.1 ft/s)	13,627 ACFM	325 K (125.0°F)	39.01 m (128 ft)	38.41 m (126 ft)	39.93 m (131 ft)

Stack Parameters			
Emergency generators			
	Scenario 1 - Worst-case	Scenario 2	Scenario 3
Ambient Potential Temp (F)	30	59	76
Stack Height (feet)	33	33	33
Stack Diameter (feet)	1.8	1.8	1.8
Stack Velocity at exit (m/s)	42.2	42.2	42.2
Stack Potential Temp (F)	893	893	893
Air-cooled chillers			
	Scenario 1 - Worst-case		
Ambient Potential Temp (F)	30		
Stack Height (feet)	109.7		
Stack Diameter (feet)	3		
Stack Velocity at exit (m/s)	9.8		
Stack Potential Temp (F)	125.0		

PETER BEST PAPER ILLUSTRATIVE EXAMPLE - SINGLE TURBINE - Assumes Heights in Table 2 are meters above ground

Plume Averaged Vertical Velocities: **"*Aviation Safety and Buoyant Plumes*," Peter Best, et. al.**

Ambient Conditions:

					Constants:		
Ambient Potential Temp θ_a	272	Kelvins	30.0	°F	Assume neutral conditions (dθ/dz=0)		
Plume Exit Conditions:					Gravity g	9.81	m/s^2
Stack Height h_s	10.06	meters	33.0	feet	λ	1.11	
Stack Diameter D	0.56	meters	1.8	feet		0.3048	meters/feet
Stack Velocity V_{exit}	42.2	m/s	138.5	ft/sec			
Volumetric Flow	10	cu.m/sec	21,189	ACFM	$\pi V_{exit}D^2/4$		Sect.2/¶1
Stack Potential Temp θ_s	752	Kelvins	893	°F	Back-Calc'd from Buoyancy Flux		
Initial Stack Buoyancy Flux F_o	21	m^4/s^3			$gV_{exit}D^2(1-\theta_a/\theta_s)/4$ = Vol.Flow(g/π)(1-θ_a/θ_s)		Sect.2/¶1
Plume Buoyancy Flux F	N/A	m^4/s^3			$\lambda^2 gVa^2(1-\theta_a/\theta_s)$ for a,V,θ_o at plume height (not used here)		

Conditions at End (Top) of Jet Phase:

Height above Stack z	3.493	meters*	11.5	feet*	6.25D, meters*=meters above stack top		Sect.3/¶1
Height above Ground z+h_s	13.551	meters	44.5	feet	h_s + 6.25D		"
Vertical Velocity V_{plume}	21.110	m/s	69.26	ft/sec	0.5V_{exit}	$V_{exit}/2$	"
Plume Top-Hat Diameter 2a	1.118	meters	3.7	feet	2D	Conservation of momentum	"

Spillane Methodology - Analytical Solutions for Calm Conditions for Plume Heights above Jet Phase

Plume Top-Hat Radius a	**Solutions in Table Below**				0.16(z-z_v), or linear increase with height	Sect.2/Eq.6
Virtual Source Height z_v	1.391	meters*	4.6	feet*	6.25D[1-(θ_a/θ_s)$^{1/2}$], meters*=meters above stack top	Sect.2/Eq.6
Height above Ground z_v+h_s	11.450	meters	37.6	feet	where (θ_a/θ_s)$^{1/2}$ = (θ_a/θ_s)$^{1/2}$= 0.6016438	

Method(1): Simplified Plume-averaged Vertical Velocity V' - Assumes Product Va constant above jet phase such that $V_{plume}(2a) = V_{exit}D$

Vertical Velocity V'	**Solutions in Table Below**			$V_{exit}D/2a'$ (conservation of buoyancy)	Sect.3&4

Method(2): Plume-averaged Vertical Velocity V given by Analytical Solution in Paper where Product Va given by equations below:

Vertical Velocity V	**Solutions in Table Below**			$\{(Va)_o^3 + 0.12F_o[(z-z_v)^2 - (6.25D-z_v)^2]\}^{(1/3)}$ / a	Sect.2.1(6)
Product $(Va)_o$	7.097	m^2/s		$V_{exit}D/2(\theta_a/\theta_s)^{1/2}$	

Table of plume Top-Hat Diameters (2a) and Plume-averaged Vertical Velocities for both Method(1) (assuming conservation of buoyancy & gaussian distribution of vertical velocities) and Method (2) (based on Peter Best's paper's Analytical Solution) starting at end of jet phase:

from 100 meters above ground in increments of 50.0 meters

				Vert.Vel (m/s)	
				Method(1)	Method(2)
Ht above Ground =	h_{plume}+h_s	D_{plume}=2a=	V_{plume}=	$\{(Va)_o^3+0.12F_o[(z-z_v)^2$
Height above stack top, meters*	meters	feet	2*0.16(z-z_v)	V_{exit}*D/2a	$-(6.25D-z_v)^2]\}^{1/3}$ / a
End of jet phase at 6.25D = 3.493 meters*	***13.551***	***44.5***	***1.118***		***21.11***
89.941 meters*	**100.000**	328.1	28.336	0.83	**1.91**
139.941 meters*	150.000	492.1	44.336	0.53	1.64
189.941 meters*	**200.000**	656.2	60.336	0.39	**1.48**
239.941 meters*	250.000	820.2	76.336	0.31	1.36
289.941 meters*	**300.000**	984.3	92.336	0.26	**1.28**
339.941 meters*	350.000	1148.3	108.336	0.22	1.21
389.941 meters*	400.000	1312.3	124.336	0.19	1.16
439.941 meters*	450.000	1476.4	140.336	0.17	1.11
489.941 meters*	**500.000**	1640.4	156.336	0.15	**1.07**
539.941 meters*	550.000	1804.5	172.336	0.14	1.04
589.941 meters*	600.000	1968.5	188.336	0.13	1.01
639.941 meters*	650.000	2132.5	204.336	0.12	0.98
689.941 meters*	**700.000**	2296.6	220.336	0.11	**0.96**
739.941 meters*	750.000	2460.6	236.336	0.10	0.94
789.941 meters*	800.000	2624.7	252.336	0.09	0.92
839.941 meters*	850.000	2788.7	268.336	0.09	0.90
889.941 meters*	900.000	2952.8	284.336	0.08	0.88
939.941 meters*	950.000	3116.8	300.336	0.08	0.86
989.941 meters*	**1000.000**	3280.8	316.336	0.07	**0.85**
1039.941 meters*	1050.000	3444.9	332.336	0.07	0.83
1089.941 meters*	1100.000	3608.9	348.336	0.07	0.82
1139.941 meters*	1150.000	3773.0	364.336	0.06	0.81
1189.941 meters*	1200.000	3937.0	380.336	0.06	0.80
1239.941 meters*	1250.000	4101.0	396.336	0.06	0.79

8.230 meters*	18.288	60.0	2.188	10.78	7.07
10.973 meters*	21.031	69.0	3.066	7.69	5.42
11.278 meters*	21.336	70.0	3.164	7.46	5.30
11.583 meters*	21.641	71.0	3.261	7.23	5.18
11.887 meters*	21.946	72.0	3.359	7.02	5.08
12.192 meters*	22.251	73.0	3.456	6.83	4.97
12.497 meters*	22.555	74.0	3.554	6.64	4.88
12.802 meters*	22.860	75.0	3.651	6.46	4.79
13.107 meters*	23.165	76.0	3.749	6.29	4.71
13.411 meters*	23.470	77.0	3.846	6.13	4.63
13.716 meters*	23.775	78.0	3.944	5.98	4.55
14.021 meters*	24.079	79.0	4.042	5.84	4.48
14.326 meters*	24.384	80.0	4.139	5.70	4.41
14.631 meters*	24.689	81.0	4.237	5.57	4.35
14.935 meters*	24.994	82.0	4.334	5.44	4.28
15.240 meters*	25.299	83.0	4.432	5.32	4.23
15.545 meters*	25.604	84.0	4.529	5.21	4.17
15.850 meters*	25.908	85.0	4.627	5.10	4.12
16.155 meters*	26.213	86.0	4.724	4.99	4.07
16.459 meters*	26.518	87.0	4.822	4.89	4.02
16.764 meters*	26.823	88.0	4.919	4.80	3.97
17.069 meters*	27.128	89.0	5.017	4.70	3.93
17.374 meters*	27.432	90.0	5.114	4.61	3.88
17.679 meters*	27.737	91.0	5.212	4.53	3.84
17.983 meters*	28.042	92.0	5.309	4.44	3.80
18.288 meters*	28.347	93.0	5.407	4.36	3.76
18.593 meters*	28.652	94.0	5.505	4.29	3.73
18.898 meters*	28.956	95.0	5.602	4.21	3.69
19.203 meters*	29.261	96.0	5.700	4.14	3.66
19.507 meters*	29.566	97.0	5.797	4.07	3.62
19.812 meters*	29.871	98.0	5.895	4.00	3.59
20.117 meters*	30.176	99.0	5.992	3.94	3.56
20.422 meters*	30.480	100.0	6.090	3.87	3.53
20.727 meters*	30.785	101.0	6.187	3.81	3.50

Stack Distances (ft)	Number of Stacks
14.96	44

ft	m/s	merged cells	Plume Diamter Feet
60	7.07	1.00	7.18
69	5.42	1.00	10.06
70	5.30	1.00	10.38
71	5.18	1.00	10.70
72	5.08	1.00	11.02
73	4.97	1.00	11.34
74	4.88	1.00	11.66
75	4.79	1.00	11.98
76	4.71	1.00	12.30
77	4.63	1.00	12.62
78	4.55	1.00	12.94
79	4.49	1.01	13.26
80	4.44	1.03	13.58
81	4.40	1.05	13.90
82	4.36	1.07	14.22
83	4.32	1.09	14.54
84	4.29	1.12	14.86
85	4.25	1.14	15.18
86	4.22	1.16	15.50
87	4.19	1.18	15.82
88	4.16	1.20	16.14
89	4.13	1.22	16.46
90	4.10	1.24	16.78
91	4.07	1.27	17.10
92	4.05	1.29	17.42
93	4.02	1.31	17.74
94	4.00	1.33	18.06
95	3.98	1.35	18.38
96	3.96	1.37	18.70
97	3.94	1.39	19.02
98	3.92	1.42	19.34
99	3.90	1.44	19.66
100	3.88	1.46	19.98
101	3.86	1.48	20.30

21.031 meters*	31.090	102.0	6.285	3.75	3.47
21.336 meters*	31.395	103.0	6.382	3.70	3.45
21.641 meters*	31.700	104.0	6.480	3.64	3.42
21.946 meters*	32.004	105.0	6.577	3.59	3.40
22.251 meters*	32.309	106.0	6.675	3.53	3.37
22.555 meters*	32.614	107.0	6.773	3.48	3.35
22.860 meters*	32.919	108.0	6.870	3.43	3.32
23.165 meters*	33.224	109.0	6.968	3.39	3.30
23.470 meters*	33.528	110.0	7.065	3.34	3.28
26.518 meters*	36.576	120.0	8.041	2.93	3.09
26.823 meters*	36.881	121.0	8.138	2.90	3.07
27.128 meters*	37.186	122.0	8.236	2.86	3.05
27.432 meters*	37.491	123.0	8.333	2.83	3.04
27.737 meters*	37.796	124.0	8.431	2.80	3.02
28.042 meters*	38.100	125.0	8.528	2.77	3.01
28.347 meters*	38.405	126.0	8.626	2.74	2.99
28.652 meters*	38.710	127.0	8.723	2.70	2.98
28.956 meters*	39.015	128.0	8.821	2.67	2.96
29.261 meters*	39.320	129.0	8.918	2.65	2.95
29.566 meters*	39.624	130.0	9.016	2.62	2.93
32.614 meters*	42.673	140.0	9.991	2.36	2.81
35.662 meters*	45.721	150.0	10.967	2.15	2.70
38.710 meters*	48.769	160.0	11.942	1.98	2.61
41.758 meters*	51.817	170.0	12.917	1.83	2.53
44.806 meters*	54.865	180.0	13.893	1.70	2.46
47.854 meters*	57.913	190.0	14.868	1.59	2.40
50.902 meters*	60.961	200.0	15.844	1.49	2.35
81.383 meters*	91.441	300.0	25.597	0.92	1.98
111.863 meters*	121.921	400.0	35.351	0.67	1.77
142.343 meters*	152.402	500.0	45.105	0.52	1.63
172.824 meters*	182.882	600.0	54.858	0.43	1.52
203.304 meters*	213.363	700.0	64.612	0.37	1.44
233.784 meters*	243.843	800.0	74.366	0.32	1.38
264.265 meters*	274.323	900.0	84.120	0.28	1.32
294.745 meters*	304.804	1000.0	93.873	0.25	1.27
325.226 meters*	335.284	1100.0	103.627	0.23	1.23
355.706 meters*	365.764	1200.0	113.381	0.21	1.20
386.186 meters*	396.245	1300.0	123.134	0.19	1.16
416.667 meters*	426.725	1400.0	132.888	0.18	1.13
447.147 meters*	457.206	1500.0	142.642	0.17	1.11
477.627 meters*	487.686	1600.0	152.396	0.15	1.08
508.108 meters*	518.166	1700.0	162.149	0.15	1.06
538.588 meters*	548.647	1800.0	171.903	0.14	1.04
569.069 meters*	579.127	1900.0	181.657	0.13	1.02
599.549 meters*	609.607	2000.0	191.410	0.12	1.00
630.029 meters*	640.088	2100.0	201.164	0.12	0.99
660.510 meters*	670.568	2200.0	210.918	0.11	0.97
690.990 meters*	701.049	2300.0	220.672	0.11	0.96
721.470 meters*	731.529	2400.0	230.425	0.10	0.94
751.951 meters*	762.009	2500.0	240.179	0.10	0.93
782.431 meters*	792.490	2600.0	249.933	0.09	0.92
812.911 meters*	822.970	2700.0	259.686	0.09	0.91
843.392 meters*	853.450	2800.0	269.440	0.09	0.90
873.872 meters*	883.931	2900.0	279.194	0.08	0.88
904.353 meters*	914.411	3000.0	288.948	0.08	0.87
934.833 meters*	944.891	3100.0	298.701	0.08	0.87
965.313 meters*	975.372	3200.0	308.455	0.08	0.86
995.794 meters*	1005.852	3300.0	318.209	0.07	0.85
1026.274 meters*	1036.333	3400.0	327.962	0.07	0.84
1056.754 meters*	1066.813	3500.0	337.716	0.07	0.83
1087.235 meters*	1097.293	3600.0	347.470	0.07	0.82
1117.715 meters*	1127.774	3700.0	357.224	0.07	0.82
1148.196 meters*	1158.254	3800.0	366.977	0.06	0.81
1178.676 meters*	1188.734	3900.0	376.731	0.06	0.80
1209.156 meters*	1219.215	4000.0	386.485	0.06	0.79

102	3.85	1.50	20.62
103	3.83	1.52	20.94
104	3.81	1.54	21.26
105	3.80	1.56	21.58
106	3.78	1.59	21.90
107	3.77	1.61	22.22
108	3.75	1.63	22.54
109	3.74	1.65	22.86
110	3.73	1.67	23.18
120	3.62	1.89	26.38
121	3.61	1.91	26.70
122	3.60	1.93	27.02
123	3.59	1.95	27.34
124	3.58	1.97	27.66
125	3.57	1.99	27.98
126	3.56	2.01	28.30
127	3.55	2.04	28.62
128	3.55	2.06	28.94
129	3.54	2.08	29.26
130	3.53	2.10	29.58
140	3.46	2.31	32.78
150	3.41	2.53	35.98
160	3.36	2.74	39.18
170	3.32	2.96	42.38
180	3.29	3.17	45.58
190	3.26	3.38	48.78
200	3.23	3.60	51.98
300	3.06	5.74	83.98
400	2.96	7.87	115.98
500	2.90	10.01	147.98
600	2.85	12.15	179.98
700	2.81	14.29	211.98
800	2.77	16.43	243.98
900	2.74	18.57	275.98
1,000	2.72	20.71	307.98
1,100	2.69	22.85	339.98
1,200	2.67	24.99	371.98
1,300	2.65	27.13	403.98
1,400	2.64	29.26	435.98
1,500	2.62	31.40	467.99
1,600	2.61	33.54	499.99
1,700	2.59	35.68	531.99
1,800	2.58	37.82	563.99
1,900	2.57	39.96	595.99
2,000	2.56	42.10	627.99
2,100	2.54	44.00	659.99
2,200	2.50	44.00	691.99
2,300	2.46	44.00	723.99
2,400	2.43	44.00	755.99
2,500	2.40	44.00	787.99
2,600	2.36	44.00	819.99
2,700	2.33	44.00	851.99
2,800	2.31	44.00	883.99
2,900	2.28	44.00	915.99
3,000	2.25	44.00	947.99
3,100	2.23	44.00	979.99
3,200	2.20	44.00	1011.99
3,300	2.18	44.00	1043.99
3,400	2.16	44.00	1075.99
3,500	2.14	44.00	1107.99
3,600	2.12	44.00	1139.99
3,700	2.10	44.00	1171.99
3,800	2.08	44.00	1203.99
3,900	2.06	44.00	1235.99
4,000	2.04	44.00	1267.99

PETER BEST PAPER ILLUSTRATIVE EXAMPLE - SINGLE TURBINE - Assumes Heights in Table 2 are meters above ground

Plume Averaged Vertical Velocities: **"*Aviation Safety and Buoyant Plumes*," Peter Best, et. al.**

Ambient Conditions:

Ambient Potential Temp θ_a	**288**	Kelvins	**59.0**	°F	Assume neutral conditions (dθ/dz=0)
Plume Exit Conditions:					Gravity g 9.81 m/s²
Stack Height h_s	**10.06**	meters	**33.0**	feet	λ 1.11
Stack Diameter D	**0.56**	meters	**1.8**	feet	0.3048 meters/feet
Stack Velocity V_{exit}	**42.2**	m/s	**138.5**	ft/sec	
Volumetric Flow	**10**	cu.m/sec	**21,189**	ACFM	$\pi V_{exit}D^2/4$ Sect.2/¶1
Stack Potential Temp θ_s	**752**	Kelvins	**893**	°F	Back-Calc'd from Buoyancy Flux
Initial Stack Buoyancy Flux F_o	**20**	m^4/s^3			$gV_{exit}D^2(1-\theta_a/\theta_s)/4$ = Vol.Flow$(g/\pi)(1-\theta_a/\theta_s)$ Sect.2/¶1
Plume Buoyancy Flux F	N/A	m^4/s^3			$\lambda^2 gVa^2(1-\theta_a/\theta_b)$ for a,V,θ_b at plume height (not used here)

Conditions at End (Top) of Jet Phase:

Height above Stack z	**3.493**	meters*	**11.5**	feet*	6.25D, meters*=meters above stack top		Sect.3/¶1
Height above Ground z+h_s	**13.551**	meters	**44.5**	feet	h_s + 6.25D		"
Vertical Velocity V_{plume}	**21.110**	m/s	**69.26**	ft/sec	$0.5V_{exit}$	$V_{exit}/2$	"
Plume Top-Hat Diameter 2a	**1.118**	meters	**3.7**	feet	2D	Conservation of momentum	"

Spillane Methodology - Analytical Solutions for Calm Conditions for Plume Heights above Jet Phase

Plume Top-Hat Radius a	**Solutions in Table Below**			$0.16(z-z_v)$, or linear increase with height	Sect.2/Eq.6
Virtual Source Height z_v	**1.330**	meters*	**4.4**	feet*	$6.25D[1-(\theta_a/\theta_s)^{1/2}]$, meters*=meters above stack top Sect.2/Eq.6
Height above Ground z_v+h_s	**11.388**	meters	**37.4**	feet	where $(\theta_a/\theta_s)^{1/2} = (\theta_a/\theta_s)^{1/2}$= 0.619203299

Method(1): Simplified Plume-averaged Vertical Velocity V' - Assumes Product Va constant above jet phase such that $V_{plume}(2a) = V_{exit}D$

Vertical Velocity V'	**Solutions in Table Below**			$V_{exit}D/2a'$ (conservation of buoyancy)	Sect.3&4

Method(2): Plume-averaged Vertical Velocity V given by Analytical Solution in Paper where Product Va given by equations below:

Vertical Velocity V	**Solutions in Table Below**			$\{(Va)_o^3 + 0.12F_o[(z-z_v)^2 - (6.25D-z_v)^2]\}^{(1/3)} / a$	Sect.2.1(6)
Product $(Va)_o$	**7.304**	m^2/s		$V_{exit}D/2(\theta_a/\theta_s)^{1/2}$	

Table of plume Top-Hat Diameters (2a) and Plume-averaged Vertical Velocities for both Method(1) (assuming conservation of buoyancy & gaussian distribution of vertical velocities) and Method (2) (based on Peter Best's paper's Analytical Solution) starting at end of jet phase:

from 100 meters above ground in increments of 50.0 meters

				Vert.Vel (m/s)	
				Method(1)	Method(2)
	Ht above Ground =	$h_{plume}+h_s$	$D_{plume}=2a=$	$V_{plume}=$	$\{(Va)_o^3+0.12F_o[(z-z_v)^2$
Height above stack top, meters*	meters	feet	$2*0.16(z-z_v)$	$V_{exit}*D/2a$	$-(6.25D-z_v)^2]\}^{1/3}$ / a
End of jet phase at 6.25D = 3.493 meters*	***13.551***	***44.5***	***1.118***		***21.11***
89.941 meters*	**100.000**	328.1	28.356	0.83	**1.89**
139.941 meters*	150.000	492.1	44.356	0.53	1.62
189.941 meters*	**200.000**	656.2	60.356	0.39	**1.46**
239.941 meters*	250.000	820.2	76.356	0.31	1.35
289.941 meters*	**300.000**	984.3	92.356	0.26	**1.27**
339.941 meters*	350.000	1148.3	108.356	0.22	1.20
389.941 meters*	400.000	1312.3	124.356	0.19	1.15
439.941 meters*	450.000	1476.4	140.356	0.17	1.10
489.941 meters*	**500.000**	1640.4	156.356	0.15	**1.06**
539.941 meters*	550.000	1804.5	172.356	0.14	1.03
589.941 meters*	600.000	1968.5	188.356	0.13	1.00
639.941 meters*	650.000	2132.5	204.356	0.12	0.97
689.941 meters*	**700.000**	2296.6	220.356	0.11	**0.95**
739.941 meters*	750.000	2460.6	236.356	0.10	0.92
789.941 meters*	800.000	2624.7	252.356	0.09	0.90
839.941 meters*	850.000	2788.7	268.356	0.09	0.89
889.941 meters*	900.000	2952.8	284.356	0.08	0.87
939.941 meters*	950.000	3116.8	300.356	0.08	0.85
989.941 meters*	**1000.000**	3280.8	316.356	0.07	**0.84**
1039.941 meters*	1050.000	3444.9	332.356	0.07	0.83
1089.941 meters*	1100.000	3608.9	348.356	0.07	0.81
1139.941 meters*	1150.000	3773.0	364.356	0.06	0.80
1189.941 meters*	1200.000	3937.0	380.356	0.06	0.79
1239.941 meters*	1250.000	4101.0	396.356	0.06	0.78

8.230 meters*	18.288	60.0	2.208	10.69	7.15
11.278 meters*	21.336	70.0	3.183	7.41	5.34
14.326 meters*	24.384	80.0	4.159	5.67	4.43
17.374 meters*	27.432	90.0	5.134	4.60	3.89
17.679 meters*	27.737	91.0	5.232	4.51	3.85
17.983 meters*	28.042	92.0	5.329	4.43	3.80
18.288 meters*	28.347	93.0	5.427	4.35	3.77
18.593 meters*	28.652	94.0	5.524	4.27	3.73
18.898 meters*	28.956	95.0	5.622	4.20	3.69
19.203 meters*	29.261	96.0	5.719	4.13	3.66
19.507 meters*	29.566	97.0	5.817	4.06	3.62
19.812 meters*	29.871	98.0	5.914	3.99	3.59
20.117 meters*	30.176	99.0	6.012	3.92	3.56
20.422 meters*	30.480	100.0	6.109	3.86	3.53
20.727 meters*	30.785	101.0	6.207	3.80	3.50
21.031 meters*	31.090	102.0	6.304	3.74	3.47
21.336 meters*	31.395	103.0	6.402	3.69	3.44
21.641 meters*	31.700	104.0	6.500	3.63	3.41
21.946 meters*	32.004	105.0	6.597	3.58	3.39
22.251 meters*	32.309	106.0	6.695	3.52	3.36
22.555 meters*	32.614	107.0	6.792	3.47	3.34
22.860 meters*	32.919	108.0	6.890	3.42	3.31
23.165 meters*	33.224	109.0	6.987	3.38	3.29
23.470 meters*	33.528	110.0	7.085	3.33	3.27
26.518 meters*	36.576	120.0	8.060	2.93	3.07
26.823 meters*	36.881	121.0	8.158	2.89	3.05
27.128 meters*	37.186	122.0	8.255	2.86	3.04
27.432 meters*	37.491	123.0	8.353	2.82	3.02

Stack Distances (ft)	Number of Stacks
14.96	44

ft	m/s	merged cells
60	7.15	1.00
70	5.34	1.00
80	4.47	1.03
90	4.11	1.25
91	4.08	1.27
92	4.06	1.29
93	4.03	1.31
94	4.01	1.33
95	3.98	1.36
96	3.96	1.38
97	3.94	1.40
98	3.92	1.42
99	3.90	1.44
100	3.88	1.46
101	3.86	1.48
102	3.84	1.51
103	3.82	1.53
104	3.81	1.55
105	3.79	1.57
106	3.78	1.59
107	3.76	1.61
108	3.75	1.63
109	3.73	1.65
110	3.72	1.68
120	3.60	1.89
121	3.59	1.91
122	3.58	1.93
123	3.57	1.95

27.737 meters²	37.796	124.0	8.450	2.79	3.00
28.042 meters²	38.100	125.0	8.548	2.76	2.99
29.566 meters²	39.624	130.0	9.036	2.61	2.92
32.614 meters²	42.673	140.0	10.011	2.36	2.79
35.662 meters²	45.721	150.0	10.986	2.15	2.68
50.902 meters²	60.961	200.0	15.863	1.49	2.32
81.383 meters²	91.441	300.0	25.617	0.92	1.96
111.863 meters²	121.921	400.0	35.371	0.67	1.75
142.343 meters²	152.402	500.0	45.124	0.52	1.61
172.824 meters²	182.882	600.0	54.878	0.43	1.51
203.304 meters²	213.363	700.0	64.632	0.37	1.43
233.784 meters²	243.843	800.0	74.385	0.32	1.36
264.265 meters²	274.323	900.0	84.139	0.28	1.31
294.745 meters²	304.804	1000.0	93.893	0.25	1.26
325.226 meters²	335.284	1100.0	103.647	0.23	1.22
355.706 meters²	365.764	1200.0	113.400	0.21	1.18
386.186 meters²	396.245	1300.0	123.154	0.19	1.15
416.667 meters²	426.725	1400.0	132.908	0.18	1.12
447.147 meters²	457.206	1500.0	142.661	0.17	1.09
477.627 meters²	487.686	1600.0	152.415	0.15	1.07
508.108 meters²	518.166	1700.0	162.169	0.15	1.05
538.588 meters²	548.647	1800.0	171.923	0.14	1.03
569.069 meters²	579.127	1900.0	181.676	0.13	1.01
599.549 meters²	609.607	2000.0	191.430	0.12	0.99
630.029 meters²	640.088	2100.0	201.184	0.12	0.98
660.510 meters²	670.568	2200.0	210.937	0.11	0.96
690.990 meters²	701.049	2300.0	220.691	0.11	0.95
721.470 meters²	731.529	2400.0	230.445	0.10	0.93
751.951 meters²	762.009	2500.0	240.199	0.10	0.92
782.431 meters²	792.490	2600.0	249.952	0.09	0.91
812.911 meters²	822.970	2700.0	259.706	0.09	0.90
843.392 meters²	853.450	2800.0	269.460	0.09	0.89
873.872 meters²	883.931	2900.0	279.214	0.08	0.87
904.353 meters²	914.411	3000.0	288.967	0.08	0.86
934.833 meters²	944.891	3100.0	298.721	0.08	0.86
965.313 meters²	975.372	3200.0	308.475	0.08	0.85
995.794 meters²	1005.852	3300.0	318.228	0.07	0.84
1026.274 meters²	1036.333	3400.0	327.982	0.07	0.83
1056.754 meters²	1066.813	3500.0	337.736	0.07	0.82
1087.235 meters²	1097.293	3600.0	347.490	0.07	0.81
1117.715 meters²	1127.774	3700.0	357.243	0.07	0.81
1148.196 meters²	1158.254	3800.0	366.997	0.06	0.80
1178.676 meters²	1188.734	3900.0	376.751	0.06	0.79
1209.156 meters²	1219.215	4000.0	386.504	0.06	0.78

124	3.56	1.98
125	3.55	2.00
130	3.51	2.10
140	3.44	2.32
150	3.38	2.53
200	3.20	3.60
300	3.03	5.74
400	2.93	7.88
500	2.86	10.02
600	2.81	12.16
700	2.77	14.30
800	2.74	16.43
900	2.71	18.57
1,000	2.69	20.71
1,100	2.66	22.85
1,200	2.64	24.99
1,300	2.62	27.13
1,400	2.61	29.27
1,500	2.59	31.41
1,600	2.58	33.55
1,700	2.56	35.69
1,800	2.55	37.82
1,900	2.54	39.96
2,000	2.53	42.10
2,100	2.51	44.00
2,200	2.47	44.00
2,300	2.44	44.00
2,400	2.40	44.00
2,500	2.37	44.00
2,600	2.34	44.00
2,700	2.31	44.00
2,800	2.28	44.00
2,900	2.25	44.00
3,000	2.23	44.00
3,100	2.20	44.00
3,200	2.18	44.00
3,300	2.16	44.00
3,400	2.14	44.00
3,500	2.11	44.00
3,600	2.09	44.00
3,700	2.08	44.00
3,800	2.06	44.00
3,900	2.04	44.00
4,000	2.02	44.00

PETER BEST PAPER ILLUSTRATIVE EXAMPLE - SINGLE TURBINE - Assumes Heights in Table 2 are meters above ground

Plume Averaged Vertical Velocities: **"*Aviation Safety and Buoyant Plumes*," Peter Best, et. al.**

Ambient Conditions:

Ambient Potential Temp θ_a	**298**	Kelvins	**76.0**	°F	Assume neutral conditions (dθ/dz=0)

Plume Exit Conditions:

Stack Height h_s	**10.06**	meters	**33.0**	feet	
Stack Diameter D	**0.56**	meters	**1.8**	feet	
Stack Velocity V_{exit}	**42.2**	m/s	**138.5**	ft/sec	
Volumetric Flow	**10**	cu.m/sec	**21,189**	ACFM	$\pi V_{exit}D^2/4$
Stack Potential Temp θ_s	**752**	Kelvins	**893**	°F	Back-Calc'd from Buoyancy Flux
Initial Stack Buoyancy Flux F_o	**20**	m^4/s^3			$gV_{exit}D^2(1-\theta_a/\theta_s)/4$ = Vol.Flow$(g/\pi)(1-\theta_a/\theta_s)$
Plume Buoyancy Flux F	N/A	m^4/s^3			$\lambda^2 g V a^2(1-\theta_a/\theta_b)$ for a,V,θ_b at plume height (not used here)

Constants:

Gravity g	9.81	m/s^2
λ	1.11	
	0.3048	meters/feet

Sect.2/¶1

Sect.2/¶1

Conditions at End (Top) of Jet Phase:

Height above Stack z	**3.493**	meters*	**11.5**	feet*	6.25D, meters*=meters above stack top		Sect.3/¶1
Height above Ground z+h_s	**13.551**	meters	**44.5**	feet	h_s + 6.25D		"
Vertical Velocity V_{plume}	**21.110**	m/s	**69.26**	ft/sec	0.5V_{exit}	V_{exit}/2	"
Plume Top-Hat Diameter 2a	**1.118**	meters	**3.7**	feet	2D	Conservation of momentum	"

Spillane Methodology - Analytical Solutions for Calm Conditions for Plume Heights above Jet Phase

Plume Top-Hat Radius a	**Solutions in Table Below**			0.16(z-z_v), or linear increase with height	Sect.2/Eq.6
Virtual Source Height z_v	**1.295**	meters*	**4.2**	feet*	6.25D[1-$(\theta_a/\theta_s)^{1/2}$], meters*=meters above stack top	Sect.2/Eq.6
Height above Ground z_v+h_s	**11.353**	meters	**37.2**	feet	where $(\theta_a/\theta_s)^{1/2}$ = $(\theta_a/\theta_s)^{1/2}$= 0.629269032	

Method(1): Simplified Plume-averaged Vertical Velocity V' - Assumes Product Va constant above jet phase such that $V_{plume}(2a) = V_{exit}D$

Vertical Velocity V'	**Solutions in Table Below**			$V_{exit}D/2a'$ (conservation of buoyancy)	Sect.3&4

Method(2): Plume-averaged Vertical Velocity V given by Analytical Solution in Paper where Product Va given by equations below:

Vertical Velocity V	**Solutions in Table Below**			$\{(Va)_o^3 + 0.12F_o[(z-z_v)^2 - (6.25D-z_v)^2]\}^{(1/3)}$ / a	Sect.2.1(6)
Product $(Va)_o$	**7.423**	m^2/s		$V_{exit}D/2(\theta_a/\theta_s)^{1/2}$	

Table of plume Top-Hat Diameters (2a) and Plume-averaged Vertical Velocities for both Method(1) (assuming conservation of buoyancy & gaussian distribution of vertical velocities) and Method (2) (based on Peter Best's paper's Analytical Solution) starting at end of jet phase:

from 100 meters above ground in increments of 50.0 meters

				Vert.Vel (m/s)	
				Method(1)	Method(2)
	Ht above Ground =	h_{plume}+h_s	D_{plume}=2a=	V_{plume}=	$\{(Va)_o^3+0.12F_o[(z-z_v)^2$
Height above stack top, meters*	meters	feet	2*0.16(z-z_v)	V_{exit}*D/2a	$-(6.25D-z_v)^2]\}^{1/3}$ / a
End of jet phase at 6.25D = 3.493 meters*	***13.551***	***44.5***	***1.118***		***21.11***
89.941 meters*	**100.000**	328.1	28.367	0.83	**1.88**
139.941 meters*	150.000	492.1	44.367	0.53	1.61
189.941 meters*	**200.000**	656.2	60.367	0.39	**1.45**
239.941 meters*	250.000	820.2	76.367	0.31	1.34
289.941 meters*	**300.000**	984.3	92.367	0.26	**1.26**
339.941 meters*	350.000	1148.3	108.367	0.22	1.19
389.941 meters*	400.000	1312.3	124.367	0.19	1.14
439.941 meters*	450.000	1476.4	140.367	0.17	1.09
489.941 meters*	**500.000**	1640.4	156.367	0.15	**1.05**
539.941 meters*	550.000	1804.5	172.367	0.14	1.02
589.941 meters*	600.000	1968.5	188.367	0.13	0.99
639.941 meters*	650.000	2132.5	204.367	0.12	0.96
689.941 meters*	**700.000**	2296.6	220.367	0.11	**0.94**
739.941 meters*	750.000	2460.6	236.367	0.10	0.92
789.941 meters*	800.000	2624.7	252.367	0.09	0.90
839.941 meters*	850.000	2788.7	268.367	0.09	0.88
889.941 meters*	900.000	2952.8	284.367	0.08	0.86
939.941 meters*	950.000	3116.8	300.367	0.08	0.85
989.941 meters*	**1000.000**	3280.8	316.367	0.07	**0.83**
1039.941 meters*	1050.000	3444.9	332.367	0.07	0.82
1089.941 meters*	1100.000	3608.9	348.367	0.07	0.81
1139.941 meters*	1150.000	3773.0	364.367	0.06	0.80
1189.941 meters*	1200.000	3937.0	380.367	0.06	0.78
1239.941 meters*	1250.000	4101.0	396.367	0.06	0.77

8.230 meters*	18.288	60.0	2.219	10.63	7.20
11.278 meters*	21.336	70.0	3.195	7.39	5.37
14.326 meters*	24.384	80.0	4.170	5.66	4.44
17.374 meters*	27.432	90.0	5.145	4.59	3.89
17.679 meters*	27.737	91.0	5.243	4.50	3.85
17.983 meters*	28.042	92.0	5.340	4.42	3.81
18.288 meters*	28.347	93.0	5.438	4.34	3.77
18.593 meters*	28.652	94.0	5.535	4.26	3.73
18.898 meters*	28.956	95.0	5.633	4.19	3.69
19.203 meters*	29.261	96.0	5.731	4.12	3.66
19.507 meters*	29.566	97.0	5.828	4.05	3.62
19.812 meters*	29.871	98.0	5.926	3.98	3.59
20.117 meters*	30.176	99.0	6.023	3.92	3.56
20.422 meters*	30.480	100.0	6.121	3.85	3.52
20.727 meters*	30.785	101.0	6.218	3.79	3.49
21.031 meters*	31.090	102.0	6.316	3.74	3.47
21.336 meters*	31.395	103.0	6.413	3.68	3.44
21.641 meters*	31.700	104.0	6.511	3.62	3.41
21.946 meters*	32.004	105.0	6.608	3.57	3.38
22.251 meters*	32.309	106.0	6.706	3.52	3.36
22.555 meters*	32.614	107.0	6.803	3.47	3.33
22.860 meters*	32.919	108.0	6.901	3.42	3.31
23.165 meters*	33.224	109.0	6.998	3.37	3.28
23.470 meters*	33.528	110.0	7.096	3.32	3.26
26.518 meters*	36.576	120.0	8.071	2.92	3.06
26.823 meters*	36.881	121.0	8.169	2.89	3.05
27.128 meters*	37.186	122.0	8.266	2.85	3.03
27.432 meters*	37.491	123.0	8.364	2.82	3.01

Stack Distances (ft)	Number of Stacks
14.96	44

ft	m/s	merged cells
60	7.20	1.00
70	5.37	1.00
80	4.48	1.04
90	4.12	1.25
91	4.09	1.27
92	4.06	1.29
93	4.03	1.32
94	4.01	1.34
95	3.98	1.36
96	3.96	1.38
97	3.94	1.40
98	3.92	1.42
99	3.90	1.44
100	3.88	1.46
101	3.86	1.49
102	3.84	1.51
103	3.82	1.53
104	3.80	1.55
105	3.79	1.57
106	3.77	1.59
107	3.76	1.61
108	3.74	1.64
109	3.73	1.66
110	3.71	1.68
120	3.59	1.89
121	3.58	1.91
122	3.57	1.94
123	3.56	1.96

27.737 meters²	37.796	124.0	8.462	2.79	3.00
28.042 meters²	38.100	125.0	8.559	2.76	2.98
50.902 meters²	60.961	200.0	15.874	1.49	2.31
81.383 meters²	91.441	300.0	25.628	0.92	1.94
111.863 meters²	121.921	400.0	35.382	0.67	1.74
142.343 meters²	152.402	500.0	45.136	0.52	1.60
172.824 meters²	182.882	600.0	54.889	0.43	1.50
203.304 meters²	213.363	700.0	64.643	0.36	1.42
233.784 meters²	243.843	800.0	74.397	0.32	1.35
264.265 meters²	274.323	900.0	84.150	0.28	1.30
294.745 meters²	304.804	1000.0	93.904	0.25	1.25
325.226 meters²	335.284	1100.0	103.658	0.23	1.21
355.706 meters²	365.764	1200.0	113.412	0.21	1.17
386.186 meters²	396.245	1300.0	123.165	0.19	1.14
416.667 meters²	426.725	1400.0	132.919	0.18	1.11
447.147 meters²	457.206	1500.0	142.673	0.17	1.09
477.627 meters²	487.686	1600.0	152.426	0.15	1.06
508.108 meters²	518.166	1700.0	162.180	0.15	1.04
538.588 meters²	548.647	1800.0	171.934	0.14	1.02
569.069 meters²	579.127	1900.0	181.688	0.13	1.00
599.549 meters²	609.607	2000.0	191.441	0.12	0.99
630.029 meters²	640.088	2100.0	201.195	0.12	0.97
660.510 meters²	670.568	2200.0	210.949	0.11	0.95
690.990 meters²	701.049	2300.0	220.702	0.11	0.94
721.470 meters²	731.529	2400.0	230.456	0.10	0.93
751.951 meters²	762.009	2500.0	240.210	0.10	0.91
782.431 meters²	792.490	2600.0	249.964	0.09	0.90
812.911 meters²	822.970	2700.0	259.717	0.09	0.89
843.392 meters²	853.450	2800.0	269.471	0.09	0.88
873.872 meters²	883.931	2900.0	279.225	0.08	0.87
904.353 meters²	914.411	3000.0	288.978	0.08	0.86
934.833 meters²	944.891	3100.0	298.732	0.08	0.85
965.313 meters²	975.372	3200.0	308.486	0.08	0.84
995.794 meters²	1005.852	3300.0	318.240	0.07	0.83
1026.274 meters²	1036.333	3400.0	327.993	0.07	0.82
1056.754 meters²	1066.813	3500.0	337.747	0.07	0.82
1087.235 meters²	1097.293	3600.0	347.501	0.07	0.81
1117.715 meters²	1127.774	3700.0	357.255	0.07	0.80
1148.196 meters²	1158.254	3800.0	367.008	0.06	0.79
1178.676 meters²	1188.734	3900.0	376.762	0.06	0.79
1209.156 meters²	1219.215	4000.0	386.516	0.06	0.78

124	3.55	1.98
125	3.54	2.00
200	3.18	3.60
300	3.01	5.74
400	2.91	7.88
500	2.85	10.02
600	2.80	12.16
700	2.76	14.30
800	2.72	16.44
900	2.69	18.58
1,000	2.67	20.72
1,100	2.64	22.85
1,200	2.62	24.99
1,300	2.61	27.13
1,400	2.59	29.27
1,500	2.57	31.41
1,600	2.56	33.55
1,700	2.55	35.69
1,800	2.53	37.83
1,900	2.52	39.97
2,000	2.51	42.10
2,100	2.50	44.00
2,200	2.46	44.00
2,300	2.42	44.00
2,400	2.39	44.00
2,500	2.35	44.00
2,600	2.32	44.00
2,700	2.29	44.00
2,800	2.26	44.00
2,900	2.24	44.00
3,000	2.21	44.00
3,100	2.19	44.00
3,200	2.16	44.00
3,300	2.14	44.00
3,400	2.12	44.00
3,500	2.10	44.00
3,600	2.08	44.00
3,700	2.06	44.00
3,800	2.04	44.00
3,900	2.02	44.00
4,000	2.01	44.00

PETER BEST PAPER ILLUSTRATIVE EXAMPLE - SINGLE TURBINE - Assumes Heights in Table 2 are meters above ground

Plume Averaged Vertical Velocities: **"*Aviation Safety and Buoyant Plumes*," Peter Best, et. al.**

Ambient Conditions:

Ambient Potential Temp θ_a	**309**	Kelvins	**96.0**	°F	Assume neutral conditions (dθ/dz=0)

Plume Exit Conditions:

Stack Height h_s	**10.06**	meters	**33.0**	feet	
Stack Diameter D	**0.56**	meters	**1.8**	feet	
Stack Velocity V_{exit}	**42.2**	m/s	**138.5**	ft/sec	
Volumetric Flow	**10**	cu.m/sec	**21,189**	ACFM	$\pi V_{exit}D^2/4$
Stack Potential Temp θ_s	**752**	Kelvins	**893**	°F	Back-Calc'd from Buoyancy Flux
Initial Stack Buoyancy Flux F_o	**19**	m^4/s^3			$gV_{exit}D^2(1-\theta_a/\theta_s)/4$ = Vol.Flow$(g/\pi)(1-\theta_a/\theta_s)$
Plume Buoyancy Flux F	N/A	m^4/s^3			$\lambda^2 gVa^2(1-\theta_a/\theta_b)$ for a,V,θ_b at plume height (not used here)

Constants:

Gravity g	9.81	m/s^2
λ	1.11	
	0.3048	meters/feet

Sect.2/¶1

Sect.2/¶1

Conditions at End (Top) of Jet Phase:

Height above Stack z	**3.493**	meters*	**11.5**	feet*	6.25D, meters*=meters above stack top		Sect.3/¶1
Height above Ground z+h_s	**13.551**	meters	**44.5**	feet	h_s + 6.25D		"
Vertical Velocity V_{plume}	**21.110**	m/s	**69.26**	ft/sec	0.5V_{exit}	V_{exit}/2	"
Plume Top-Hat Diameter 2a	**1.118**	meters	**3.7**	feet	2D	Conservation of momentum	"

Spillane Methodology - Analytical Solutions for Calm Conditions for Plume Heights above Jet Phase

Plume Top-Hat Radius a	**Solutions in Table Below**			0.16($z-z_v$), or linear increase with height	Sect.2/Eq.6
Virtual Source Height z_v	**1.254**	meters*	**4.1**	feet*	6.25D[1-$(\theta_a/\theta_s)^{1/2}$], meters*=meters above stack top	Sect.2/Eq.6
Height above Ground z_v+h_s	**11.313**	meters	**37.1**	feet	where $(\theta_a/\theta_s)^{1/2}$ = $(\theta_a/\theta_s)^{1/2}$= 0.640908708	

Method(1): Simplified Plume-averaged Vertical Velocity V' - Assumes Product Va constant above jet phase such that $V_{plume}(2a) = V_{exit}D$

Vertical Velocity V'	**Solutions in Table Below**			$V_{exit}D/2a'$ (conservation of buoyancy)	Sect.3&4

Method(2): Plume-averaged Vertical Velocity V given by Analytical Solution in Paper where Product Va given by equations below:

Vertical Velocity V	**Solutions in Table Below**			$\{(Va)_o^3 + 0.12F_o[(z-z_v)^2 - (6.25D-z_v)^2]\}^{(1/3)}$ / a	Sect.2.1(6)
Product $(Va)_o$	**7.560**	m^2/s		$V_{exit}D/2(\theta_a/\theta_s)^{1/2}$	

Table of plume Top-Hat Diameters (2a) and Plume-averaged Vertical Velocities for both Method(1) (assuming conservation of buoyancy & gaussian distribution of vertical velocities) and Method (2) (based on Peter Best's paper's Analytical Solution) starting at end of jet phase:

from 100 meters above ground in increments of 50.0 meters

Height above stack top, meters*	**Ht above Ground =** meters	h_{plume}+h_s feet	D_{plume}=2a= 2*0.16($z-z_v$)	**Vert.Vel (m/s) Method(1)** V_{plume}= V_{exit}*D/2a	**Method(2)** $\{(Va)_o^3+0.12F_o[(z-z_v)^2$ $-(6.25D-z_v)^2]\}^{1/3}$ / a
End of jet phase at 6.25D = 3.493 meters*	***13.551***	***44.5***	***1.118***		***21.11***
89.941 meters*	**100.000**	328.1	28.380	0.83	**1.86**
139.941 meters*	150.000	492.1	44.380	0.53	1.60
189.941 meters*	**200.000**	656.2	60.380	0.39	**1.44**
239.941 meters*	250.000	820.2	76.380	0.31	1.33
289.941 meters*	**300.000**	984.3	92.380	0.26	**1.25**
339.941 meters*	350.000	1148.3	108.380	0.22	1.18
389.941 meters*	400.000	1312.3	124.380	0.19	1.13
439.941 meters*	450.000	1476.4	140.380	0.17	1.08
489.941 meters*	**500.000**	1640.4	156.380	0.15	**1.05**
539.941 meters*	550.000	1804.5	172.380	0.14	1.01
589.941 meters*	600.000	1968.5	188.380	0.13	0.98
639.941 meters*	650.000	2132.5	204.380	0.12	0.96
689.941 meters*	**700.000**	2296.6	220.380	0.11	**0.93**
739.941 meters*	750.000	2460.6	236.380	0.10	0.91
789.941 meters*	800.000	2624.7	252.380	0.09	0.89
839.941 meters*	850.000	2788.7	268.380	0.09	0.87
889.941 meters*	900.000	2952.8	284.380	0.08	0.86
939.941 meters*	950.000	3116.8	300.380	0.08	0.84
989.941 meters*	**1000.000**	3280.8	316.380	0.07	**0.83**
1039.941 meters*	1050.000	3444.9	332.380	0.07	0.81
1089.941 meters*	1100.000	3608.9	348.380	0.07	0.80
1139.941 meters*	1150.000	3773.0	364.380	0.06	0.79
1189.941 meters*	1200.000	3937.0	380.380	0.06	0.78
1239.941 meters*	1250.000	4101.0	396.380	0.06	0.77

8.230 meters*	18.288	60.0	2.232	10.57	7.26
11.278 meters*	21.336	70.0	3.208	7.36	5.40
14.326 meters*	24.384	80.0	4.183	5.64	4.46
17.374 meters*	27.432	90.0	5.158	4.57	3.90
17.679 meters*	27.737	91.0	5.256	4.49	3.85
17.983 meters*	28.042	92.0	5.353	4.41	3.81
18.288 meters*	28.347	93.0	5.451	4.33	3.77
18.593 meters*	28.652	94.0	5.548	4.25	3.73
18.898 meters*	28.956	95.0	5.646	4.18	3.69
19.203 meters*	29.261	96.0	5.744	4.11	3.66
19.507 meters*	29.566	97.0	5.841	4.04	3.62
19.812 meters*	29.871	98.0	5.939	3.97	3.59
20.117 meters*	30.176	99.0	6.036	3.91	3.55
20.422 meters*	30.480	100.0	6.134	3.85	3.52
20.727 meters*	30.785	101.0	6.231	3.79	3.49
21.031 meters*	31.090	102.0	6.329	3.73	3.46
21.336 meters*	31.395	103.0	6.426	3.67	3.43
21.641 meters*	31.700	104.0	6.524	3.62	3.41
21.946 meters*	32.004	105.0	6.621	3.56	3.38
22.251 meters*	32.309	106.0	6.719	3.51	3.35
22.555 meters*	32.614	107.0	6.816	3.46	3.33
22.860 meters*	32.919	108.0	6.914	3.41	3.30
23.165 meters*	33.224	109.0	7.012	3.36	3.28
23.470 meters*	33.528	110.0	7.109	3.32	3.26
26.518 meters*	36.576	120.0	8.084	2.92	3.05
26.823 meters*	36.881	121.0	8.182	2.88	3.04
27.128 meters*	37.186	122.0	8.279	2.85	3.02
27.432 meters*	37.491	123.0	8.377	2.82	3.00

Stack Distances (ft)	Number of Stacks
14.96	44

ft	m/s	merged cells
60	7.26	1.00
70	5.40	1.00
80	4.50	1.04
90	4.12	1.25
91	4.09	1.28
92	4.07	1.30
93	4.04	1.32
94	4.01	1.34
95	3.99	1.36
96	3.96	1.38
97	3.94	1.40
98	3.92	1.42
99	3.90	1.45
100	3.88	1.47
101	3.86	1.49
102	3.84	1.51
103	3.82	1.53
104	3.80	1.55
105	3.78	1.57
106	3.77	1.60
107	3.75	1.62
108	3.74	1.64
109	3.72	1.66
110	3.71	1.68
120	3.58	1.90
121	3.57	1.92
122	3.56	1.94
123	3.55	1.96

27.737 meters²	37.796	124.0	8.475	2.78	2.99
28.042 meters²	38.100	125.0	8.572	2.75	2.97
50.902 meters²	60.961	200.0	15.887	1.48	2.29
81.383 meters²	91.441	300.0	25.641	0.92	1.93
111.863 meters²	121.921	400.0	35.395	0.67	1.72
142.343 meters²	152.402	500.0	45.149	0.52	1.59
172.824 meters²	182.882	600.0	54.902	0.43	1.48
203.304 meters²	213.363	700.0	64.656	0.36	1.41
233.784 meters²	243.843	800.0	74.410	0.32	1.34
264.265 meters²	274.323	900.0	84.163	0.28	1.29
294.745 meters²	304.804	1000.0	93.917	0.25	1.24
325.226 meters²	335.284	1100.0	103.671	0.23	1.20
355.706 meters²	365.764	1200.0	113.425	0.21	1.16
386.186 meters²	396.245	1300.0	123.178	0.19	1.13
416.667 meters²	426.725	1400.0	132.932	0.18	1.10
447.147 meters²	457.206	1500.0	142.686	0.17	1.08
477.627 meters²	487.686	1600.0	152.439	0.15	1.05
508.108 meters²	518.166	1700.0	162.193	0.15	1.03
538.588 meters²	548.647	1800.0	171.947	0.14	1.01
569.069 meters²	579.127	1900.0	181.701	0.13	0.99
599.549 meters²	609.607	2000.0	191.454	0.12	0.98
630.029 meters²	640.088	2100.0	201.208	0.12	0.96
660.510 meters²	670.568	2200.0	210.962	0.11	0.95
690.990 meters²	701.049	2300.0	220.715	0.11	0.93
721.470 meters²	731.529	2400.0	230.469	0.10	0.92
751.951 meters²	762.009	2500.0	240.223	0.10	0.91
782.431 meters²	792.490	2600.0	249.977	0.09	0.89
812.911 meters²	822.970	2700.0	259.730	0.09	0.88
843.392 meters²	853.450	2800.0	269.484	0.09	0.87
873.872 meters²	883.931	2900.0	279.238	0.08	0.86
904.353 meters²	914.411	3000.0	288.992	0.08	0.85
934.833 meters²	944.891	3100.0	298.745	0.08	0.84
965.313 meters²	975.372	3200.0	308.499	0.08	0.83
995.794 meters²	1005.852	3300.0	318.253	0.07	0.82
1026.274 meters²	1036.333	3400.0	328.006	0.07	0.82
1056.754 meters²	1066.813	3500.0	337.760	0.07	0.81
1087.235 meters²	1097.293	3600.0	347.514	0.07	0.80
1117.715 meters²	1127.774	3700.0	357.268	0.07	0.79
1148.196 meters²	1158.254	3800.0	367.021	0.06	0.79
1178.676 meters²	1188.734	3900.0	376.775	0.06	0.78
1209.156 meters²	1219.215	4000.0	386.529	0.06	0.77

124	3.54	1.98
125	3.53	2.00
200	3.16	3.61
300	2.98	5.75
400	2.89	7.88
500	2.82	10.02
600	2.77	12.16
700	2.73	14.30
800	2.70	16.44
900	2.67	18.58
1,000	2.65	20.72
1,100	2.62	22.86
1,200	2.60	25.00
1,300	2.58	27.13
1,400	2.57	29.27
1,500	2.55	31.41
1,600	2.54	33.55
1,700	2.52	35.69
1,800	2.51	37.83
1,900	2.50	39.97
2,000	2.49	42.11
2,100	2.48	44.00
2,200	2.44	44.00
2,300	2.40	44.00
2,400	2.37	44.00
2,500	2.33	44.00
2,600	2.30	44.00
2,700	2.27	44.00
2,800	2.25	44.00
2,900	2.22	44.00
3,000	2.19	44.00
3,100	2.17	44.00
3,200	2.15	44.00
3,300	2.12	44.00
3,400	2.10	44.00
3,500	2.08	44.00
3,600	2.06	44.00
3,700	2.04	44.00
3,800	2.03	44.00
3,900	2.01	44.00
4,000	1.99	44.00

PETER BEST PAPER ILLUSTRATIVE EXAMPLE - SINGLE TURBINE - Assumes Heights in Table 2 are meters above ground

Plume Averaged Vertical Velocities: **"*Aviation Safety and Buoyant Plumes*," Peter Best, et. al.**

Ambient Conditions:

					Constants:		
Ambient Potential Temp θ_a	272	Kelvins	30.0	°F	Assume neutral conditions (dθ/dz=0)		
Plume Exit Conditions:					Gravity g	9.81	m/s²
Stack Height h_s	33.43	meters	109.7	feet	λ	1.11	
Stack Diameter D	0.91	meters	3.0	feet		0.3048	meters/feet
Stack Velocity V_{exit}	9.8	m/s	32.1	ft/sec			
Volumetric Flow	6	cu.m/sec	13,627	ACFM	$\pi V_{exit}D^2/4$		Sect.2/¶1
Stack Potential Temp θ_s	325	Kelvins	125	°F	Back-Calc'd from Buoyancy Flux		
Initial Stack Buoyancy Flux F_o	3	m^4/s^3			$gV_{exit}D^2(1-\theta_a/\theta_s)/4$ = Vol.Flow(g/π)(1-θ_a/θ_s)		Sect.2/¶1
Plume Buoyancy Flux F	N/A	m^4/s^3			$\lambda^2 gVa^2(1-\theta_a/\theta_s)$ for a,V,θ_o at plume height (not used here)		

Conditions at End (Top) of Jet Phase:

Height above Stack z	5.715	meters*	18.8	feet*	6.25D, meters*=meters above stack top		Sect.3/¶1
Height above Ground z+h_s	39.142	meters	128.4	feet	h_s + 6.25D		"
Vertical Velocity V_{plume}	4.897	m/s	16.07	ft/sec	0.5V_{exit}	$V_{exit}/2$	"
Plume Top-Hat Diameter 2a	1.829	meters	6.0	feet	2D	Conservation of momentum	"

Spillane Methodology - Analytical Solutions for Calm Conditions for Plume Heights above Jet Phase

Plume Top-Hat Radius a	**Solutions in Table Below**				0.16(z-z_v), or linear increase with height	Sect.2/Eq.6
Virtual Source Height z_v	0.485	meters*	1.6	feet*	6.25D[1-$(\theta_a/\theta_s)^{1/2}$], meters*=meters above stack top	Sect.2/Eq.6
Height above Ground z_v+h_s	33.912	meters	111.3	feet	where $(\theta_a/\theta_s)^{1/2}$ = $(\theta_a/\theta_s)^{1/2}$= 0.915158554	

Method(1): Simplified Plume-averaged Vertical Velocity V' - Assumes Product Va constant above jet phase such that $V_{plume}(2a) = V_{exit}D$

Vertical Velocity V'	**Solutions in Table Below**		$V_{exit}D/2a'$ (conservation of buoyancy)	Sect.3&4

Method(2): Plume-averaged Vertical Velocity V given by Analytical Solution in Paper where Product Va given by equations below:

Vertical Velocity V	**Solutions in Table Below**		$\{(Va)_o^3 + 0.12F_o [(z-z_v)^2 - (6.25D-z_v)^2]\}^{(1/3)}$ / a	Sect.2.1(6)
Product $(Va)_o$	4.098	m^2/s	$V_{exit}D/2(\theta_a/\theta_s)^{1/2}$	

Table of plume Top-Hat Diameters (2a) and Plume-averaged Vertical Velocities for both Method(1) (assuming conservation of buoyancy & gaussian distribution of vertical velocities) and Method (2) (based on Peter Best's paper's Analytical Solution) starting at end of jet phase:

from 100 meters above ground in increments of 50.0 meters

				Vert.Vel (m/s)	
				Method(1)	Method(2)
	Ht above Ground =	h_{plume}+h_s	D_{plume}=2a=	V_{plume}=	{$(Va)_o^3$+0.12F_o[(z-z_v)²
Height above stack top, meters*	meters	feet	2*0.16(z-z_v)	V_{exit}*D/2a	-(6.25D-z_v)²]}^1/3 / a
End of jet phase at 6.25D = 5.715 meters*	***39.142***	***128.4***	***1.829***		***4.90***
66.573 meters*	**100.000**	328.1	21.148	0.42	**1.14**
116.573 meters*	150.000	492.1	37.148	0.24	0.94
166.573 meters*	**200.000**	656.2	53.148	0.17	**0.83**
216.573 meters*	250.000	820.2	69.148	0.13	0.76
266.573 meters*	**300.000**	984.3	85.148	0.11	**0.71**
316.573 meters*	350.000	1148.3	101.148	0.09	0.67
366.573 meters*	400.000	1312.3	117.148	0.08	0.64
416.573 meters*	450.000	1476.4	133.148	0.07	0.61
466.573 meters*	**500.000**	1640.4	149.148	0.06	**0.59**
516.573 meters*	550.000	1804.5	165.148	0.05	0.57
566.573 meters*	600.000	1968.5	181.148	0.05	0.55
616.573 meters*	650.000	2132.5	197.148	0.05	0.54
666.573 meters*	**700.000**	2296.6	213.148	0.04	**0.52**
716.573 meters*	750.000	2460.6	229.148	0.04	0.51
766.573 meters*	800.000	2624.7	245.148	0.04	0.50
816.573 meters*	850.000	2788.7	261.148	0.03	0.49
866.573 meters*	900.000	2952.8	277.148	0.03	0.48
916.573 meters*	950.000	3116.8	293.148	0.03	0.47
966.573 meters*	**1000.000**	3280.8	309.148	0.03	**0.46**
1016.573 meters*	1050.000	3444.9	325.148	0.03	0.45
1066.573 meters*	1100.000	3608.9	341.148	0.03	0.45
1116.573 meters*	1150.000	3773.0	357.148	0.03	0.44
1166.573 meters*	1200.000	3937.0	373.148	0.02	0.43
1216.573 meters*	1250.000	4101.0	389.148	0.02	0.43

3.150 meters*	36.576	120.0	0.853	10.50	9.23
3.454 meters*	36.881	121.0	0.950	9.42	8.31
3.759 meters*	37.186	122.0	1.048	8.55	7.57
4.064 meters*	37.491	123.0	1.145	7.82	6.95
4.369 meters*	37.796	124.0	1.243	7.21	6.44
4.674 meters*	38.100	125.0	1.340	6.68	6.00
4.978 meters*	38.405	126.0	1.438	6.23	5.62
5.283 meters*	38.710	127.0	1.535	5.83	5.29
5.588 meters*	39.015	128.0	1.633	5.48	5.01
5.893 meters*	39.320	129.0	1.731	5.17	4.75
6.198 meters*	39.624	130.0	1.828	4.90	4.53
6.502 meters*	39.929	131.0	1.926	4.65	4.33
6.807 meters*	40.234	132.0	2.023	4.43	4.15
7.112 meters*	40.539	133.0	2.121	4.22	3.98
7.417 meters*	40.844	134.0	2.218	4.04	3.83
7.722 meters*	41.149	135.0	2.316	3.87	3.70
8.026 meters*	41.453	136.0	2.413	3.71	3.58
8.331 meters*	41.758	137.0	2.511	3.57	3.46
8.636 meters*	42.063	138.0	2.608	3.43	3.36
8.941 meters*	42.368	139.0	2.706	3.31	3.26
9.246 meters*	42.673	140.0	2.803	3.19	3.18
9.551 meters*	42.977	141.0	2.901	3.09	3.09
9.855 meters*	43.282	142.0	2.999	2.99	3.02
10.160 meters*	43.587	143.0	3.096	2.89	2.95
10.465 meters*	43.892	144.0	3.194	2.80	2.88
10.770 meters*	44.197	145.0	3.291	2.72	2.82
11.075 meters*	44.501	146.0	3.389	2.64	2.76
11.379 meters*	44.806	147.0	3.486	2.57	2.70
11.684 meters*	45.111	148.0	3.584	2.50	2.65
11.989 meters*	45.416	149.0	3.681	2.43	2.60
12.294 meters*	45.721	150.0	3.779	2.37	2.56
27.534 meters*	60.961	200.0	8.656	1.03	1.62
58.014 meters*	91.441	300.0	18.409	0.49	1.20
88.495 meters*	121.921	400.0	28.163	0.32	1.03

	Stack Distances (ft)	Number of Stacks
	3.67	1248

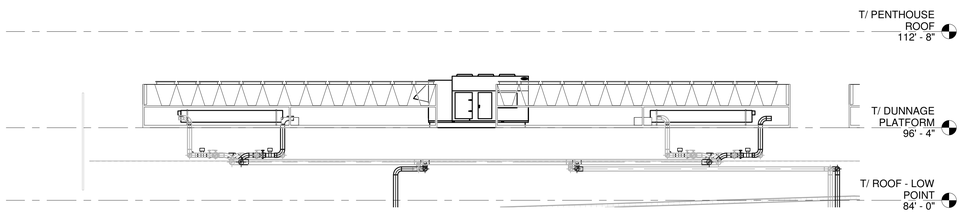
ft	m/s	merged cells	Plume Diamter Feet
120	10.35	1.58	2.80
121	9.44	1.67	3.12
122	8.71	1.76	3.44
123	8.10	1.84	3.76
124	7.59	1.93	4.08
125	7.15	2.02	4.40
126	6.77	2.10	4.72
127	6.44	2.19	5.04
128	6.15	2.28	5.36
129	5.90	2.37	5.68
130	5.67	2.45	6.00
131	5.46	2.54	6.32
132	5.28	2.63	6.64
133	5.11	2.72	6.96
134	4.96	2.80	7.28
135	4.82	2.89	7.60
136	4.70	2.98	7.92
137	4.58	3.06	8.24
138	4.48	3.15	8.56
139	4.38	3.24	8.88
140	4.29	3.33	9.20
141	4.20	3.41	9.52
142	4.13	3.50	9.84
143	4.05	3.59	10.16
144	3.99	3.68	10.48
145	3.92	3.76	10.80
146	3.86	3.85	11.12
147	3.81	3.94	11.44
148	3.76	4.02	11.76
149	3.71	4.11	12.08
150	3.66	4.20	12.40
200	2.77	8.56	28.40
300	2.45	17.29	60.40
400	2.34	26.02	92.40

118.975 meters*	152.402	500.0	37.917	0.24	0.93
149.455 meters*	182.882	600.0	47.671	0.19	0.86
179.936 meters*	213.363	700.0	57.424	0.16	0.81
210.416 meters*	243.843	800.0	67.178	0.13	0.77
240.897 meters*	274.323	900.0	76.932	0.12	0.74
271.377 meters*	304.804	1000.0	86.685	0.10	0.71
301.857 meters*	335.284	1100.0	96.439	0.09	0.68
332.338 meters*	365.764	1200.0	106.193	0.08	0.66
362.818 meters*	396.245	1300.0	115.947	0.08	0.64
393.298 meters*	426.725	1400.0	125.700	0.07	0.62
423.779 meters*	457.206	1500.0	135.454	0.07	0.61
454.259 meters*	487.686	1600.0	145.208	0.06	0.60
484.739 meters*	518.166	1700.0	154.961	0.06	0.58
515.220 meters*	548.647	1800.0	164.715	0.05	0.57
545.700 meters*	579.127	1900.0	174.469	0.05	0.56
576.181 meters*	609.607	2000.0	184.223	0.05	0.55
606.661 meters*	640.088	2100.0	193.976	0.05	0.54
637.141 meters*	670.568	2200.0	203.730	0.04	0.53
667.622 meters*	701.049	2300.0	213.484	0.04	0.52
698.102 meters*	731.529	2400.0	223.238	0.04	0.52
728.582 meters*	762.009	2500.0	232.991	0.04	0.51
759.063 meters*	792.490	2600.0	242.745	0.04	0.50
789.543 meters*	822.970	2700.0	252.499	0.04	0.49
820.024 meters*	853.450	2800.0	262.252	0.03	0.49
850.504 meters*	883.931	2900.0	272.006	0.03	0.48
880.984 meters*	914.411	3000.0	281.760	0.03	0.48
911.465 meters*	944.891	3100.0	291.514	0.03	0.47
941.945 meters*	975.372	3200.0	301.267	0.03	0.47
972.425 meters*	1005.852	3300.0	311.021	0.03	0.46
1002.906 meters*	1036.333	3400.0	320.775	0.03	0.46
1033.386 meters*	1066.813	3500.0	330.528	0.03	0.45
1063.867 meters*	1097.293	3600.0	340.282	0.03	0.45
1094.347 meters*	1127.774	3700.0	350.036	0.03	0.44
1124.827 meters*	1158.254	3800.0	359.790	0.02	0.44
1155.308 meters*	1188.734	3900.0	369.543	0.02	0.44
1185.788 meters*	1219.215	4000.0	379.297	0.02	0.43
1185.788 meters*	1219.215	4000.0	379.297	0.02	0.43
1185.788 meters*	1219.215	4000.0	379.297	0.02	0.43

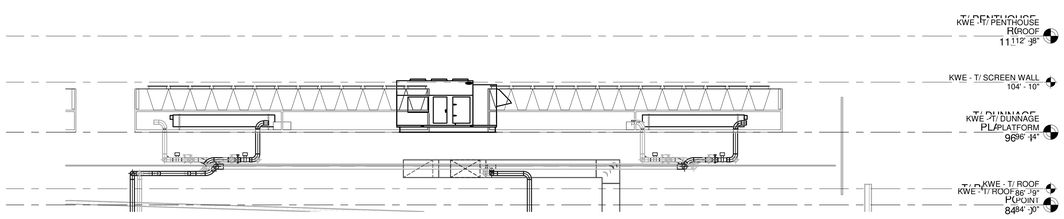
500	2.27	34.74	124.40
600	2.22	43.47	156.40
700	2.18	52.20	188.40
800	2.15	60.93	220.40
900	2.13	69.65	252.40
1,000	2.10	78.38	284.40
1,100	2.08	87.11	316.40
1,200	2.07	95.84	348.40
1,300	2.05	104.56	380.40
1,400	2.04	113.29	412.40
1,500	2.02	122.02	444.40
1,600	2.01	130.74	476.40
1,700	2.00	139.47	508.40
1,800	1.99	148.20	540.40
1,900	1.98	156.93	572.40
2,000	1.97	165.65	604.40
2,100	1.96	174.38	636.41
2,200	1.96	183.11	668.41
2,300	1.95	191.84	700.41
2,400	1.94	200.56	732.41
2,500	1.93	209.29	764.41
2,600	1.93	218.02	796.41
2,700	1.92	226.74	828.41
2,800	1.91	235.47	860.41
2,900	1.91	244.20	892.41
3,000	1.90	252.93	924.41
3,100	1.90	261.65	956.41
3,200	1.89	270.38	988.41
3,300	1.89	279.11	1020.41
3,400	1.88	287.84	1052.41
3,500	1.88	296.56	1084.41
3,600	1.87	305.29	1116.41
3,700	1.87	314.02	1148.41
3,800	1.86	322.74	1180.41
3,900	1.86	331.47	1212.41
4,000	1.86	340.20	1244.41
4,000	1.86	340.20	1244.41
4,000	1.86	340.20	1244.41

ATTACHMENT TRANS DR-28

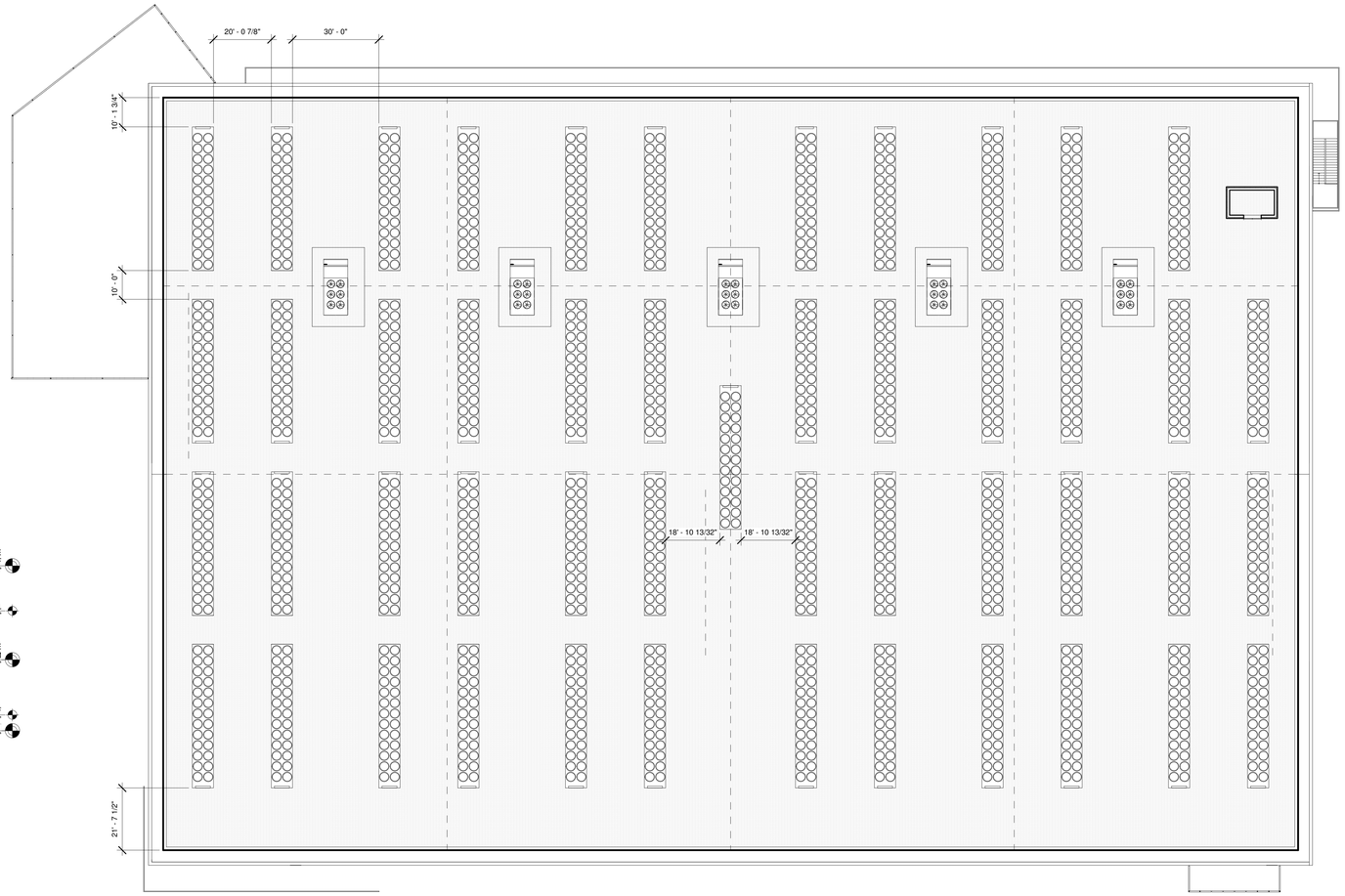
CA3DC Roof Plan



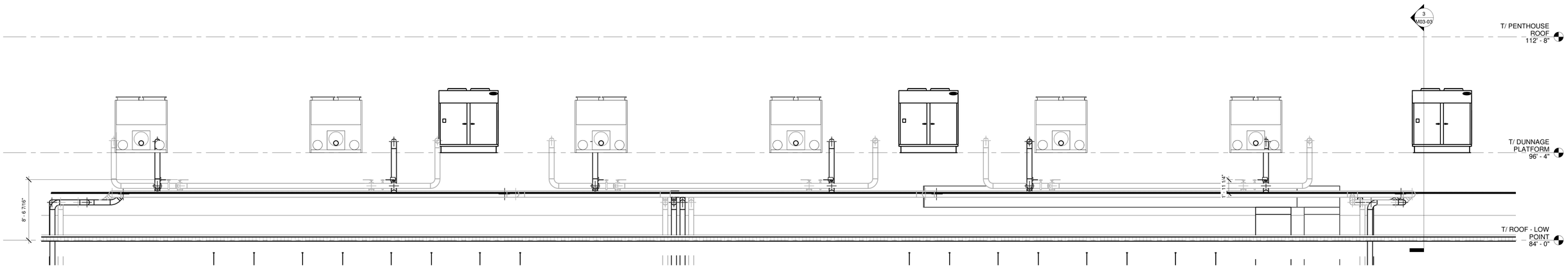
2 ROOF SECTION EAST
1" = 10'-0"



3 ROOF SECTION WEST
1" = 10'-0"



1 ROOF PLAN
1" = 20'-0"



4 ROOF SECTION NORTH
3/16" = 1'-0"

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