Ice Station Case Study

BASELINE 400 W MH V.S. AES SFX24-655 COMPARISON
WITH TRADITIONAL SKYLIGHT WITH ADVANCED SKYLIGHT

AREA DEMENSIONS		
BUILDING	Length	185
	Width	232
	Ceiling Height	25
	Total Sq. Ft.	**42,920**

HID LIGHTING DESIGN	
Number of Fixtures	100
Lamp Watts Per Fix	400
Ballast Watts per Fi	60
Total Watts	**46000**

RECOMMENDED CHANGE	
Number of Fixtures	100
Lamp Watts Per Fixture	287
Ballast Watts per Fixture	287
Total Watts	**28700**

HID LOAD PROFILE	
Connected Load kW	46
Watts Per Sq. Ft.	1.071761417
Price Per kWH	$0.15
Hours of Operation	5840
Annual Cost	**$40,296.00**

RECOMMENDED LOAD PROFILE	
Connected Load kWH	28.7
Watts Per Sq. Ft.	0.668685927
Price Per kWH	$0.15
Hours of Operation	5840
Annual Cost	**$25,141.20**

Total Annual Savings **$15,154.80**

TRAD DAYLIGHT SAVINGS		
Total Hours	0	
Annual kWH Savings	0	
Total Annual Savings	**$0.00**	
Total Annual Cost	**$40,296.00**	

ADV DAYLIGHT SAVINGS	
Total Hours	1825
Annual kWH Savings	52377.5
Total Annual Savings	**$7,856.63**
Total Annual Cost	**$17,284.58**
Grand Total Annual Saving	**$23,011.43**

HID LIGHTING COST	
Material cost	
Traditional Skylight	$0.00
400W Metal Halide	$15,000.00
Panel Control	?
Total	**$25,000.00**
Labor Cost	
Electrical	$10,000
Day Lighting	$0

RECOMMENDED LIGHTING COST	
Material cost	
Advanced Skylight	$50,150.00
MAF28855	$25,000.00
Panel Control	$5,500.00
Total	**$116,300.00**
SBD REBATE	**$55,000.00**
Adjusted Total	**$36,300.00**
Labor Cost	
Electrical	$15,000
Day Lighting	$20,650

Return on investment for Adjusted Total Cost	**1.6**	**YEARS**
Return on investment for Total Cost	**2.7**	**YEARS**

SkyCalc: Skylight Design Assistant - Graphic Results

Company Name: VALENCIA ICE STATION

Project Description: HYBRID LIGHTING PROJECT

Effective Aperture = 1.76%, Skylight to Floor Ratio (SFR) = 2.20%

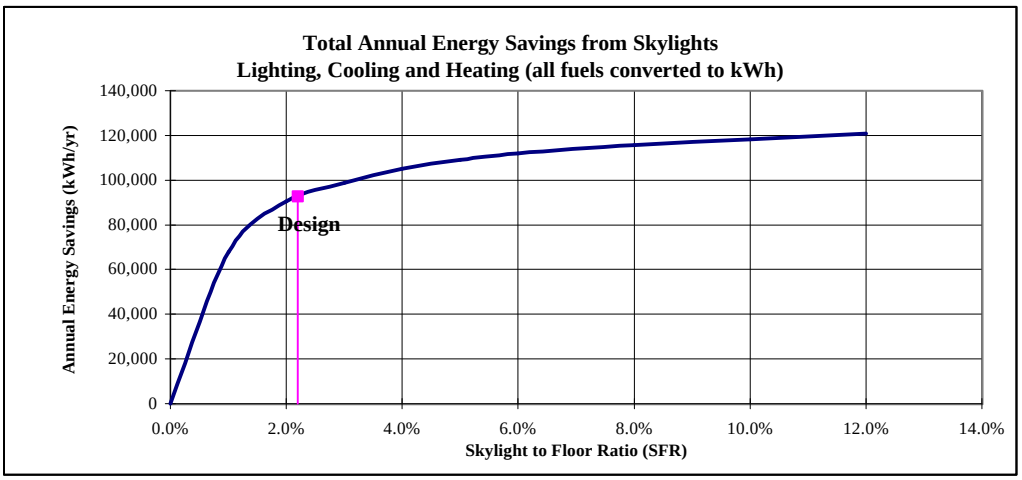
Average daylight footcandles (fc)

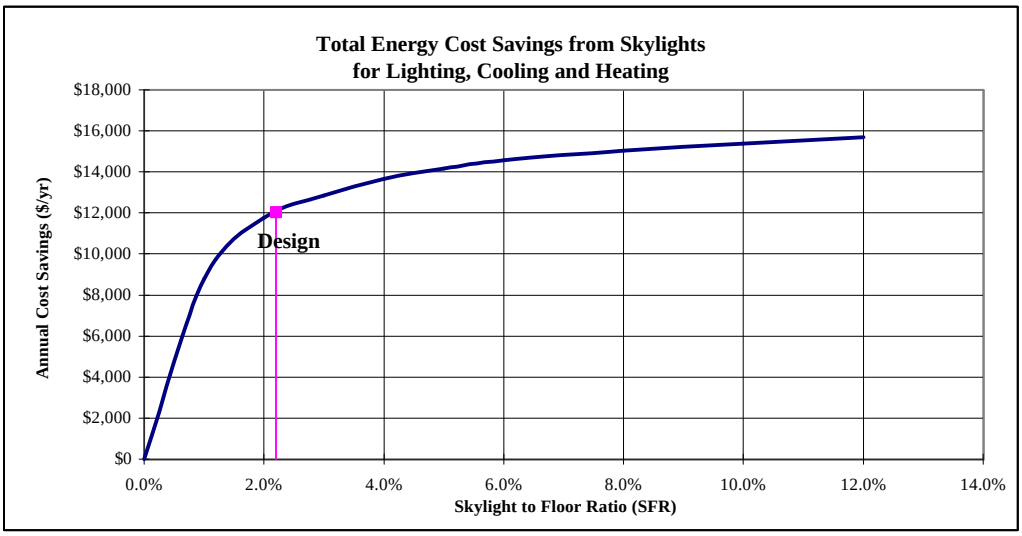
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	0	0	0	0	0	0	0	7	23	51	73	88	86	75	51	25	7	0	0	0	0	0	0	0
Feb	0	0	0	0	0	0	2	11	34	69	92	106	108	102	80	44	16	4	0	0	0	0	0	0
Mar	0	0	0	0	0	0	6	22	56	86	115	127	131	119	97	61	28	7	0	0	0	0	0	0
Apr	0	0	0	0	0	2	15	43	79	109	135	150	151	142	119	86	42	14	1	0	0	0	0	0
May	0	0	0	0	0	7	23	54	86	122	141	159	164	152	128	94	49	19	5	0	0	0	0	0
Jun	0	0	0	0	0	8	24	49	81	118	152	170	176	162	135	104	59	25	6	0	0	0	0	0
Jul	0	0	0	0	0	6	23	57	94	129	151	169	173	165	138	104	61	25	6	0	0	0	0	0
Aug	0	0	0	0	0	4	18	49	92	126	155	173	170	159	128	88	46	17	4	0	0	0	0	0
Sep	0	0	0	0	0	2	12	35	69	98	128	140	141	131	102	65	28	7	0	0	0	0	0	0
Oct	0	0	0	0	0	0	6	25	57	86	109	123	122	108	76	39	12	2	0	0	0	0	0	0
Nov	0	0	0	0	0	0	3	15	39	70	88	101	97	78	49	21	6	0	0	0	0	0	0	0
Dec	0	0	0	0	0	0	0	8	26	50	75	87	82	64	41	18	5	0	0	0	0	0	0	0

Design Illuminance = 40 fc

< 4 fc; < 20 fc; < 40 fc; > 40 fc;

Location = Los Angeles, CA





SkyCalc: Skylight Design Assistant - Tabular Results

Company Name: VALENCIA ICE STATION
Project Description: HYBRID LIGHTING PROJECT

Electric Lighting Usage	kWh/yr		
Ltg. Energy without Skylights	178,774	Lighting Fraction Saved	52%
Lighting Energy w/ Skylights	86,132	Full daylighting (h/yr)	2,847

Savings from Design Skylighting System

Savings		Annual Energy Savings (kWh/yr)	Annual Cost Savings ($/yr)
Lighting		92,642	$12,044
Cooling			
Heating			
Total		**92,642**	**$12,044**

Skylighting System Description

Skylight unit size (ft^2)	16.0
Number of Skylights	59
Total Skylight Area (ft^2)	944
Skylight to Floor Ratio (SFR)	2.2%
Effective Aperture	1.8%
Floor Area per Skylight	729
Skylight U-value	0.540
Skylight SHGC	24%
Skylight T_{vis}	94%
Well Efficiency (WF)	85%
Dirt and Screen Factor	100%
Overall Skylight System Tvis	80%
Skylight CU	106%

Site Description

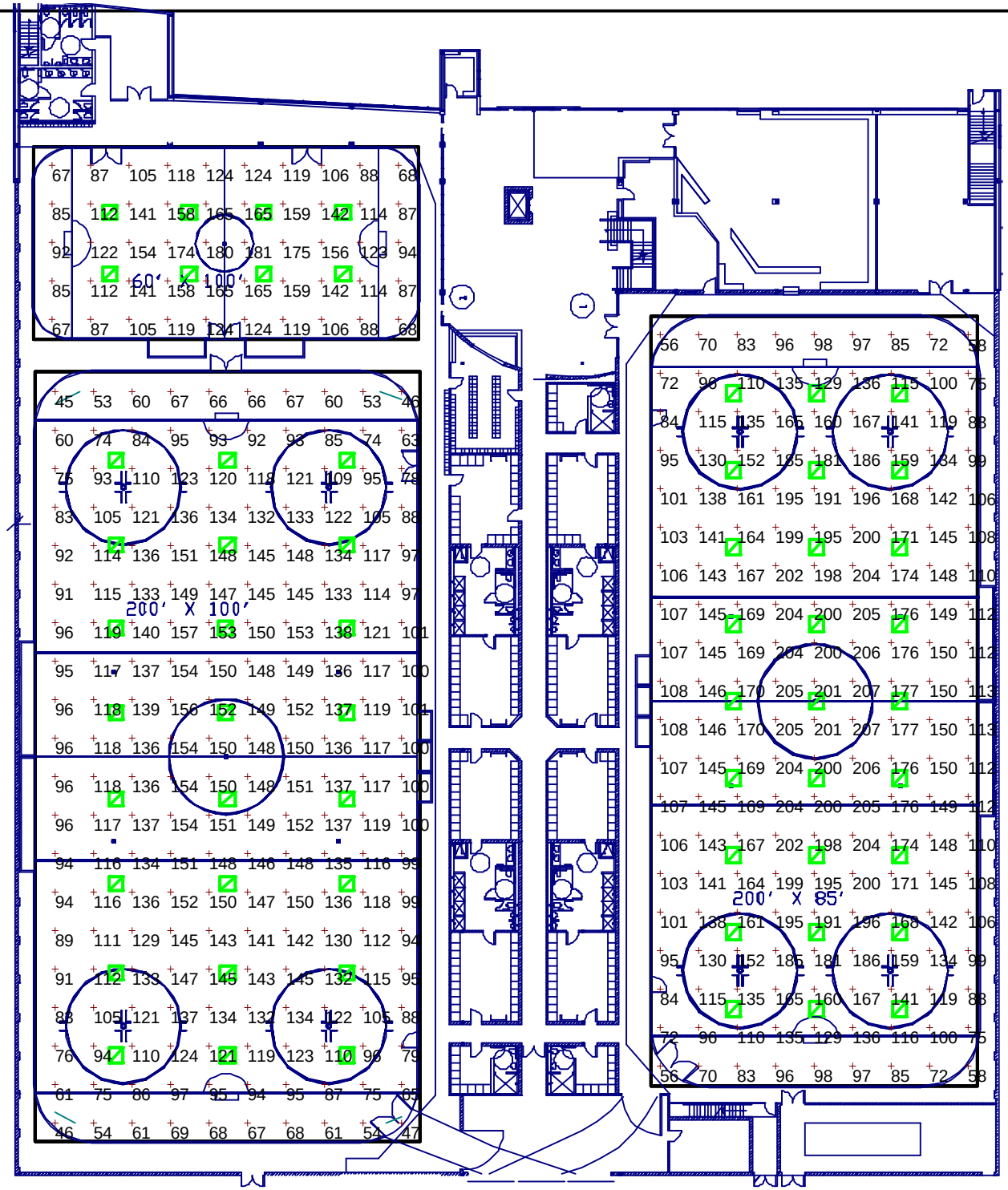
Climate Location	Los Angeles, CA	
Climate Zone	6	
Building Type	User_Defined_1	
Building Area	43,000	(ft^2)

Elecric Lighting System Description

Lighting Type	Industrial fluorescent	
Lighting Control	3 level + off switching	
Light Level Setpoint	50	fc
Lighting Density	0.67	W/ft^2
Connected Load	28.8	kW
Fraction Controlled	100%	

Plan View

Scale 1" = 40'



Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

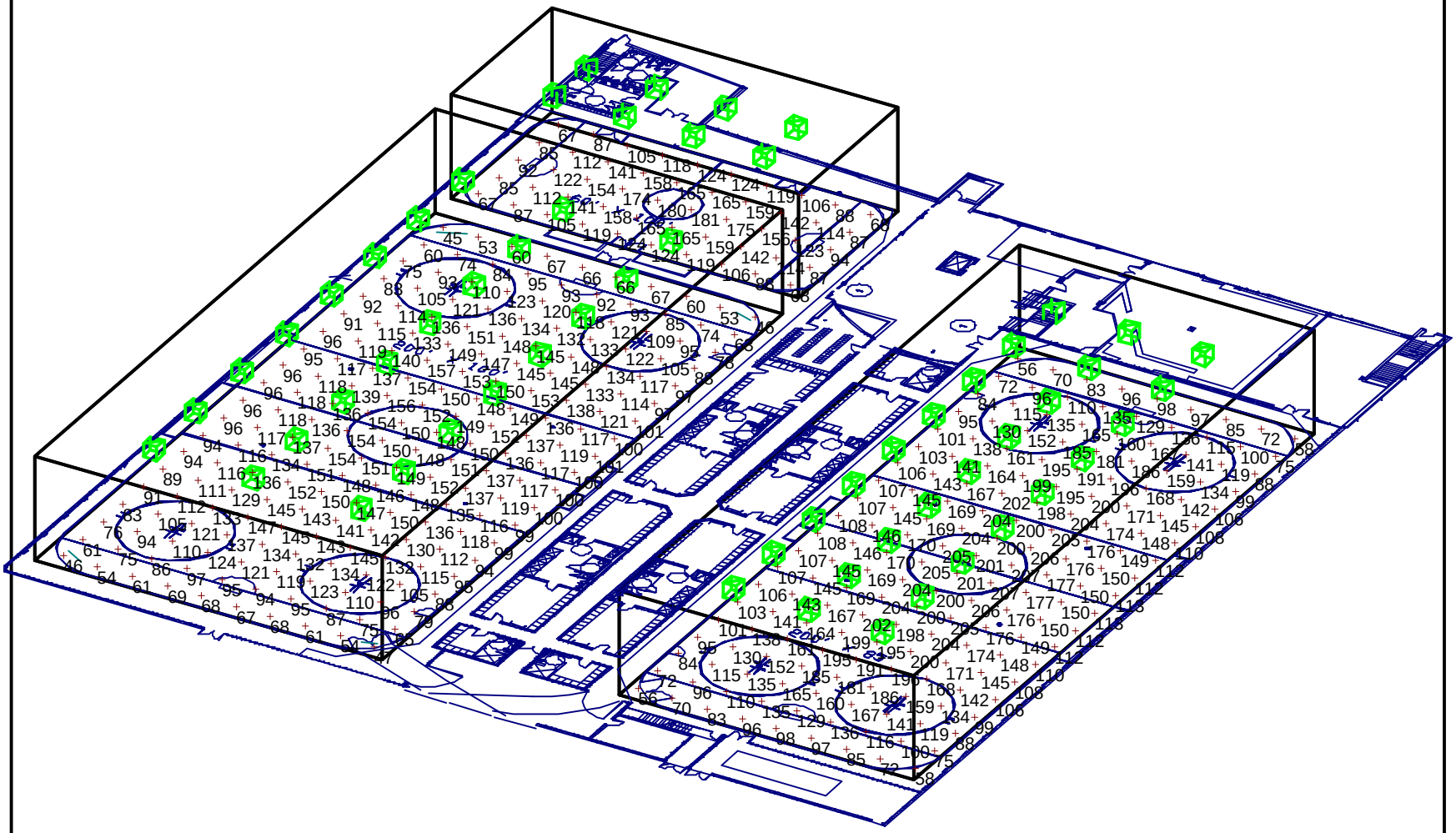
SKYLUME DAY SERIES LAYOUT

Designer
GBERNAL

Date
Mar 6 2001

Scale

Drawing No.



North Elevation

Scale 1" = 40'

Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

SKYLUME DAY SERIES LAYOUT

Designer
GBERNAL

Date
Mar 6 2001

Scale

Drawing No.

STATISTICS

Description	Avg	Max	Min	Max/Min	Avg/Min
Floor-50'x100'	122 fc	181 fc	67 fc	2.7:1	1.8:1
Floor-100'x 200'	114 fc	156 fc	45 fc	3.5:1	2.5:1
Floor-85'x 200'	143 fc	206 fc	56 fc	3.7:1	2.6:1

LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF
	Skylight	59		PROJECT: AES		dlx5252t.ies	140000	0.75

Calculated values include direct and interreflected components.

VALENCIA ICE STATION

SKYLUME DAY SERIES LAYOUT

Designer
GBERNAL

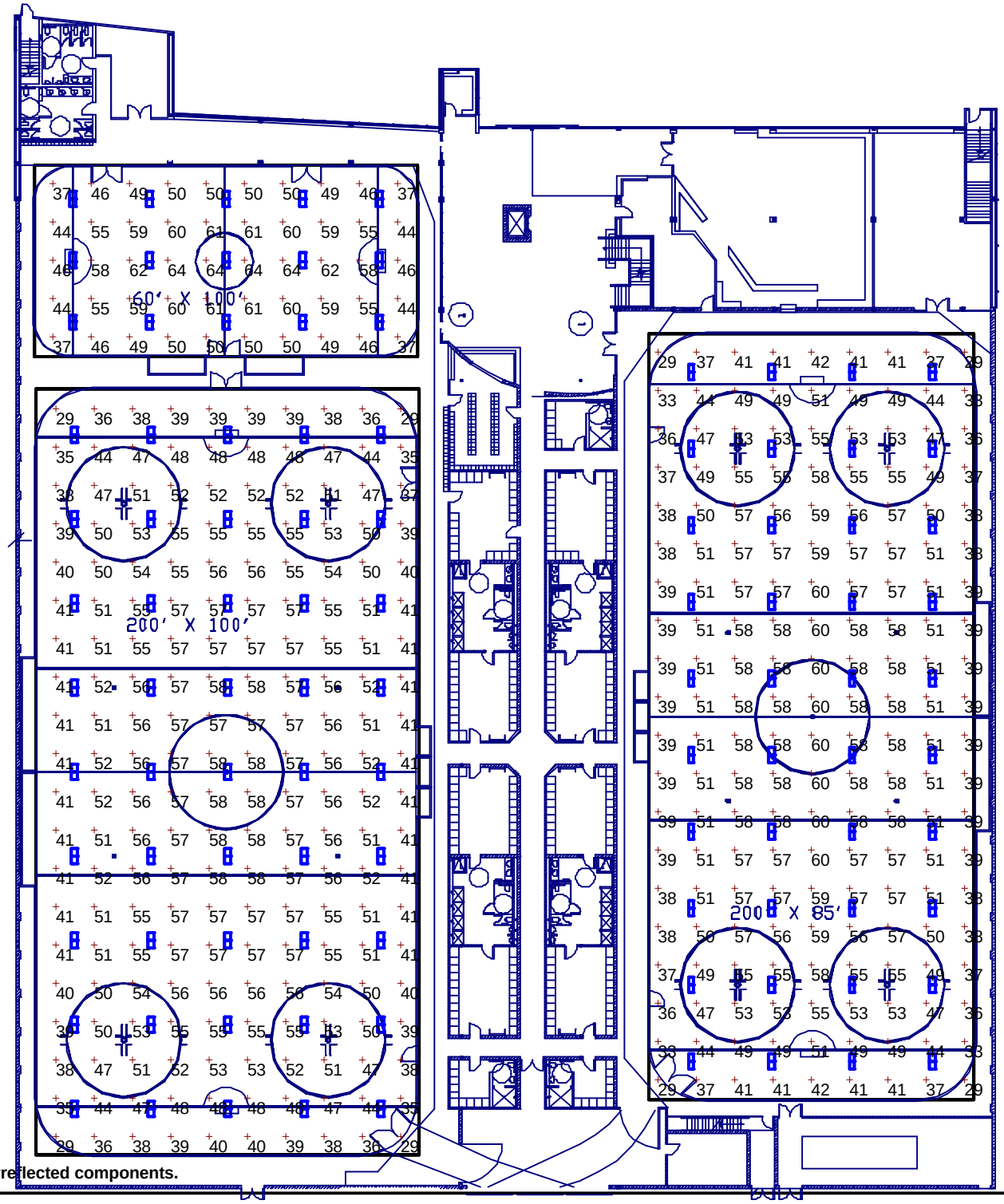
Date
Mar 6 2001

Scale

Drawing No.

Plan View

Scale 1" = 40'



Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

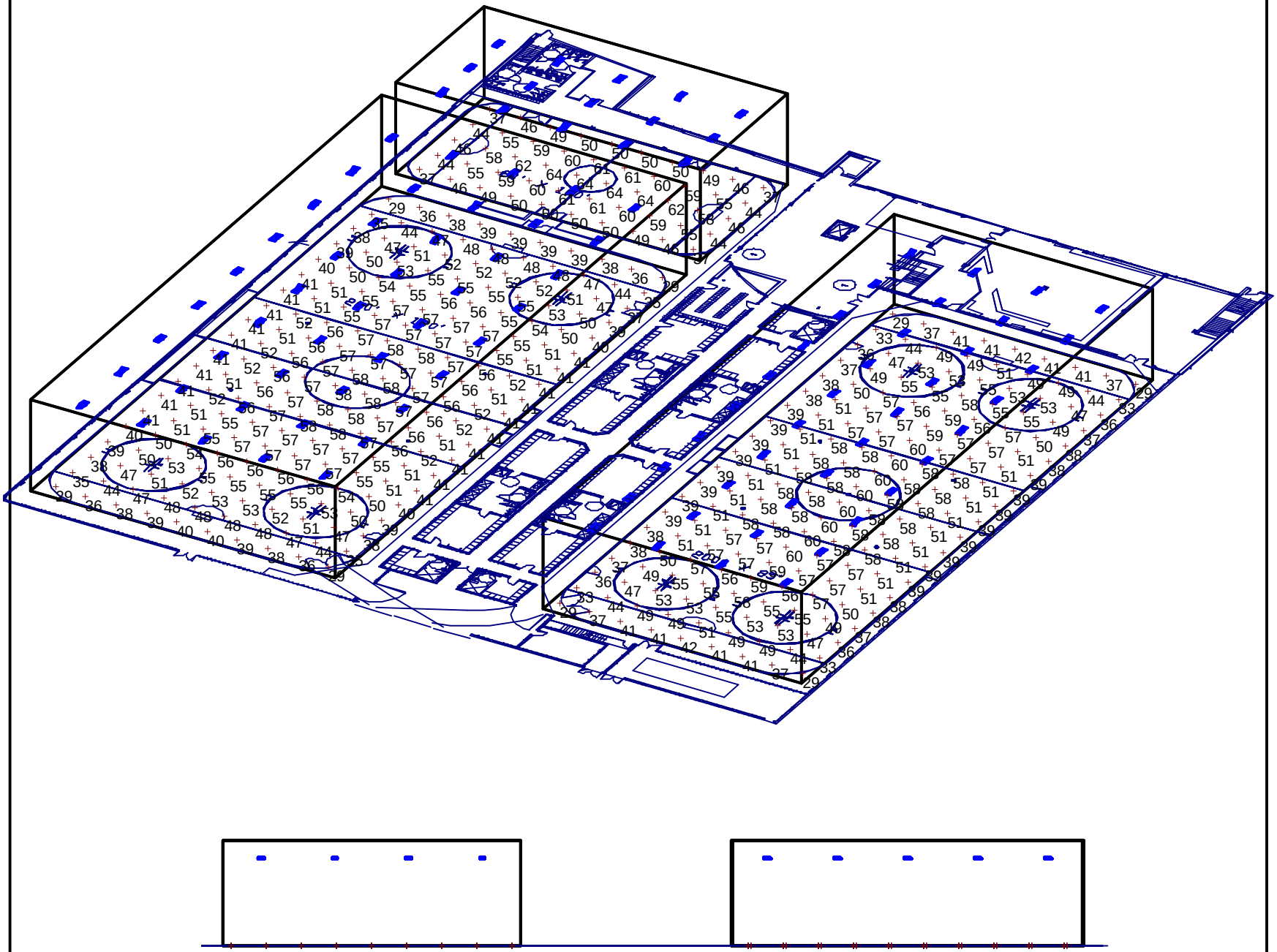
SFX24655

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4



North Elevation

Scale 1" = 40'

Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

SFX24655

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4

LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF
	A	100	AES-MAF28-6550-0	WITH SPECULAR REFLECTORS AND LENS - FIXTURE SET TO 0 DEGREES	SIX SYLVANIA 55 WATT CPFL LAMPS	T14758t.IES	38400	0.81

STATISTICS

Description	Avg	Max	Min	Max/Min	Avg/Min
Floor-50'x100'	53 fc	64 fc	37 fc	1.7:1	1.4:1
Floor-100'x 200'	49 fc	58 fc	29 fc	2.0:1	1.7:1
Floor-85'x 200'	49 fc	60 fc	28 fc	2.1:1	1.8:1

Calculated values include direct and interreflected components.

AES Light Conditioning Systems

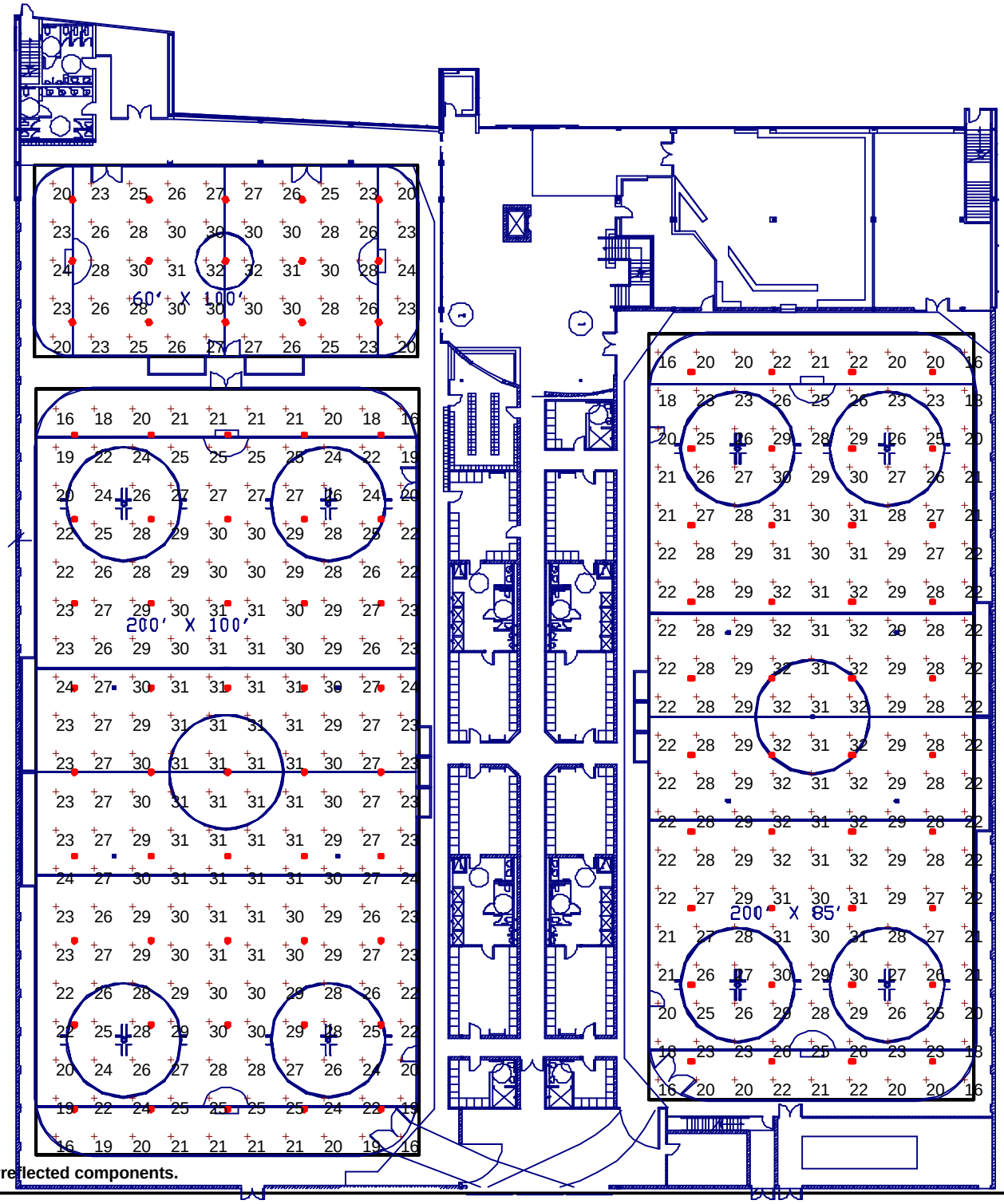
VALENCIA ICE STATION
SFX24655

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4



Plan View

Scale 1" = 40'

Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

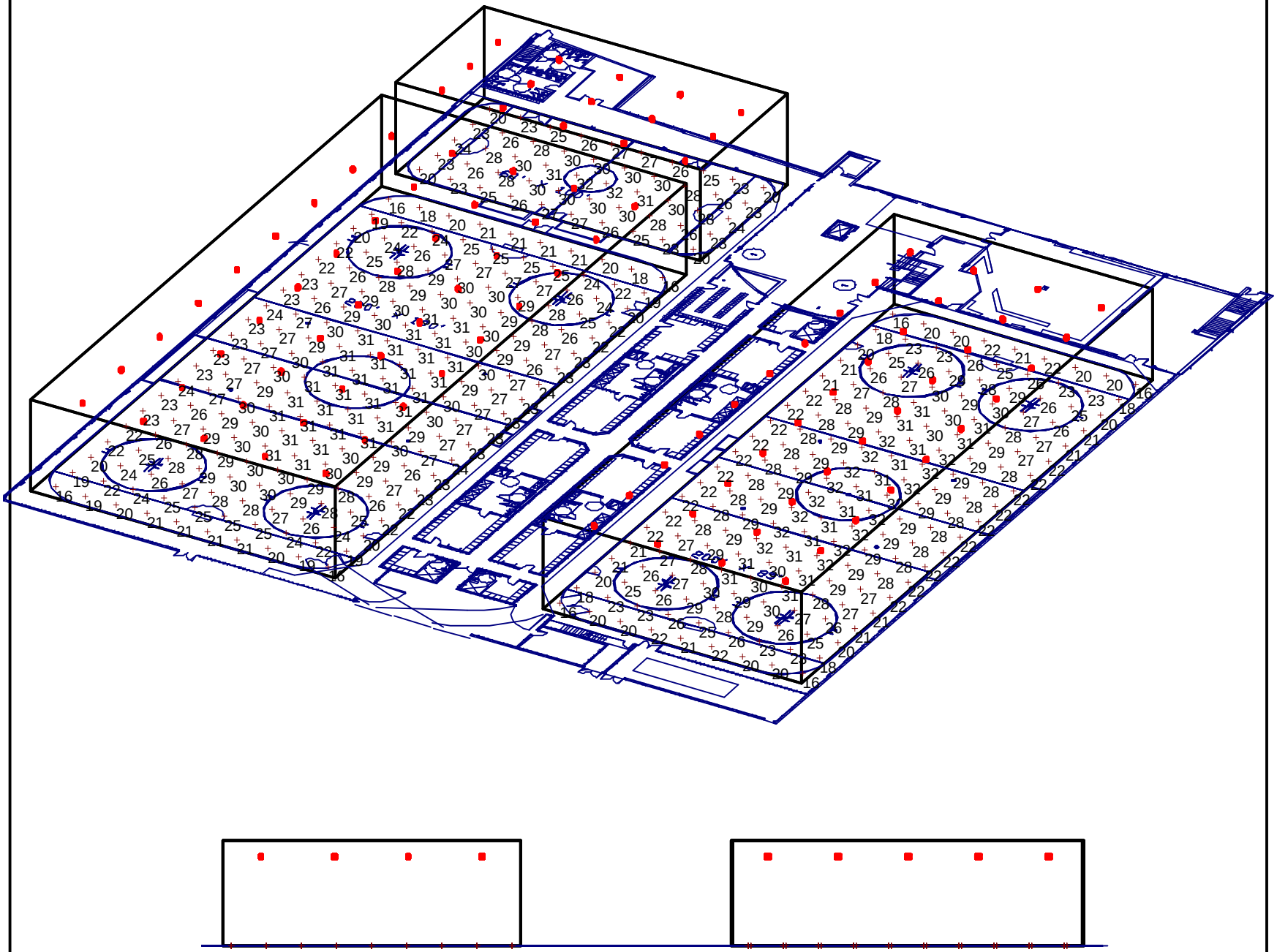
LITHONIA 400WATT METAL HALIDE
THV SERIES OPEN REFLECTOR

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4



North Elevation

Scale 1" = 40'

Calculated values include direct and interreflected components.

AES Light Conditioning Systems

VALENCIA ICE STATION

LITHONIA 400WATT METAL HALIDE
THV SERIES OPEN REFLECTOR

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4

LUMINAIRE SCHEDULE

Symbol	Label	Qty	Catalog Number	Description	Lamp	File	Lumens	LLF
	B	100	THV 400H A14	OPEN REFLECTOR	400 WATT MV	18690.ies	23000	0.65

STATISTICS

Description	Avg	Max	Min	Max/Min	Avg/Min
Floor-50'x100'	26 fc	32 fc	20 fc	1.6:1	1.3:1
Floor-100'x 200'	26 fc	31 fc	16 fc	1.9:1	1.6:1
Floor-85'x 200'	26 fc	32 fc	16 fc	2.0:1	1.6:1

Calculated values include direct and interreflected components.

VALENCIA ICE STATION

LITHONIA 400WATT METAL HALIDE
THV SERIES OPEN REFLECTOR

Designer
Gus Bernal

Date
Jul 12 1999

Scale
see scale

Report No.
ValenciaRink4

DAYLIGHTING *initiative*

Design tools and information from The Pacific Gas and Electric Company

Skylighting and Retail Sales

An Investigation into the Relationship Between Daylighting and Human Performance

Detailed Report

August 20, 1999

Submitted to:

George Loisos
Pacific Gas and Electric Company
on behalf of the
California Board for Energy Efficiency Third Party Program

Submitted by:

HESCHONG MAHONE GROUP
11626 Fair Oaks Blvd. #302
Fair Oaks, CA 95628

ACKNOWLEDGEMENTS

This study was performed on behalf of the California Board for Energy Efficiency for the Third Party Program administered by Pacific Gas and Electric, as part of PG&E contract 460 000 8215. George Loisos was the project manager and Mona Yew the Contract Administrator.

Lisa Heschong, Partner in the HESCHONG MAHONE GROUP, directed the study. She has been assisted at the HESCHONG MAHONE GROUP by Douglas Mahone, Kalpana Kuttaiah, Nehemiah Stone, Cathy Chappell, Jon McHugh, and Jackie Burton.

Stacia Okura of RLW Analytics conducted the statistical analysis under the direction of Dr. Roger Wright, Principal, RLW Analytics.

Barbara Erwine of Cascadia Consulting and Michael Holtz of Architectural Energy Corporation participated in initial study design and analysis methodology.

We are deeply indebted to the personnel at the participating company who made this study possible, by providing data and allowing us access to facilities. Many other companies were involved in the initial phases of this study, as we sought to identify the best possible participants. We greatly appreciate the time and effort that they put into helping us identify sources.

We are very thankful to the many other people who also made this study possible, through their interest in the significance of this work and willingness to provide helpful information and support. We would especially like to thank those who took the time to review and comment on the draft reports: Gregg Ander, Dr. Ed Arens, Dr. Gale Berger, Dr. Robert Clear, Dr. Rick Diamond, Dr. Margaret Morris, and Dr. David Wyon; and Steven Selkowitz who organized the review.

1. EXECUTIVE SUMMARY

This study looks at the effect of daylighting on human performance. It specifically focuses on skylighting as a way to isolate daylight as an illumination source, and avoid all of the other qualities associated with daylighting from windows. In this project, we established a statistically compelling connection between skylighting and retail sales, and between daylighting and student performance. This report focuses on the retail analysis.

We analyzed data on the sales performance of a chain retailer that operates a set of nearly identical stores. The analysis included 108 stores, where two thirds of the stores have skylighting and one third do not. The design and operation of all the store sites is remarkably uniform, with the exception of the presence of skylights in some. The electric lighting was primarily fluorescent. Daylight from the skylights often provided more than two to three times the target illumination levels. Photo-sensor controls turned off some of the fluorescent lights when daylight levels exceeded target illumination.

The monthly gross sales per store were averaged over an 18-month period running from February 1 of one year to August 31 of the next. This average sales figure was transformed into a “sales index” that we could manipulate statistically, but that did not reveal actual dollar performance. Stores in the sample were located within a limited geographic region that had similar climatic conditions. Buildings in the study fell within constrained ranges of size and age. The geographic region has a relatively sunny climate. All of the stores in the data set are one story.

The multivariate regression analysis allowed us to control for the influence of other variables which might influence sales. Other variables considered included the size and age of the store, hours of operation, and economic characteristics associated with the zip code location.

Skylights were found to be positively and significantly correlated to higher sales. All other things being equal, an average non-skylit store in the chain would likely have 40% higher sales with the addition of skylights, with a probable range between 31% and 49%. This was found with 99% statistical certainty. After the number of hours open per week, the presence of skylights was the best predictor of the sales per store of all the variables that we considered. Thus, if a typical non-skylit store were averaging sales of $2/sf, then its sales might be expected to increase to between $2.61 and $2.98 with the addition of a skylighting system.

The skylights are seen to have a major impact on the overall operation of the chain. Were the chain to add the skylighting system to the remaining 33% of its stores, yearly gross sales are predicted to increase by 11%. The difference between having none of their stores skylit and all their stores skylit is an increase of up to a 40% in gross sales for the retail chain.

DAYLIGHTING *initiative*

Design tools and information from The Pacific Gas and Electric Company

Daylighting in Schools

An Investigation into the Relationship Between Daylighting and Human Performance

Condensed Report

August 20, 1999

Submitted to:

George Loisos
The Pacific Gas and Electric Company
on behalf of the
California Board for Energy Efficiency Third Party Program

Submitted by:

HESCHONG MAHONE GROUP
11626 Fair Oaks Blvd. #302
Fair Oaks, CA 95628

ACKNOWLEDGEMENTS

This study was performed on behalf of the California Board for Energy Efficiency for the Third Party Program administered by Pacific Gas and Electric, as part of PG&E contract 460 000 8215. George Loisos was the project manager and Mona Yew the Contract Administrator.

Lisa Heschong, Partner in the Heschong Mahone Group, directed the study. She has been assisted at the Heschong Mahone Group by Douglas Mahone, Kalpana Kuttaiah, Nehemiah Stone, Cathy Chappell, Jon McHugh, and Jackie Burton.

Stacia Okura of RLW Analytics conducted the statistical analysis under the direction of Dr. Roger Wright, Principal, RLW Analytics.

Barbara Erwine of Cascadia Conservation investigated daylighting conditions at the Seattle Public Schools. Neal Digert and Ken Baker of Architectural Energy Corporation investigated daylighting conditions at Poudre School District in Fort Collins, Colorado. Both Cascadia Conservation and Architectural Energy Corporation participated in data acquisition and development of the analysis methodology.

We are deeply indebted to the school district personnel who made this study possible, by providing data and allowing us access to district records and facilities. Jeff Bristow and Chuck Berridge at Capistrano Unified School District in Southern California, Mike O'Connell at Seattle City Public Schools in Washington State and Hugh Mowery at Poudre School District in Fort Collins, Colorado, provided access to their district's data and assisted with its interpretation. Dave Doomey, Ken Harkner and Bob Sendzik at Capistrano, Kathy Johnson at Seattle and Mike Spearnak at Poudre helped provide information about and access to their district facilities.

We are very thankful to the many other people who also made this study possible, through their interest in the significance of this work and their willingness to provide helpful information and support. We would especially like to thank those who took the time to review and comment on the draft reports: Gregg Ander, Dr. Ed Arens, Dr. Gale Berger, Dr. Robert Clear, Dr. Rick Diamond, Dr. Judith Heerwagen, Dr. Paul Holland, Dr. Gage Kingsbury, Eleanor Lee, Dr. Margaret Morris, and Dr. David Wyon; and Steven Selkowitz who organized the review.

EXECUTIVE SUMMARY

This study looks at the effect of daylighting on human performance. It includes a focus on skylighting as a way to isolate illumination effects from other qualities associated with daylighting from windows, such as view and ventilation. In this project, we established a statistically compelling connection between daylighting and student performance, and between skylighting and retail sales. This report focuses on the school analysis.

We obtained student performance data from three elementary school districts and looked for a correlation to the amount of daylight provided by each student's classroom environment. We used data from second through fifth grade students in elementary schools for two reasons: because there is extensive data available from highly standardized tests administered to these students, and because elementary school students are generally assigned to one teacher in one classroom for the school year. Thus, we reasoned that if the physical environment does indeed have an effect on student performance, we would be mostly likely to be able to establish such a correlation by looking at the performance of elementary school students.

We analyzed test score results for over 21,000 students from the three districts, located in Orange County, California, Seattle, Washington, and Fort Collins, Colorado. The data sets included information about student demographic characteristics and participation in special school programs. We reviewed architectural plans, aerial photographs and maintenance records and visited a sample of the schools in each district to classify the daylighting conditions in over 2000 classrooms. Each classroom was assigned a series of codes on a simple 0-5 scale indicating the size and tint of its windows, the presence and type of any skylighting, and the overall amount of daylight expected.

The study used multivariate linear regression analysis to control for other influences on student performance. Regressions were compared using data from two separate tests, math and reading, for each district. Each math and reading model was also run separately using first the window and skylight codes, and then the overall daylight code. We reasoned that if daylight effects were truly robust the variables should perform similarly in all models. Thus, we created a total of twelve models for comparison, consisting of four models for each of three districts.

The daylighting conditions at the Capistrano school district were the most diverse, and the data from that district were also the most detailed. Thus Capistrano became our most precise model. In this district, we were able to study the change in student test scores over a school year. Controlling for all other influences, we found that students with the most daylighting in their classrooms progressed 20% faster on math tests and 26% on reading tests in one year than those with the least. Similarly, students in classrooms with the largest window areas were found to progress 15% faster in math and 23% faster in reading than

those with the least. And students that had a well-designed skylight in their room, one that diffused the daylight throughout the room and which allowed teachers to control the amount of daylight entering the room, also improved 19-20% faster than those students without a skylight. We also identified another window-related effect, in that students in classrooms where windows could be opened were found to progress 7-8% faster than those in rooms with fixed windows. This occurred regardless of whether the classroom also had air conditioning. These effects were all observed with 99% statistical certainty.

The studies in Seattle and Fort Collins used the final scores on math and reading tests at the end of the school year, rather than the amount of change from the beginning of the year. In both of these districts we also found positive, and highly significant, effects for daylighting. Students in classrooms with the most daylighting were found to have 7% to 18% higher scores than those in rooms with the least.

The three districts have different curricula and teaching styles, different school building designs and very different climates. Yet the results of the studies show consistently positive and highly significant effects. This consistency supports the proposition that there is a valid and predictable effect of daylighting on student performance.

The results of this study of student performance, when considered along with those of the companion study showing the positive effect of skylighting on retail sales, also strongly support the thesis that these performance benefits from daylighting can be translated to other building types and human activities.

ROY ASSOCIATES • *Consulting Engineers*

39199 Liberty St., Suite B-2 • Fremont, CA 94538-1501 • Tel: (510) 794-8091 • Fax: (510) 794-7250

September 7, 2000

Sun Microsystems
7777 Gateway Boulevard
Newark, CA 94560

Attention: Mr. Ben Thompson/Project Manager

Subject: Fixture comparison for Sun Microsystems located at 7777 Gateway Boulevard, Newark, California

Reference: Meeting August 4, 2000 at the subject facility

Dear Mr. Thompson:

As discussed in the reference meeting, we have completed our comparison of the two proposed fixtures for rows 9 & 10 for the subject building. Enclosed are two (2) copies of the report for your review and comment.

As shown in the report we have evaluated two (2) lighting fixtures:

- Fixture 1: AES model MAF24-855-P-C-27-41
- Fixture 2: SPORTLITE model LX800-T42-AL-277

As discussed in the attached report, the foot-candle measurements were performed on August 24, 2000 from 9:30 p.m. to 10:30 p.m. Two types of measurements were performed: horizontal and vertical. The horizontal foot-candle illumination levels are contained in Figures 1 through 8 and vertical foot-candle levels are contained in Figures 9 and 10.

As indicated in Figures 1 through 10, the illumination levels under Fixture #1 at each measured point were higher than those of fixture #2. The horizontal readings for Fixture #1 produced on average 148% more foot-candles (53.37 FC) than Fixture #2 (36.14 FC). With the vertical readings, Fixture #1 produced on average 124 % more foot-candles (23.46 FC) than Fixture #2 (18.96 FC).

In addition, we have performed an economic analysis that considers the initial fixture and installation cost and annual operating cost for Fixtures #1 and #2. It should be noted that it would require 1.5 times the number of fixtures of Fixture #2 to produce the desired

illumination levels of Fixture #1. This analysis considers the installation cost as discussed in the Referenced meeting, which was later converted on an each fixture basis for comparison purposes. As indicated in Table #1, the unit cost of Fixture #1 is 208% higher ($625) than the unit cost for Fixture #2 ($300). The installation cost for Fixture #1 is 78% lower ($97,135) of the installation cost for Fixture #2 ($127,704). The total annual estimated cost for Fixture #1 is $21,535 whereas the annual estimated cost for Fixture #2 is $23,584.

We hope the information provided in the attached report will be useful in selecting the type of fixtures that will provide the desired illumination levels for the workplace environment

Should you have any questions and/or comments, do not hesitate to call me at (510)794-8091.

Sincerely,
ROY ASSOCIATES

Sanat K. Roy, P.E.
Principal

Attachment