OPEN ACCESS

remote sensing

ISSN 2072-4292

www.mdpi.com/journal/remotesensing

Supplementary Information

Aladdin's Magic Lamp: Active Target Calibration of the DMSP OLS. *Remote Sens.* 2014, *6*, 12708–12722

Benjamin T. Tuttle [1], Sharolyn Anderson [2], Chris Elvidge [3], Tilottama Ghosh [4], Kim Baugh [4] and Paul Sutton [1,2,*]

[1] Department of Geography and the Environment, University of Denver, Boettcher West, Room 120, 2050 E. Iliff Ave., Denver, CO 80208, USA; E-Mail: bentuttle.du@gmail.com

[2] School of the Natural and Built Environments, University of South Australia, GPO Box 2471 Adelaide, SA 5001, Australia; E-Mail: sharolyn.anderson@unisa.edu.au

[3] National Geophysical Data Center, 325 Broadway, E/GC2, Boulder, CO 80305, USA; E-Mail: Chris.Elvidge@noaa.gov

[4] University of Colorado, Boulder, Cooperative Institute for Research in Environmental Sciences, 325 Broadway, E/GC2, Boulder, CO 80305, USA; E-Mails: tilottama.ghosh@noaa.gov (T.G.); kim.baugh@noaa.gov (K.B.)

External Editors: Richard Müller and Prasad S. Thenkabail

* Author to whom correspondence should be addressed; E-Mail: psutton@du.edu; Tel.: +1-303-503-1575; Fax: +1-303-871-2201.

---

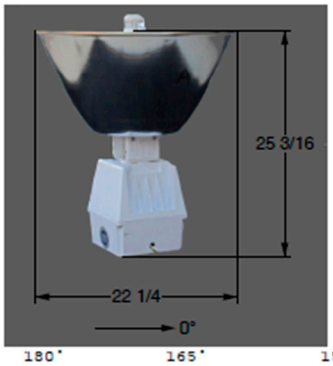
1. Introduction

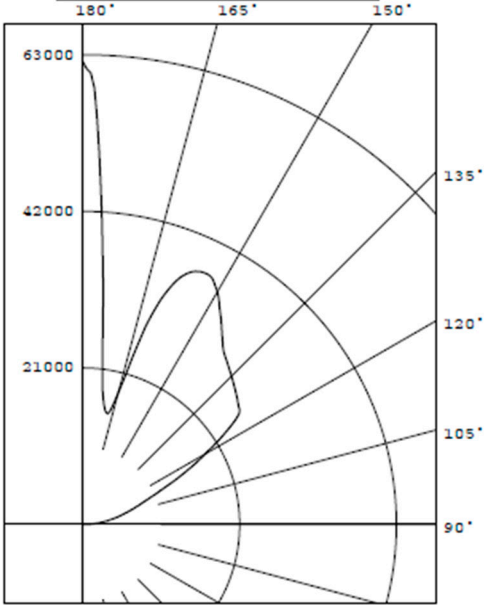
The following four figures (Figures S1–S4) each four pages long are the independent third-party testing reports as we received them. We removed the individual names but all data and the format is original. Thus, this representation preserves the original format. Independent Testing Labs (ITL) is an independent light testing laboratory that provides lighting manufacturers, designers, architects, the government and others an accurate, efficient and unbiased source of evaluation for virtually every type of lighting. In order to get an accurate characterization of the lights used in this research the lights were sent to ITL for independent testing. The results from ITL provided in this supplement provide a characterization of the directional output of the lights as well as the spectral signature.

Figure S1. Report Number: ITL74069.

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74069 PAGE: 1 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: A
LUMINAIRE: CAST WHITE PAINTED METAL BALLAST HOUSING WITH FABRICATED WHITE PAINTED METAL ADJUSTABLE REFLECTOR/SOCKET MOUNTING PLATE, SPUN SEMI-SPECULAR METAL REFLECTOR, OPEN TOP. REFLECTOR MOUNT SET TO LOWEST POSITION.
LAMP: ONE 1000-WATT CLEAR E-25 HIGH PRESSURE SODIUM, SYLVANIA LU/1000/ECO, VERTICAL BASE-DOWN POSITION.
BALLAST: HOWARD LIGHTING PRODUCTS HAL220-1000-HPS-4T
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE BALLAST.
TOTAL INPUT WATTS = 1107.0 AT 120.0 VOLTS
TEST DISTANCE = 33.25 FEET





DEG	CANDELA	LUMENS
0	0	
5	0	0
15	0	0
25	0	0
35	0	0
45	0	0
55	0	0
65	0	0
75	0	0
85	48	93
90	431	
95	1951	2225
105	5933	6385
115	12854	13133
125	25318	21612
135	28144	21793
145	32406	20355
155	37384	16963
165	18228	6360
175	31355	2502
180	62029	

ZONAL LUMEN SUMMARY

ZONE	LUMENS	%FIXT
0- 30	0	0.0
0- 40	0	0.0
0- 60	0	0.0
0- 90	93	0.1
90-120	21744	19.5
90-130	43356	38.9
90-150	85504	76.7
90-180	111329	99.9
0-180	111423	100.0

EFFICACY = 100.7 lm/W
CIE TYPE - INDIRECT

THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

Figure S1. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74069 PAGE: 2 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER

CANDELA DISTRIBUTION

0.0	0	160.5	32732
2.5	0	161.0	31761
5.0	0	161.5	30443
7.5	0	162.0	29241
10.0	0	162.5	27653
12.5	0	163.0	25448
15.0	0	163.5	23257
17.5	0	164.0	21161
20.0	0	164.5	19448
22.5	0	165.0	18228
25.0	0	165.5	17150
27.5	0	166.0	16286
30.0	0	166.5	15704
32.5	0	167.0	15388
35.0	0	167.5	15246
37.5	0	168.0	15273
40.0	0	168.5	15413
42.5	0	169.0	15622
45.0	0	169.5	15929
47.5	0	170.0	16259
50.0	0	170.5	16705
52.5	0	171.0	17294
55.0	0	171.5	17925
57.5	0	172.0	18766
60.0	0	172.5	20050
62.5	0	173.0	21573
65.0	0	173.5	23297
67.5	0	174.0	25325
70.0	0	174.5	28088
72.5	0	175.0	31355
75.0	0	175.5	34319
77.5	0	176.0	37670
80.0	0	176.5	41531
82.5	19	177.0	45485
85.0	48	177.5	49992
87.5	59	178.0	54591
90.0	431	178.5	58568
95.0	1951	179.0	60591
100.0	3839	179.5	61092
105.0	5933	180.0	62029
110.0	8492		
115.0	12854		
120.0	18937		
125.0	25318		
127.5	26262		
130.0	26880		
132.5	27492		
135.0	28144		
137.5	28839		
140.0	29590		
142.5	30747		
145.0	32406		
147.5	34164		
150.0	36023		
151.0	36598		
152.0	37148		
153.0	37450		
154.0	37485		
155.0	37384		
156.0	37159		
157.0	36735		
158.0	36061		
159.0	35023		
160.0	33585		

Figure S1. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74069 PAGE: 3 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER

5-DEGREE ZONAL LUMEN SUMMARY

0- 5	0
5- 10	0
10- 15	0
15- 20	0
20- 25	0
25- 30	0
30- 35	0
35- 40	0
40- 45	0
45- 50	0
50- 55	0
55- 60	0
60- 65	0
65- 70	0
70- 75	0
75- 80	0
80- 85	12
85- 90	82
90- 95	652
95-100	1573
100-105	2615
105-110	3770
110-115	5405
115-120	7728
120-125	10229
125-130	11382
130-135	11112
135-140	10682
140-145	10295
145-150	10060
150-155	9379
155-160	7584
160-165	4465
165-170	1895
170-175	1467
175-180	1035

10-DEGREE ZONAL LUMEN SUMMARY

0- 10	0
0- 20	0
0- 30	0
0- 40	0
0- 50	0
0- 60	0
0- 70	0
0- 80	0
0- 90	93
0-100	2319
0-110	8704
0-120	21838
0-130	43449
0-140	65243
0-150	85598
0-160	102561
0-170	108920
0-180	111423

Figure S1. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74069 PAGE: 4 OF 4

ISSUE DATE: 09/28/12

PREPARED FOR: UNIVERSITY OF DENVER

COEFFICIENTS OF UTILIZATION - ZONAL CAVITY METHOD

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20

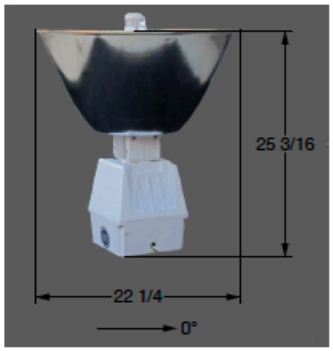
RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
0	95	95	95	95	81	81	81	81	56	56	56	32	32	32	10	10	10	0
1	87	83	79	76	74	71	68	65	48	47	45	28	27	26	9	9	8	0
2	79	72	66	62	67	62	57	53	42	40	37	24	23	22	8	7	7	0
3	72	63	56	51	61	54	49	44	37	34	31	21	20	18	7	6	6	0
4	65	56	48	43	56	48	42	37	33	29	26	19	17	16	6	6	5	0
5	60	49	42	36	51	42	36	32	29	25	22	17	15	13	5	5	4	0
6	55	44	36	31	47	38	32	27	26	22	19	15	13	11	5	4	4	0
7	50	39	32	27	43	34	28	23	23	19	17	14	11	10	4	4	3	0
8	47	35	28	23	40	30	24	20	21	17	14	12	10	9	4	3	3	0
9	43	32	25	20	37	27	22	18	19	15	13	11	9	8	4	3	3	0
10	40	29	22	18	34	25	19	16	17	14	11	10	8	7	3	3	2	0

ALL CANDELA, LUMENS, LUMINANCE, AND VCP VALUES IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS TEST SAMPLE.

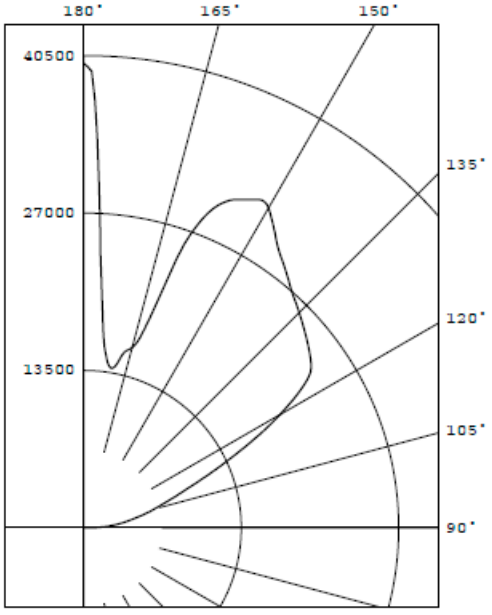
Figure S2. Report Number: ITL74070.

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74070 PAGE: 1 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: B
LUMINAIRE: CAST WHITE PAINTED METAL BALLAST HOUSING WITH FABRICATED WHITE PAINTED METAL ADJUSTABLE REFLECTOR/SOCKET MOUNTING PLATE, SPUN SEMI-SPECULAR METAL REFLECTOR, OPEN TOP. REFLECTOR MOUNT SET TO LOWEST POSITION.
LAMP: ONE 1000-WATT CLEAR E-25 HIGH PRESSURE SODIUM, SYLVANIA LU/1000/ECO, VERTICAL BASE-DOWN POSITION.
BALLAST: HOWARD LIGHTING PRODUCTS HAL220-1000-HPS-4T
NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE BALLAST.
TOTAL INPUT WATTS = 1057.9 AT 120.0 VOLTS
TEST DISTANCE = 33.25 FEET



DEG	CANDELA	LUMENS
0	0	
5	0	0
15	0	0
25	0	0
35	0	0
45	0	0
55	0	0
65	0	0
75	1	4
85	74	142
90	601	
95	2513	2682
105	6284	6792
115	13555	13716
125	23787	20602
135	26124	20220
145	29111	18370
155	31076	14224
165	15992	5149
175	18461	1682
180	39826	



ZONAL LUMEN SUMMARY

ZONE	LUMENS	%FIXT
0- 30	0	0.0
0- 40	0	0.0
0- 60	0	0.0
0- 90	147	0.1
90-120	23190	22.4
90-130	43792	42.3
90-150	82381	79.5
90-180	103437	99.9
0-180	103584	100.0

EFFICACY = 97.9 lm/W
CIE TYPE - INDIRECT

Figure S2. *Cont.*

INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74070 PAGE: 2 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER

CANDELA DISTRIBUTION

0.0	0	160.5	25846
2.5	0	161.0	24342
5.0	0	161.5	22260
7.5	0	162.0	20453
10.0	0	162.5	19055
12.5	0	163.0	17855
15.0	0	163.5	17045
17.5	0	164.0	16547
20.0	0	164.5	16223
22.5	0	165.0	15992
25.0	0	165.5	15834
27.5	0	166.0	15723
30.0	0	166.5	15616
32.5	0	167.0	15469
35.0	0	167.5	15212
37.5	0	168.0	14798
40.0	0	168.5	14393
42.5	0	169.0	14137
45.0	0	169.5	13978
47.5	0	170.0	13895
50.0	0	170.5	13909
52.5	0	171.0	14030
55.0	0	171.5	14186
57.5	0	172.0	14424
60.0	0	172.5	14784
62.5	0	173.0	15158
65.0	0	173.5	15639
67.5	0	174.0	16285
70.0	0	174.5	17198
72.5	0	175.0	18461
75.0	1	175.5	19810
77.5	4	176.0	21513
80.0	22	176.5	23493
82.5	54	177.0	26450
85.0	74	177.5	29690
87.5	81	178.0	33273
90.0	601	178.5	36641
95.0	2513	179.0	39154
100.0	4218	179.5	39538
105.0	6284	180.0	39826
110.0	8951		
115.0	13555		
120.0	19425		
125.0	23787		
127.5	24434		
130.0	24990		
132.5	25542		
135.0	26124		
137.5	26694		
140.0	27421		
142.5	28255		
145.0	29111		
147.5	30377		
150.0	31691		
151.0	31972		
152.0	31904		
153.0	31586		
154.0	31306		
155.0	31076		
156.0	30739		
157.0	30219		
158.0	29513		
159.0	28377		
160.0	26865		

Figure S2. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74070 PAGE: 4 OF 4

ISSUE DATE: 09/28/12

PREPARED FOR: UNIVERSITY OF DENVER

COEFFICIENTS OF UTILIZATION - ZONAL CAVITY METHOD

EFFECTIVE FLOOR CAVITY REFLECTANCE 0.20

RC	80				70				50			30			10			0
RW	70	50	30	10	70	50	30	10	50	30	10	50	30	10	50	30	10	0
0	95	95	95	95	81	81	81	81	56	56	56	32	32	32	10	10	10	0
1	87	83	79	76	74	71	68	65	48	47	45	28	27	26	9	9	8	0
2	79	72	66	62	67	62	57	53	42	40	37	24	23	22	8	7	7	0
3	72	63	56	51	61	54	49	44	37	34	31	21	20	18	7	6	6	0
4	65	56	48	43	56	48	42	37	33	29	26	19	17	16	6	6	5	0
5	60	49	42	36	51	42	36	32	29	25	22	17	15	13	5	5	4	0
6	55	44	36	31	47	38	32	27	26	22	19	15	13	11	5	4	4	0
7	50	39	32	27	43	34	28	23	23	19	17	14	11	10	4	4	3	0
8	47	35	28	23	40	30	24	20	21	17	14	12	10	9	4	3	3	0
9	43	32	25	20	37	27	22	18	19	15	13	11	9	8	4	3	3	0
10	40	29	22	18	34	25	19	16	17	14	11	10	8	7	3	3	2	0

ALL CANDELA, LUMENS, LUMINANCE, AND VCP VALUES IN THIS REPORT ARE BASED ON ABSOLUTE PHOTOMETRY. THE COEFFICIENT OF UTILIZATION VALUES ARE BASED ON THE TOTAL ABSOLUTE LUMEN OUTPUT OF THIS TEST SAMPLE.

Figure S2. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74070 PAGE: 3 OF 4
ISSUE DATE: 09/28/12
PREPARED FOR: UNIVERSITY OF DENVER

5-DEGREE ZONAL LUMEN SUMMARY

0- 5	0
5- 10	0
10- 15	0
15- 20	0
20- 25	0
25- 30	0
30- 35	0
35- 40	0
40- 45	0
45- 50	0
50- 55	0
55- 60	0
60- 65	0
65- 70	0
70- 75	0
75- 80	4
80- 85	28
85- 90	115
90- 95	853
95-100	1829
100-105	2810
105-110	3982
110-115	5699
115-120	8018
120-125	9988
125-130	10613
130-135	10323
135-140	9897
140-145	9426
145-150	8943
150-155	8009
155-160	6216
160-165	3359
165-170	1790
170-175	1070
175-180	612

10-DEGREE ZONAL LUMEN SUMMARY

0- 10	0
0- 20	0
0- 30	0
0- 40	0
0- 50	0
0- 60	0
0- 70	0
0- 80	4
0- 90	147
0-100	2828
0-110	9621
0-120	23337
0-130	43938
0-140	64158
0-150	82528
0-160	96752
0-170	101902
0-180	103584

Figure S3. Report Number: ITL74071.

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74071 Page 1 of 4
DATE: 11/14/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: A

LUMINAIRE: CAST WHITE PAINTED METAL BALLAST HOUSING WITH FABRICATED WHITE PAINTED METAL ADJUSTABLE REFLECTOR/SOCKET MOUNTING PLATE, SPUN SEMI-SPECULAR METAL REFLECTOR, OPEN TOP. REFLECTOR MOUNT SET TO LOWEST POSITION.

LAMP: ONE 1000-WATT CLEAR E-25 HIGH PRESSURE SODIUM, SYLVANIA LU/1000/ECO, VERTICAL BASE-DOWN POSITION.

BALLAST: HOWARD LIGHTING PRODUCTS HAL220-1000-HPS-4T

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE BALLAST.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #8	01/26/13
	Ocean Optics QE65000 Spectroradiometer	06/05/13
	ITL 2.0 meter Diameter Integrating Sphere, 4PI Geometry	06/05/13

OBJECT OF TEST: Measure the Spectral Power Distribution (SPD), Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y) and electrical data including ANSI C82.77-2002 Power Factor (PF) to the test sample. Calculate the photometric candela to normalized Operational Linescan System (OLS) radiometer intensity ratio.

PROCEDURE: The test sample was provided by the customer and had an unknown number of burn hours. The test sample was mounted inside the integrating sphere and allowed to stabilize. After stabilization occurred, measurements were taken. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the test sample operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-51. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

Figure S3. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74071 Page 2 of 4
DATE: 11/14/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: A

RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.5205
Chromaticity Ordinate y	0.4175
Correlated Color Temp CCT (K)	2078
Color Rendering Index (CRIa)	34
Color Rendering Index 1 (Light greyish red)	26
Color Rendering Index 2 (Dark greyish yellow)	69
Color Rendering Index 3 (Strong yellowish green)	63
Color Rendering Index 4 (Moderate yellowish green)	9
Color Rendering Index 5 (Light bluish green)	25
Color Rendering Index 6 (Light blue)	62
Color Rendering Index 7 (Light violet)	45
Color Rendering Index 8 (Light reddish purple)	-27
Color Rendering Index 9 (Strong red)	-154
Color Rendering Index 10 (Strong yellow)	50
Color Rendering Index 11 (Strong green)	-15
Color Rendering Index 12 (Strong blue)	41
Color Rendering Index 13 (Light yellowish pink (skin))	29
Color Rendering Index 14 (Moderate olive green (leaf))	76
Photometric lumen to normalized OLS intensity ratio	0.00291
ELECTRICAL FOR SPECTRORADIOMETRIC TEST	
Input Voltage (Volts AC)	120.0
Input Current (Amps AC)	10.10
Input Power (Watts)	1106.9
Input Power Factor (%)	91.3

Figure S3. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74071
DATE: 11/14/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: A

RESULTS:

Wavelength	mW per nm	Wavelength	mW per nm	Wavelength	mW per nm
380	58.808	605	3557.948	830	480.518
385	57.434	610	2666.682	835	577.950
390	65.498	615	3072.950	840	1268.945
395	83.139	620	1688.795	845	7073.105
400	101.541	625	1404.709	850	4498.356
405	127.360	630	1209.094	855	834.633
410	123.425	635	1063.139	860	427.129
415	114.889	640	950.761	865	277.804
420	117.473	645	858.767	870	197.682
425	124.329	650	777.087	875	160.194
430	132.454	655	743.258	880	136.556
435	158.632	660	688.853	885	126.379
440	194.506	665	627.004	890	119.475
445	122.045	670	686.924	895	113.690
450	340.711	675	673.374	900	118.380
455	193.647	680	557.816	905	119.423
460	112.166	685	442.165	910	100.878
465	312.437	690	374.880	915	100.049
470	350.623	695	343.467	920	101.557
475	273.605	700	326.064	925	102.473
480	74.893	705	313.162	930	101.001
485	83.327	710	302.515	935	97.563
490	127.136	715	292.795	940	92.603
495	246.996	720	283.732	945	86.270
500	1680.222	725	276.737	950	79.362
505	138.016	730	270.241	955	74.128
510	112.133	735	265.158	960	70.445
515	616.730	740	267.383	965	67.729
520	115.544	745	262.957	970	65.998
525	117.350	750	263.668	975	63.022
530	123.035	755	294.771	980	60.419
535	131.591	760	262.640	985	59.205
540	150.926	765	258.310	990	58.747
545	215.037	770	469.188	995	59.756
550	679.972	775	440.397	1000	60.573
555	864.505	780	303.240	1005	63.602
560	952.237	785	485.626	1010	68.308
565	1486.730	790	352.479	1015	69.545
570	5778.590	795	261.400	1020	64.457
575	2508.055	800	272.785	1025	59.647
580	3938.879	805	279.603	1030	57.876
585	3458.626	810	305.002	1035	54.132
590	128.260	815	339.748	1040	49.850
595	3886.452	820	389.200	1045	47.093
600	4630.139	825	444.187	1050	46.365

Figure S3. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74071
DATE: 11/14/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: A

RESULTS:

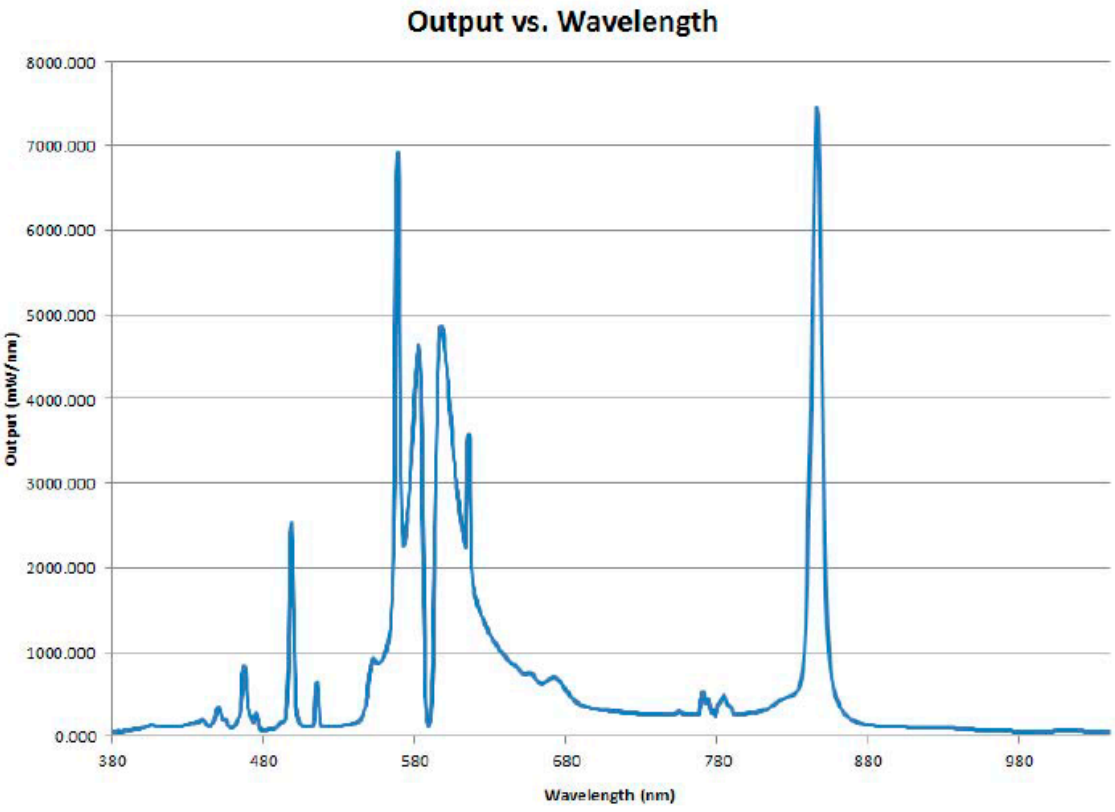
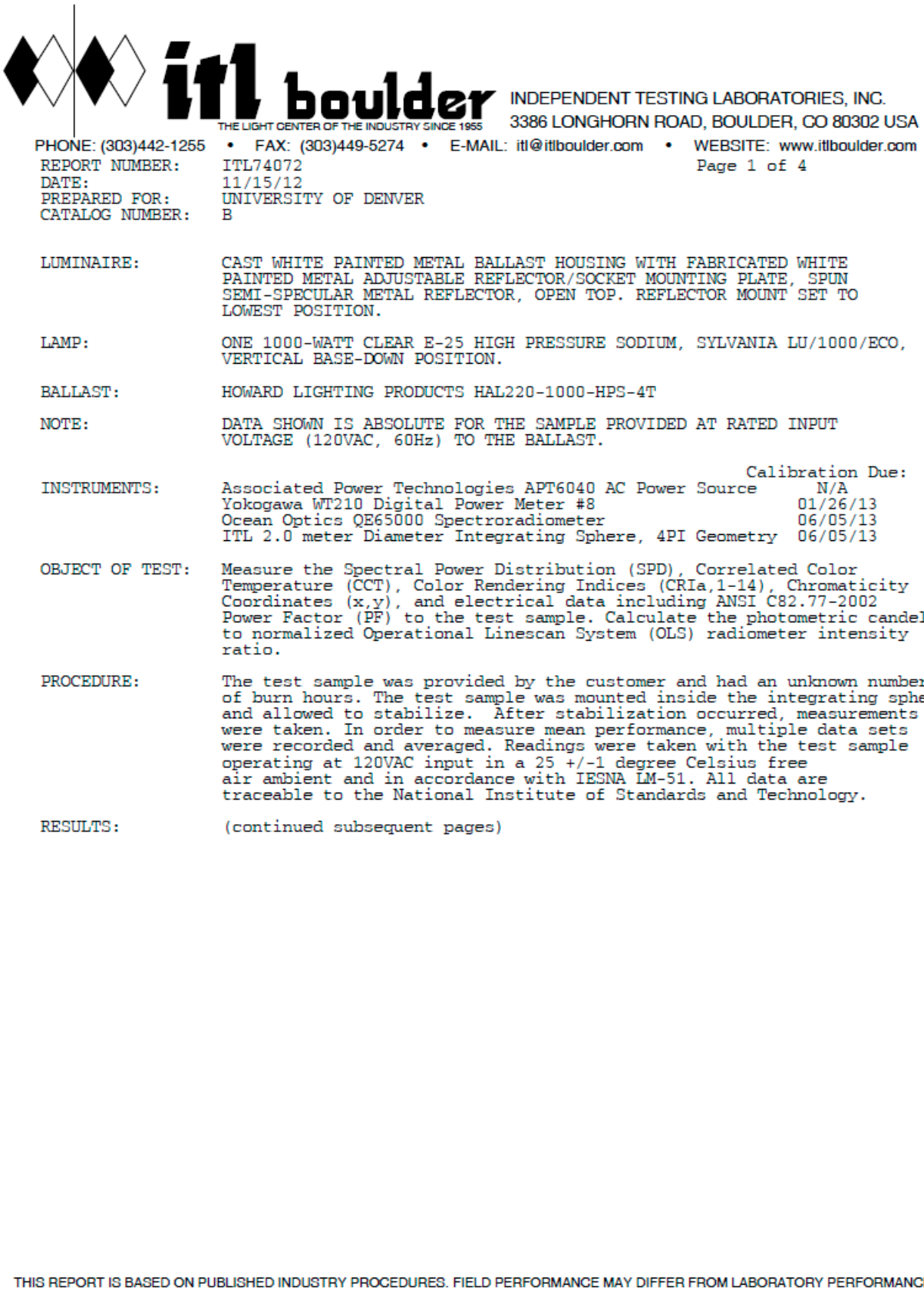


Figure S4. Report Number: ITL74072.



itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955

INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA

PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74072 Page 1 of 4
DATE: 11/15/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: B

LUMINAIRE: CAST WHITE PAINTED METAL BALLAST HOUSING WITH FABRICATED WHITE PAINTED METAL ADJUSTABLE REFLECTOR/SOCKET MOUNTING PLATE, SPUN SEMI-SPECULAR METAL REFLECTOR, OPEN TOP. REFLECTOR MOUNT SET TO LOWEST POSITION.

LAMP: ONE 1000-WATT CLEAR E-25 HIGH PRESSURE SODIUM, SYLVANIA LU/1000/ECO, VERTICAL BASE-DOWN POSITION.

BALLAST: HOWARD LIGHTING PRODUCTS HAL220-1000-HPS-4T

NOTE: DATA SHOWN IS ABSOLUTE FOR THE SAMPLE PROVIDED AT RATED INPUT VOLTAGE (120VAC, 60Hz) TO THE BALLAST.

INSTRUMENTS:		Calibration Due:
	Associated Power Technologies APT6040 AC Power Source	N/A
	Yokogawa WT210 Digital Power Meter #8	01/26/13
	Ocean Optics QE65000 Spectroradiometer	06/05/13
	ITL 2.0 meter Diameter Integrating Sphere, 4PI Geometry	06/05/13

OBJECT OF TEST: Measure the Spectral Power Distribution (SPD), Correlated Color Temperature (CCT), Color Rendering Indices (CRIa,1-14), Chromaticity Coordinates (x,y), and electrical data including ANSI C82.77-2002 Power Factor (PF) to the test sample. Calculate the photometric candela to normalized Operational Linescan System (OLS) radiometer intensity ratio.

PROCEDURE: The test sample was provided by the customer and had an unknown number of burn hours. The test sample was mounted inside the integrating sphere and allowed to stabilize. After stabilization occurred, measurements were taken. In order to measure mean performance, multiple data sets were recorded and averaged. Readings were taken with the test sample operating at 120VAC input in a 25 +/-1 degree Celsius free air ambient and in accordance with IESNA LM-51. All data are traceable to the National Institute of Standards and Technology.

RESULTS: (continued subsequent pages)

THIS REPORT IS BASED ON PUBLISHED INDUSTRY PROCEDURES. FIELD PERFORMANCE MAY DIFFER FROM LABORATORY PERFORMANCE.

Figure S4. *Cont.*

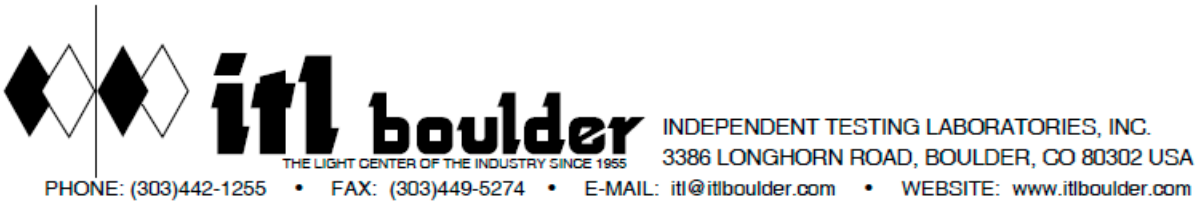
itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74072
DATE: 11/15/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: B

RESULTS:

SPECTRORADIOMETRIC	
Observer	CIE 1931 2 degree
Chromaticity Ordinate x	0.5200
Chromaticity Ordinate y	0.4179
Correlated Color Temp CCT (K)	2085
Color Rendering Index (CRIa)	38
Color Rendering Index 1 (Light greyish red)	31
Color Rendering Index 2 (Dark greyish yellow)	70
Color Rendering Index 3 (Strong yellowish green)	67
Color Rendering Index 4 (Moderate yellowish green)	14
Color Rendering Index 5 (Light bluish green)	29
Color Rendering Index 6 (Light blue)	62
Color Rendering Index 7 (Light violet)	49
Color Rendering Index 8 (Light reddish purple)	-18
Color Rendering Index 9 (Strong red)	-134
Color Rendering Index 10 (Strong yellow)	51
Color Rendering Index 11 (Strong green)	-10
Color Rendering Index 12 (Strong blue)	42
Color Rendering Index 13 (Light yellowish pink (skin))	33
Color Rendering Index 14 (Moderate olive green (leaf))	79
Photometric lumen to normalized OLS intensity ratio	0.00299
ELECTRICAL FOR SPECTRORADIOMETRIC TEST	
Input Voltage (Volts AC)	120.0
Input Current (Amps AC)	9.85
Input Power (Watts)	1056.1
Input Power Factor (%)	89.3

Figure S4. *Cont.*



REPORT NUMBER: ITL74072
DATE: 11/15/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: B

RESULTS:

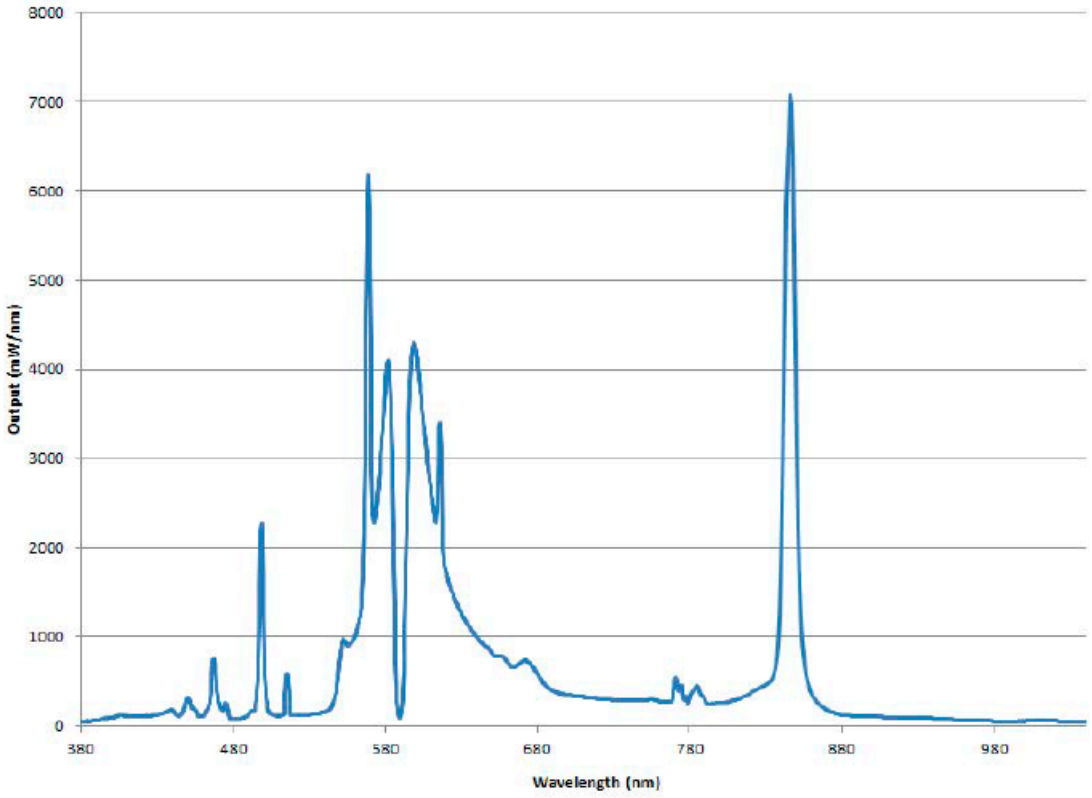
Wavelength	mW per nm	Wavelength	mW per nm	Wavelength	mW per nm
380	48.506	605	3434.076	830	453.219
385	51.517	610	2653.586	835	545.979
390	66.810	615	3062.273	840	1199.618
395	84.208	620	1732.906	845	6578.988
400	98.854	625	1458.068	850	4189.511
405	121.732	630	1264.676	855	803.190
410	115.610	635	1118.814	860	399.355
415	107.364	640	1002.590	865	266.337
420	111.182	645	908.028	870	189.416
425	116.194	650	820.613	875	151.506
430	124.119	655	786.682	880	128.354
435	149.184	660	725.526	885	118.704
440	181.035	665	662.231	890	113.332
445	116.391	670	722.279	895	107.399
450	320.553	675	704.863	900	111.956
455	185.151	680	585.128	905	110.552
460	110.078	685	466.818	910	95.688
465	299.628	690	397.941	915	94.629
470	321.844	695	367.181	920	97.743
475	257.147	700	350.059	925	98.632
480	77.252	705	338.091	930	95.579
485	85.940	710	327.506	935	93.483
490	126.291	715	318.652	940	87.581
495	237.079	720	309.201	945	81.006
500	1425.320	725	302.892	950	74.929
505	137.004	730	295.716	955	70.143
510	117.193	735	289.825	960	66.535
515	575.197	740	291.772	965	63.983
520	121.695	745	285.330	970	62.393
525	124.796	750	285.063	975	59.483
530	130.103	755	310.891	980	56.545
535	139.045	760	280.577	985	55.572
540	159.455	765	274.979	990	55.037
545	227.280	770	486.550	995	56.666
550	733.475	775	444.570	1000	56.331
555	910.692	780	306.243	1005	59.682
560	1008.254	785	460.644	1010	64.802
565	1520.592	790	333.385	1015	65.368
570	5039.092	795	251.584	1020	61.762
575	2541.090	800	254.734	1025	56.634
580	3768.274	805	269.192	1030	54.740
585	2534.603	810	287.082	1035	52.092
590	103.033	815	321.582	1040	46.608
595	3057.483	820	367.791	1045	45.149
600	4226.539	825	421.800	1050	44.023

Figure S4. *Cont.*

itl boulder
THE LIGHT CENTER OF THE INDUSTRY SINCE 1955
INDEPENDENT TESTING LABORATORIES, INC.
3386 LONGHORN ROAD, BOULDER, CO 80302 USA
PHONE: (303)442-1255 • FAX: (303)449-5274 • E-MAIL: itl@itlboulder.com • WEBSITE: www.itlboulder.com

REPORT NUMBER: ITL74072
DATE: 11/15/12
PREPARED FOR: UNIVERSITY OF DENVER
CATALOG NUMBER: B

RESULTS:



Acknowledgments

This research was funded in part by and NASA Earth Space Science Fellowship and an ASPRS Rocky Mountain Region Scholarship. Finally, this research could not have been completed without the cooperation and assistance of the Air Force Weather Agency, National Oceanic and Atmospheric Administration, and Nation Geophysical Data Center.