

William H. Gates Hall

University of Washington School of Law



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The Pennsylvania State University

Architectural Engineering

Lighting/Electrical Option

Senior Thesis – Spring 2007

Advisors: Dr. Mistrick & Ted Dannerth


William H. Gates Hall - Seattle, WA

Building Overview

Building Name: William H. Gates Hall

Location: Seattle, WA

Owner: University of Washington,
School of Law

Size: 196,000 square feet
6 floors (2 below grade)

Building Cost: \$82.7 million

Architect: Mahlum Architects



William H. Gates Hall - Seattle, WA

Building Uses

- Law Library
- Mock Courtrooms
- Classrooms
- Seminar Rooms
- Administrative Offices
- Computer Laboratories
- Conference Rooms
- Law Office Clinic



- **Lighting Depth**
 - Library
 - Galleria
 - Terrace
 - Courtroom
- **Electrical Depth**
 - Transformer Redesign (Central vs. Distributed Transformers)
- **Sustainability Breadth**
 - Feasibility Study of Rainwater Catchment System to Supply Cooling Tower Water Makeup
- **Construction Management Breadth**
 - Cost Analysis of Rainwater Catchment System
- **Conclusions**





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Lighting Depth

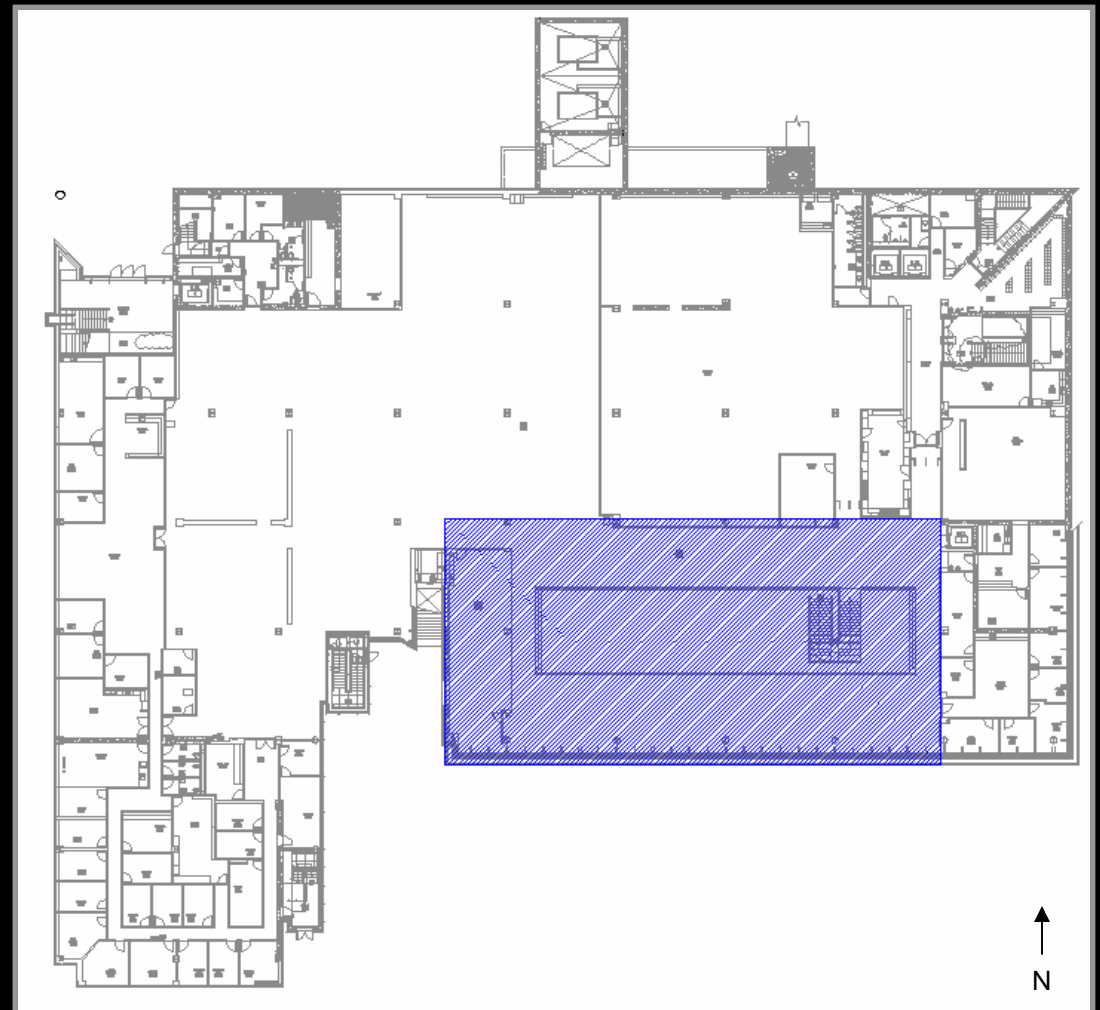
Marion Gould Gallagher Law Library

William H. Gates Hall - Seattle, WA

Lighting Depth - Law Library

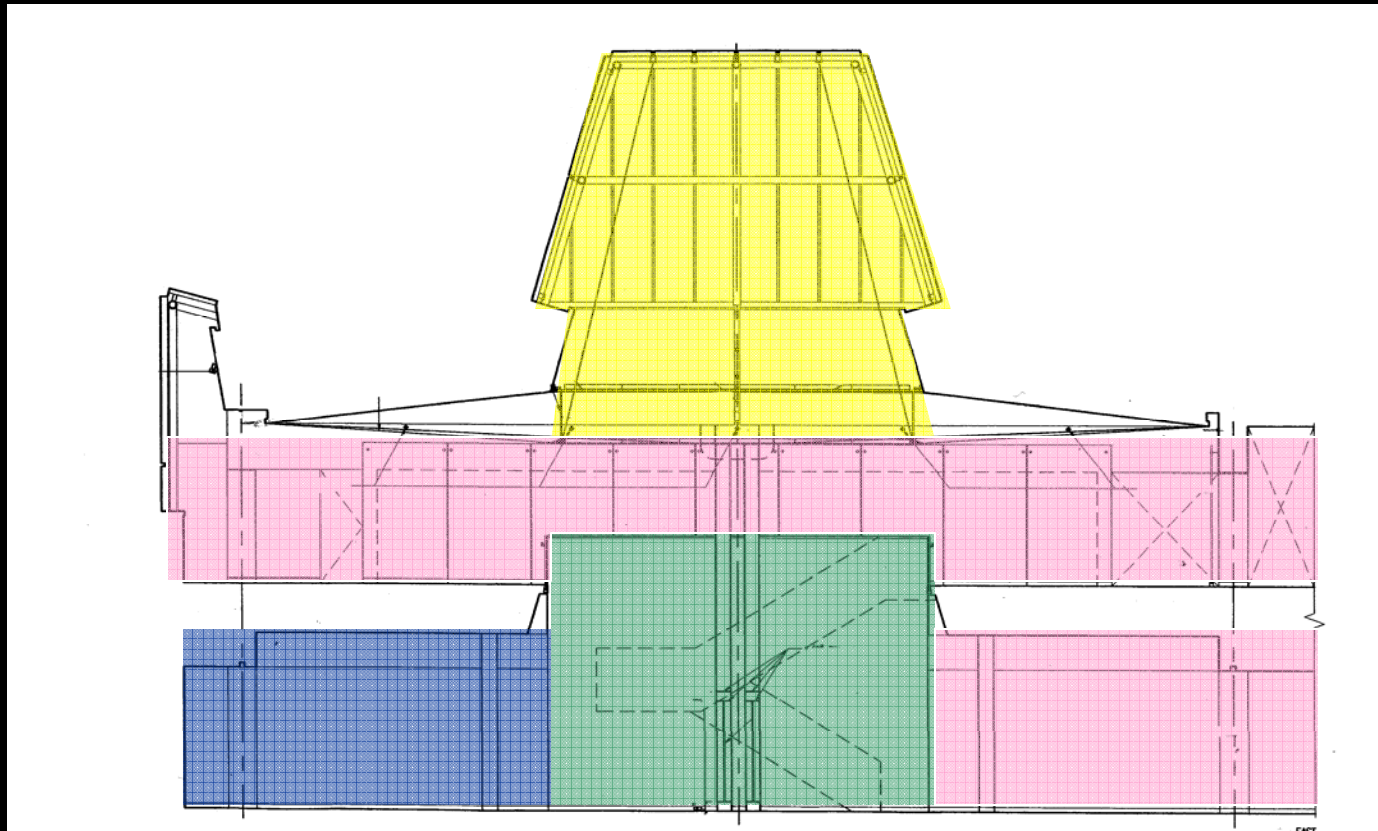
Location: 2 levels below grade
Level L1 & L2

Functions: Reading Area
Stacks
Computer stations



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Lighting Depth - Law Library



Key Features

- Skylights
- Reading Area
- Double height central area
- Stacks

Design Goals

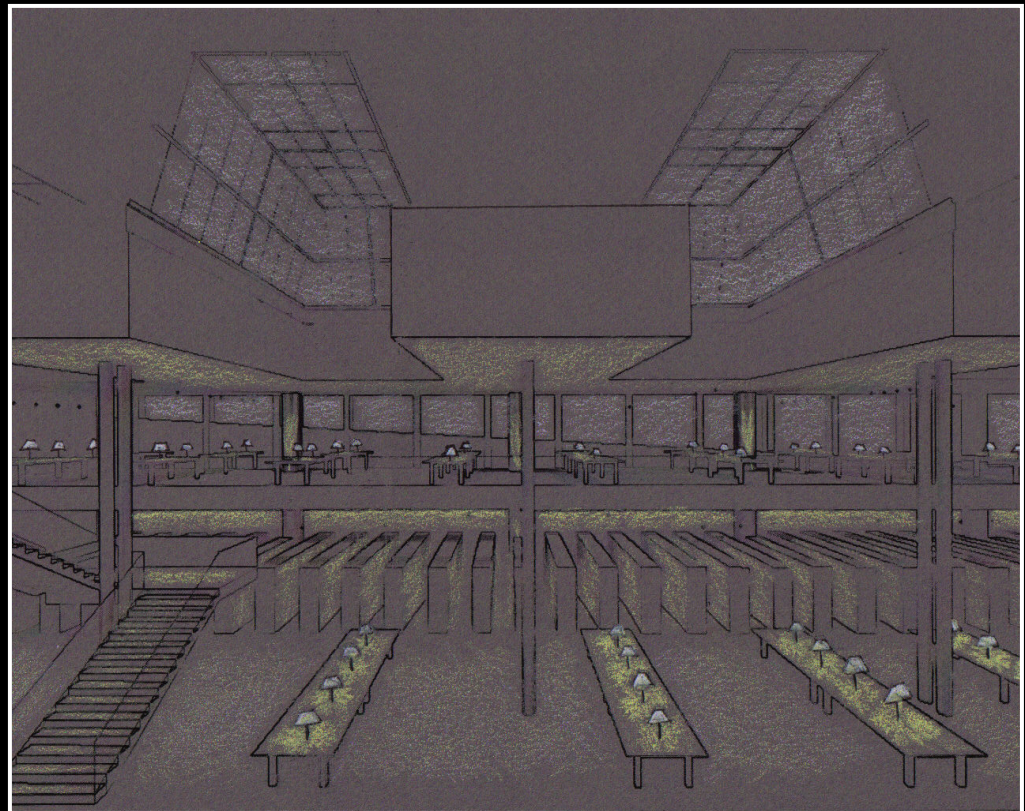
- Create an interesting, but not distracting, space
- Provide adequate light levels for visual tasks
- Integrate Skylights

Target Illuminance Levels

- Horizontal (Work Plane): 30 fc
- Vertical (Stacks): 20-30fc

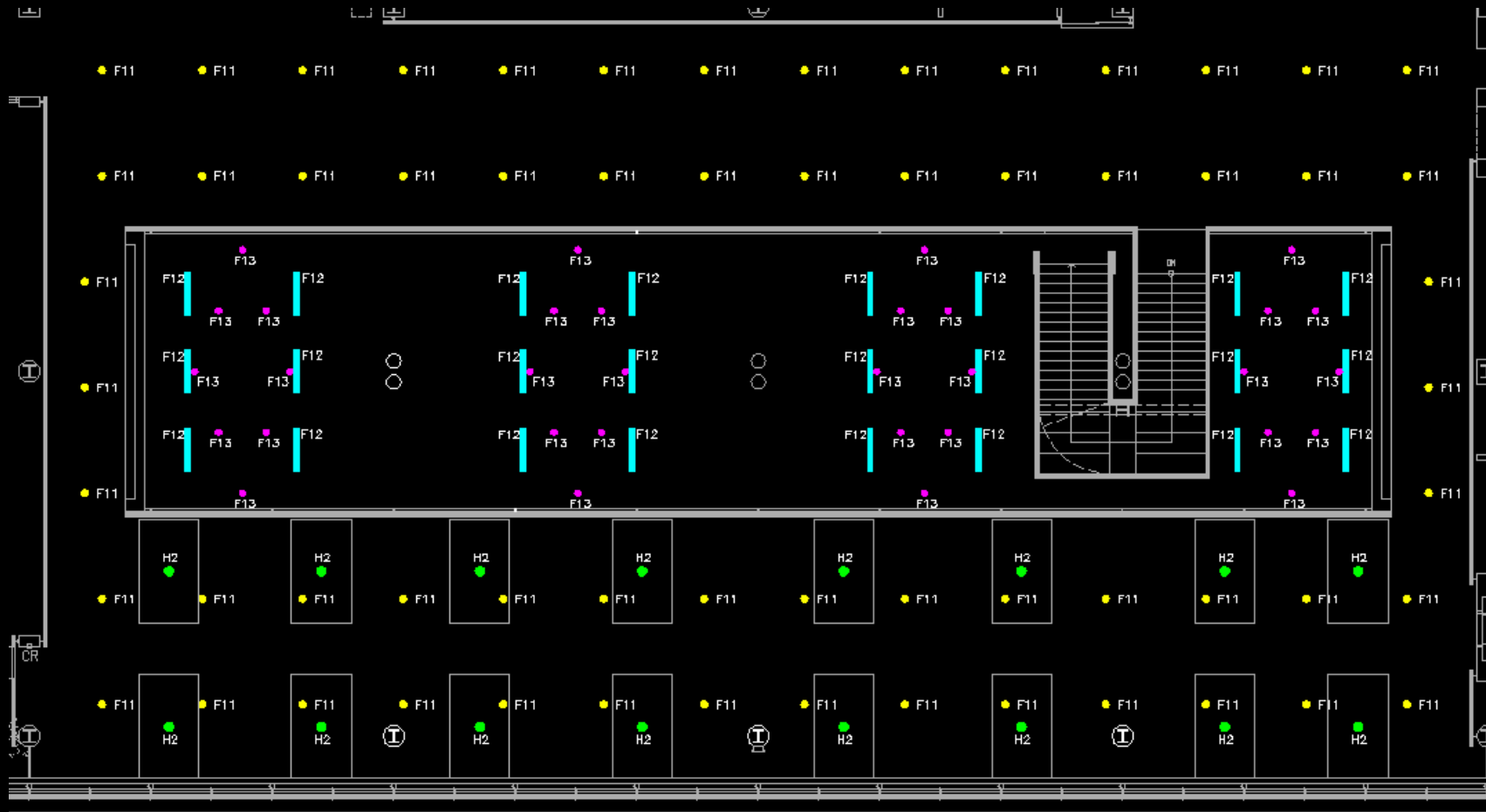
Power Density

- ASHRAE/IESNA 90.1 – 1.9 W/ft²



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Lighting Depth - Law Library



H2
(1)100W
A19



F11
(1)42W
CFL



F12
(1)32W
T8



F13
(2)39W
FT



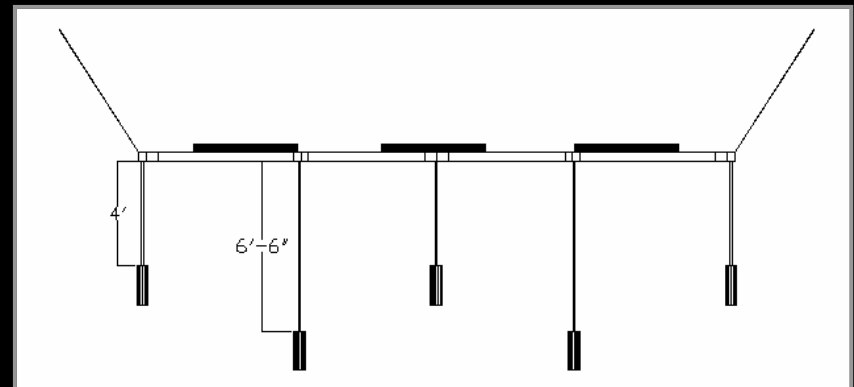
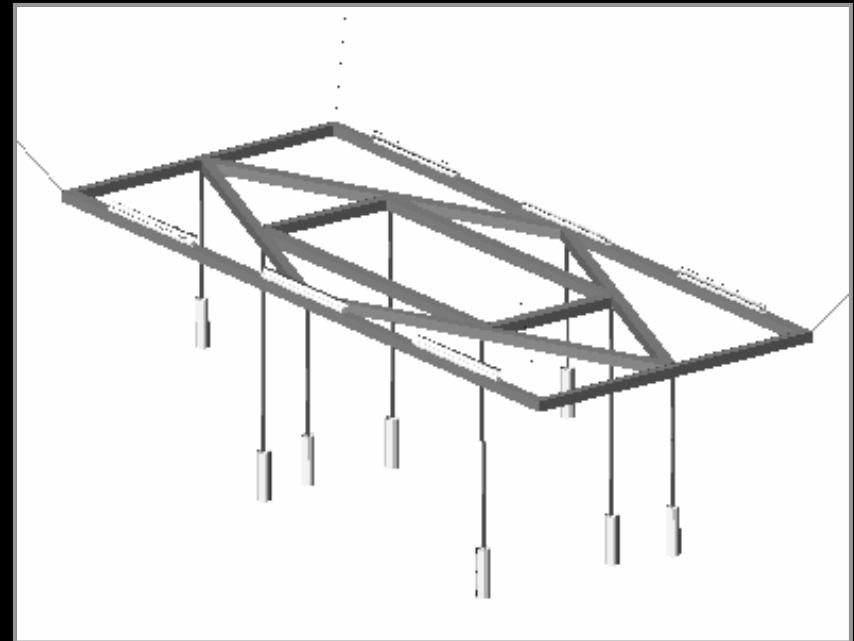
F14
(1)28W
T5


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Lighting Depth - Law Library

Custom Fixture

- Below Each Skylight
- Aluminum Tubing Structure
- (6) Asymmetrical Uplights
- (8) Pendants
 - Suspended at two different lengths



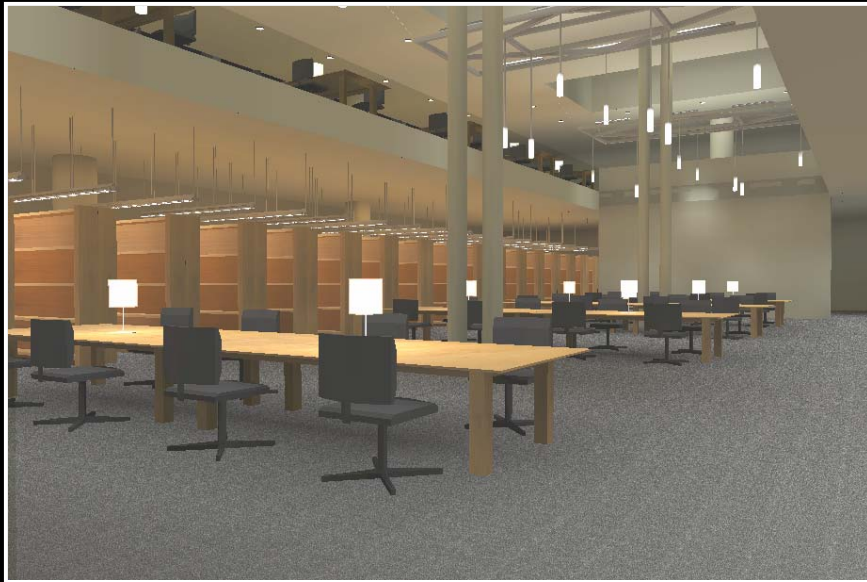
William H. Gates Hall - Seattle, WA

Lighting Depth - Law Library



William H. Gates Hall - Seattle, WA

Lighting Depth - Law Library



Design Illuminance Values (avg)

Horizontal: Reading Tables: 51 fc
Cubicles: 32 fc
Computer Stations: 35 fc
Vertical: Stacks: 23 fc

Meets Target Illuminance Levels

Design Power Density

Total Watts: 12,844 W
Area: 25,000 ft²
Power Density: 0.51 W/ft²

Meets Power Density Requirements





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Electrical Depth

Central vs. Distributed Transformers

Design Goals:

- Change from Central Transformers to Distributed Transformers
- Decrease Wire Size Running Through Building
- Decrease System Cost

Existing Transformers:

TRANSFORMER SCHEDULE							
TAG	PRIMARY VOLTAGE	SECONDARY VOLTAGE	SIZE	TYPE	TEMP. RISE	MOUNTING	REMARKS
TR-NWB2-N01	13.8 KV,3PH,3W	480Y/277V,3PH,4W	2500	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-4 RATED
TR-NWB2-N02	480V,3PH,3W.	208Y/120V,3PH,4W	500	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-NWB2-N03	480V,3PH,3W.	208Y/120V,3PH,4W	500	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-NWB2-N04	480V,3PH,3W.	208Y/120V,3PH,4W	225	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-NWB2-N05	480V,3PH,3W.	208Y/120V,3PH,4W	225	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-NWB2-N06	480V,3PH,3W.	208Y/120V,3PH,4W	45	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-SW01-N01	480V,3PH,3W.	208Y/120V,3PH,4W	112.5	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED
TR-NE04-N06	480V,3PH,3W.	208Y/120V,3PH,4W	75	DRY TYPE	150 DEGREE C	PAD MOUNTED ON FLOOR	K-13 RATED

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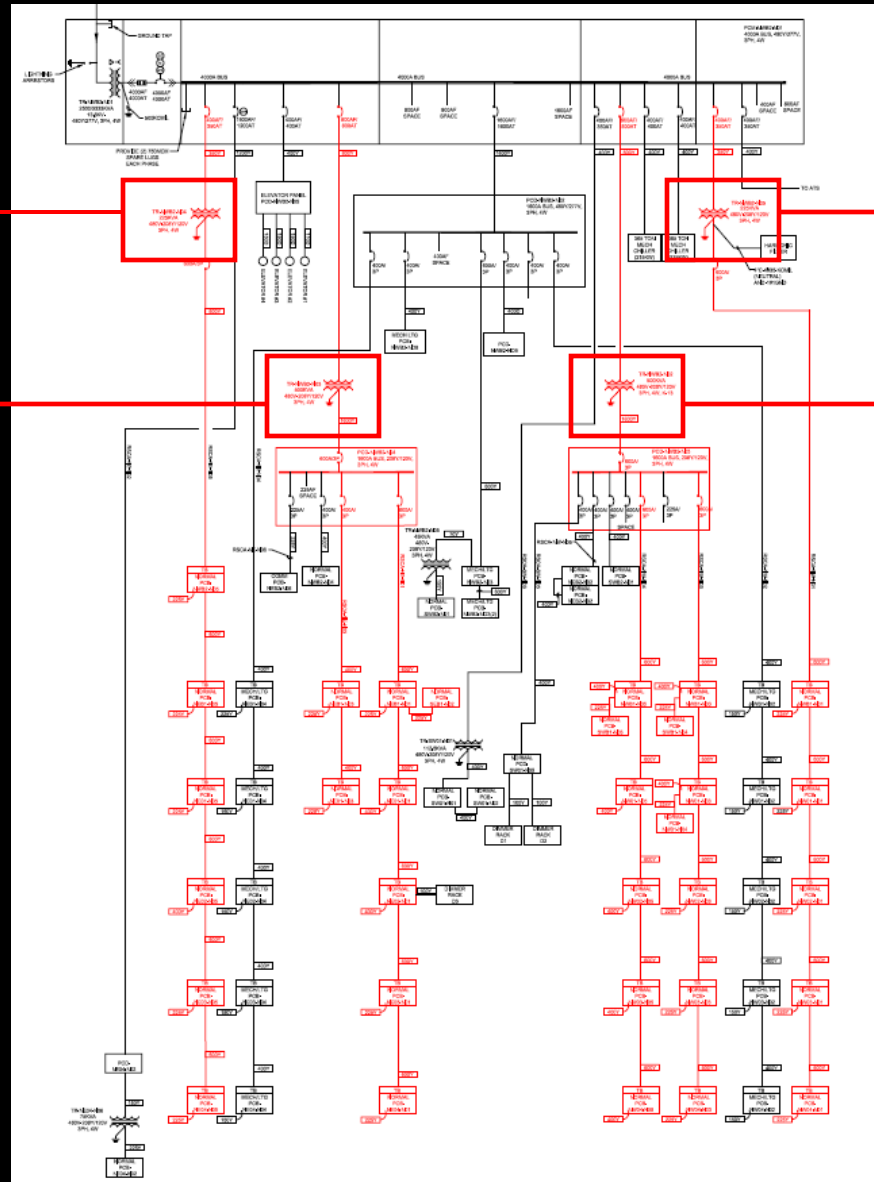
Electrical Depth

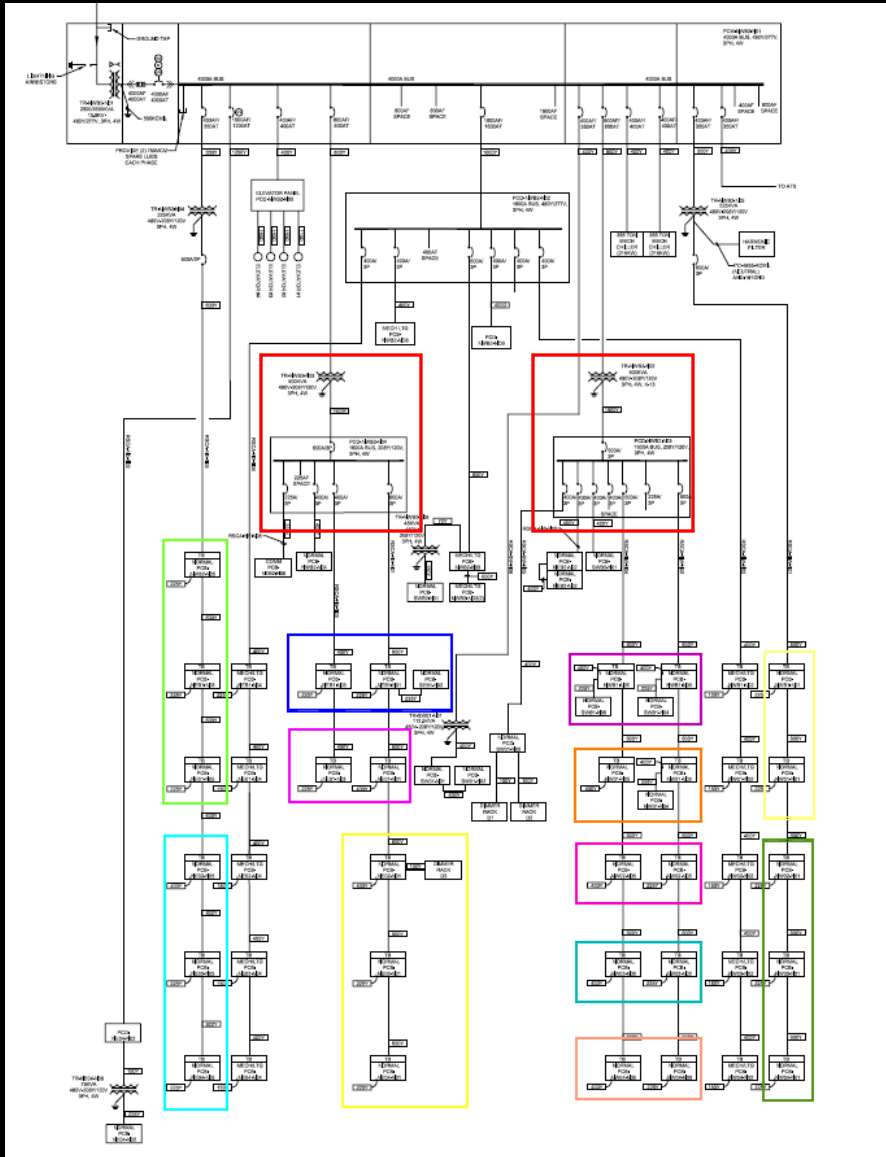
225 KVA Transformer

225 KVA Transformer

500 KVA Transformer

500 KVA Transformer





Distributed Transformers

- Panelboards in Same Closet or on Adjacent Floors Grouped Together
- 14 Total
- Range from 45 KVA to 150 KVA

EXISTING SYSTEM

TRANSFORMERS

480-208/120V, 3 PH, 4W - K-13 RATED, VENTILATED

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
225 KVA	\$18,100	EA.	2	\$36,200
500 KVA	\$37,200			

SUBTOTAL \$110,600

TRANSFORMER PROTECTION

ENCLOSED CIRCUIT BREAKERS, NEMA 1

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
600A	\$3,900	EA.	2	\$7,800
SUBTOTAL				\$7,800

SWITCHGEAR BREAKERS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
400A	\$3,775	EA.	2	\$7,550
800A	\$5,900	EA.	2	\$11,800
SUBTOTAL				\$19,350

MOLDED CASE CIRCUIT BREAKERS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
400A	\$3,775	EA.	1	\$3,775
600A	\$4,650	EA.	5	\$23,250
SUBTOTAL				\$27,025

DISTRIBUTION PANEL

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
1600A	\$4,850	EA.	2	\$9,700
SUBTOTAL				\$9,700

PANELBOARDS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
225A	\$2,025	EA.	23	\$46,575
400A	\$3,025	EA.	9	\$27,225
SUBTOTAL				\$73,800

FEEDER & CONDUIT

FEEDER DESIG.	WIRE	NO. SETS	QUANTITY	SIZE	COST (INCL. O&P)	UNITS	LENGTH (L.F.)	TOTAL COST
225Y	PHASE	1	3	4/0	\$420.00	C.L.F.	595	\$7,497.00
	NEUTRAL		1	4/0	\$420.00	C.L.F.	595	\$2,499.00
	GROUND		1	4	\$136.00	C.L.F.	595	\$809.20
	CONDUIT		1	2-1/2"	\$17.60	L.F.	595	\$10,472.00
350Y	PHASE	1	3	500 KCMIL	\$765.00	C.L.F.	20	\$459.00
	NEUTRAL		1	500 KCMIL	\$765.00	C.L.F.	20	\$153.00
	GROUND		1	2	\$178.00	C.L.F.	20	\$35.60
	CONDUIT		1	3"	\$22.50	L.F.	20	\$450.00
400Y	PHASE	2	3	3/0	\$355.00	C.L.F.	324	\$6,901.20
	NEUTRAL		1	3/0	\$355.00	C.L.F.	324	\$2,300.40
	GROUND		1	2	\$178.00	C.L.F.	324	\$1,153.44
	CONDUIT		1	2-1/2"	\$17.60	L.F.	324	\$5,702.40
600Y	PHASE	2	3	350 KCMIL	\$595.00	C.L.F.	980	\$34,986.00
	NEUTRAL		1	350 KCMIL	\$595.00	C.L.F.	980	\$11,662.00
	GROUND		1	1	\$209.00	C.L.F.	980	\$4,096.40
	CONDUIT		1	3"	\$22.50	L.F.	980	\$22,050.00
800Y	PHASE	3	3	300 KCMIL	\$535.00	C.L.F.	20	\$963.00
	NEUTRAL		1	300 KCMIL	\$535.00	C.L.F.	20	\$321.00
	GROUND		1	1/0	\$250.00	C.L.F.	20	\$150.00
	CONDUIT		1	3"	\$22.50	L.F.	20	\$450.00
1600Y	PHASE	5	3	500 KCMIL	\$765.00	C.L.F.	10	\$1,147.50
	NEUTRAL		1	500 KCMIL	\$765.00	C.L.F.	10	\$382.50
	GROUND							
	CONDUIT							

SUBTOTAL \$115,125.64

EXISTING SYSTEM TOTAL \$363,400.64

PROPOSED SYSTEM

TRANSFORMERS

480-208/120V, 3 PH, 4W - K-13 RATED, VENTILATED

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
45 KVA	\$4,300	EA.	3	\$12,900
75 KVA	\$5,750	EA.	4	\$23,000
112.5 KVA	\$10,500	EA.	5	\$52,500
150 KVA	\$12,500			

SUBTOTAL \$113,400

TRANSFORMER PROTECTION

ENCLOSED CIRCUIT BREAKERS, NEMA 1

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
100A	\$755	EA.	1	\$755
225A	\$1,575	EA.	12	\$18,900
400A	\$2,750	EA.	6	\$16,500
SUBTOTAL				\$36,155

SWITCHGEAR BREAKERS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
225A	\$2,850	EA.	1	\$2,850
400A	\$3,775	EA.	1	\$3,775
600A	\$4,650	EA.	1	\$4,650
800A	\$5,900	EA.	1	\$5,900
SUBTOTAL				\$17,175

MOLDED CASE CIRCUIT BREAKERS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
400A	\$3,775	EA.	2	\$7,550
SUBTOTAL				\$7,550

DISTRIBUTION PANEL

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
400A	\$2,550	EA.	2	\$5,100
SUBTOTAL				\$5,100

PANELBOARDS

SIZE	COST (INCL. O&P)	UNITS	QUANTITY	TOTAL COST
225A	\$2,025	EA.	23	\$46,575
400A	\$3,025	EA.	9	\$27,225
SUBTOTAL				\$73,800

FEEDER & CONDUIT

FEEDER DESIG.	WIRE	NO. SETS	QUANTITY	SIZE	COST (INCL. O&P)	UNITS	LENGTH (L.F.)	TOTAL COST
100Y	PHASE	1	3	1	\$209.00	C.L.F.	10	\$62.70
	NEUTRAL		1	1	\$209.00	C.L.F.	10	\$20.90
	GROUND		1	8	\$78.00	C.L.F.	10	\$7.80
	CONDUIT		1	2"	\$11.15	L.F.	10	\$111.50
225Y	PHASE	1	3	4/0	\$420.00	C.L.F.	892	\$11,239.20
	NEUTRAL		1	4/0	\$420.00	C.L.F.	892	\$3,746.40
	GROUND		1	4	\$136.00	C.L.F.	892	\$1,213.12
	CONDUIT		1	2-1/2"	\$17.60	L.F.	892	\$15,699.20
400Y	PHASE	2	3	3/0	\$355.00	C.L.F.	404	\$8,605.20
	NEUTRAL		1	3/0	\$355.00	C.L.F.	404	\$2,868.40
	GROUND		1	2	\$178.00	C.L.F.	404	\$1,438.24
	CONDUIT		1	2-1/2"	\$17.60	L.F.	404	\$7,110.40
600Y	PHASE	2	3	350 KCMIL	\$595.00	C.L.F.	206	\$7,354.20
	NEUTRAL		1	350 KCMIL	\$595.00	C.L.F.	206	\$2,451.40
	GROUND		1	2	\$178.00	C.L.F.	206	\$861.08
	CONDUIT		1	3"	\$22.50	L.F.	206	\$4,635.00
800Y	PHASE	3	3	300 KCMIL	\$535.00	C.L.F.	180	\$8,667.00
	NEUTRAL		1	300 KCMIL	\$535.00	C.L.F.	180	\$2,889.00
	GROUND							
	CONDUIT							

SUBTOTAL \$84,177.84

PROPOSED SYSTEM TOTAL \$337,357.84

Proposed System Savings = \$26,042.80

System Recommended



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Sustainability Breadth

A Feasibility Study of Implementing a
Rainwater Catchment System to Offset
Cooling Tower Water Makeup

Rainwater Catchment System Design Goals

- Utilize Seattle's Rainy Climate
- Offset Building Non-Potable Water Demands
- Increase the University's Commitment to Sustainability



Makeup Water Requirements

Cooling Towers

- (2) Cooling Towers
- 825 GPM each

Makeup Water per Cooling Tower

- Evaporation: 6.82 GPM
- Drift: 0.0165 GPM
- Blowdown: 0.98 GPM
- Total Makeup Water = 7.82 GPM

8 GPM per Cooling Tower

Month	Makeup Water Needed (GPM)	Days A Month	Makeup Water per Cooling Tower (Gallons)	Total Makeup Water (2 Cooling Towers)
January	8	31	357,120	714,240
February	8	28	322,560	645,120
March	8	31	357,120	714,240
April	8	30	345,600	691,200
May	8	31	357,120	714,240
June	8	30	345,600	691,200
July	8	31	357,120	714,240
August	8	31	357,120	714,240
September	8	30	345,600	691,200
October	8	31	357,120	714,240
November	8	30	345,600	691,200
December	8	31	357,120	714,240
		Total	4,204,800	8,409,600

Collectible Water

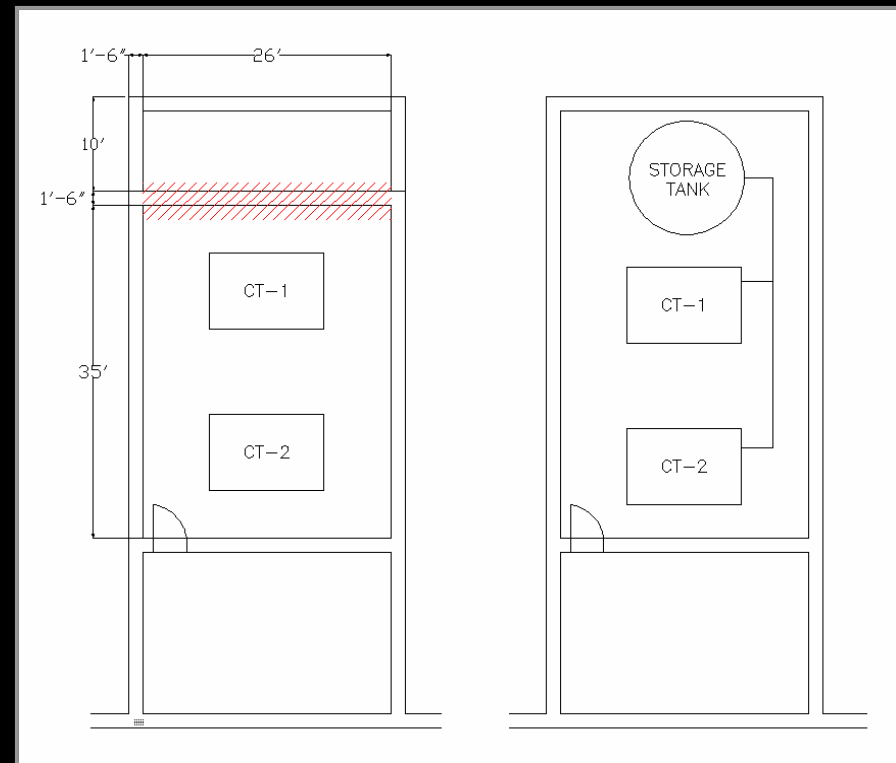
Month	Monthly Rainfall (Inches)	Roof Surface Area (Sq. Ft.)	Monthly Catchment (Gallons)
January	5.4	48,500	157,140
February	4	48,500	116,400
March	3.8	48,500	110,580
April	2.5	48,500	72,750
May	1.8	48,500	52,380
June	1.6	48,500	46,560
July	0.9	48,500	26,190
August	1.2	48,500	34,920
September	1.9	48,500	55,290
October	3.3	48,500	96,030
November	5.7	48,500	165,870
December	6	48,500	174,600
		Total	1,108,710

Potential to Offset Cooling Tower Makeup Water

Month	Water Catchment (Gallons)	Makeup Water Required (Gallons)	Makeup Water Demand After Rainwater	Percentage of Water Use Offset
January	157,140	714,240	557,100	22.0%
February	116,400	645,120	528,720	18.0%
March	110,580	714,240	603,660	15.5%
April	72,750	691,200	618,450	10.5%
May	52,380	714,240	661,860	7.3%
June	46,560	691,200	644,640	6.7%
July	26,190	714,240	688,050	3.7%
August	34,920	714,240	679,320	4.9%
September	55,290	691,200	635,910	8.0%
October	96,030	714,240	618,210	13.4%
November	165,870	691,200	525,330	24.0%
December	174,600	714,240	539,640	24.4%

System Components & Considerations

- Water Storage
 - Fiberglass Cistern
 - 10,000 gallons
 - 12' diameter, 12' height
- Pump
- Filtration & Water Treatment
- Additional Water Supply



Cooling Tower Pit Expansion



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Construction Management Breadth

Cost Analysis of Rainwater
Catchment System

Proposed System First Cost			
Rainwater Catchment System			
Component	Quantity	Unit Cost	Cost
Cistern - 10,000 gal	1	\$10,000.00	\$10,000.00
First Flush Diverter	1	\$137.46	\$137.46
PVC Piping - 2"	40 L.F.	\$3.30	\$132.00
		Subtotal	\$10,269.46
Cooling Tower Pit Addition			
Component	Size	Unit Cost	Cost
Excavation	192.6 C.Y.	\$11.40	\$2,195.64
Slab On Grade	260 S.F.	\$6.05	\$1,573.00
Foundation Walls	51.1 C.Y.	\$325.00	\$16,607.50
(Including Formwork, Concrete, Reinforcement & Finishing)			
		Subtotal	\$20,376.14
Total System First Cost			\$30,645.60

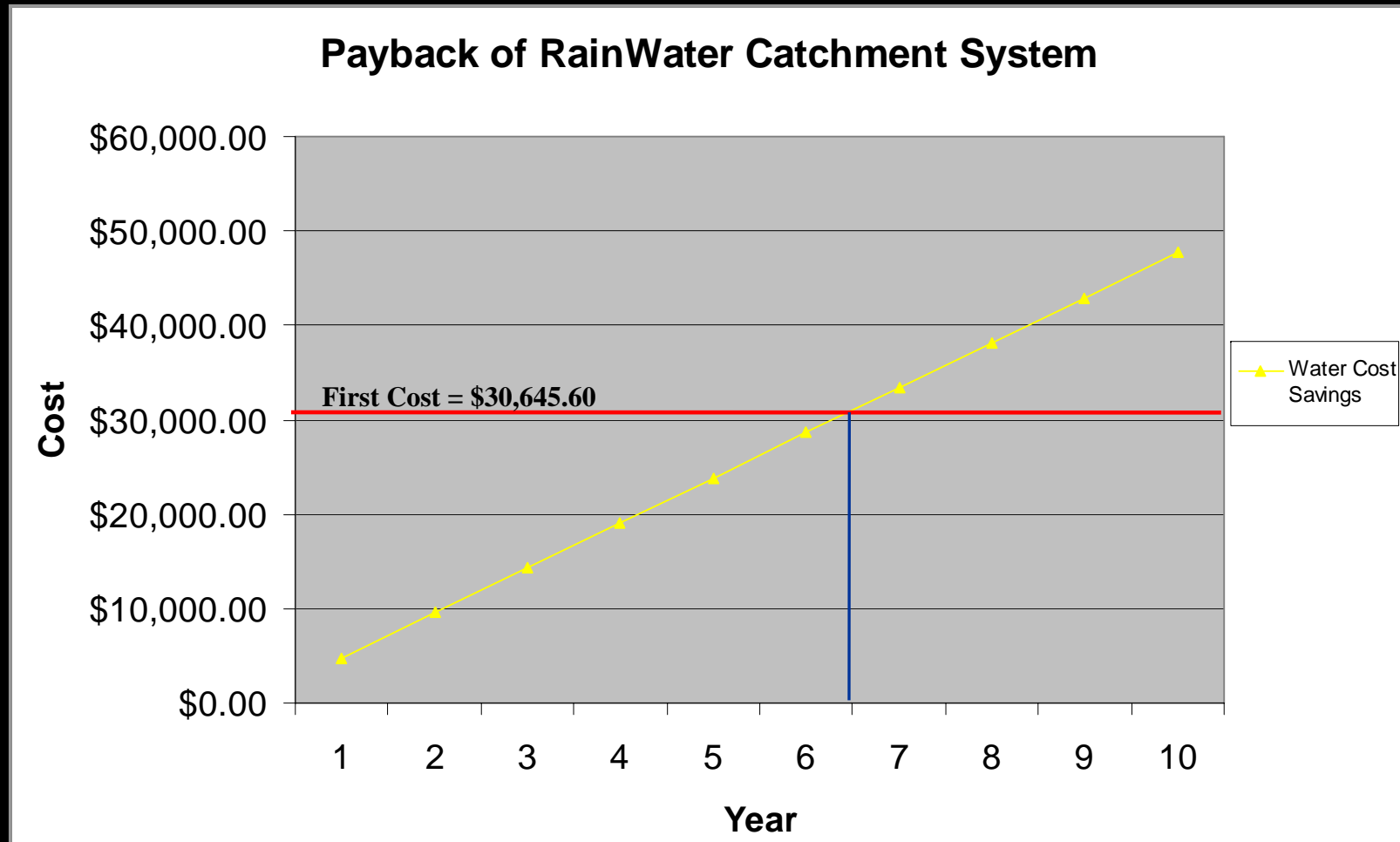
Total Water Cost using 100% Supply Water

Month	Makeup Water (Gallons)	Cost per 100 gallons	Cost per Month
January	714,240	\$0.43	\$3,071.23
February	645,120	\$0.43	\$2,774.02
March	714,240	\$0.43	\$3,071.23
April	691,200	\$0.43	\$2,972.16
May	714,240	\$0.43	\$3,071.23
June	691,200	\$0.43	\$2,972.16
July	714,240	\$0.43	\$3,071.23
August	714,240	\$0.43	\$3,071.23
September	691,200	\$0.43	\$2,972.16
October	714,240	\$0.43	\$3,071.23
November	691,200	\$0.43	\$2,972.16
December	714,240	\$0.43	\$3,071.23
Total Yearly Makeup Water			\$36,161.28

Total Water Cost After Rainwater Contribution

Month	Makeup Water (Gallons)	Cost per 100 gallons	Cost per Month
January	557,100	\$0.43	\$2,395.53
February	528,720	\$0.43	\$2,273.50
March	603,660	\$0.43	\$2,595.74
April	618,450	\$0.43	\$2,659.34
May	661,860	\$0.43	\$2,846.00
June	644,640	\$0.43	\$2,771.95
July	688,050	\$0.43	\$2,958.62
August	679,320	\$0.43	\$2,921.08
September	635,910	\$0.43	\$2,734.41
October	618,210	\$0.43	\$2,658.30
November	525,330	\$0.43	\$2,258.92
December	539,640	\$0.43	\$2,320.45
Total Yearly Makeup Water C			\$31,393.83

Yearly Water Cost Savings = \$4,767.45



Payback Period of 6.5 Years

System Life of 25 Years

System Recommended

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Conclusions

Lighting Depth – Law Library

- Meets Design Goals
- Meets Target Illuminance Levels
- Meets Power Density Requirements

Electrical Depth – Transformer Redesign

- Changed from Central to Distributed Transformers
- Decreased Wire Sizes
- Decreased System Cost by Approximately \$26,000

Sustainability Breadth – Rainwater Catchment System

- Able to Collect 1.1 Million Gallons of Water per Year
- Potentially Monthly Water Savings of up to 25%

Construction Management Breadth – Cost Analysis

- Yearly Water Cost Savings of \$4,767
- Payback of 6.5 Years





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Acknowledgements

Special Thanks to:

Hargis Engineers
Mahlum Architects
University of Washington
Capital Projects

AE Faculty & Staff

AE Classmates

Friends & Family

A photograph of a modern, multi-story building with extensive glass facades. The building is situated on a green lawn with a paved walkway. There are some trees and a pergola structure in the foreground. The sky is clear and blue. The text "Questions?" is overlaid in the upper center, and "Thank You!" is overlaid in the lower center.

Questions?

Thank You!