

ST. ELIZABETH'S NEW HOSPITAL

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Construction Management



AE Senior Thesis 2008

ST. ELIZABETH'S NEW HOSPITAL

2700 MARTIN LUTHER KING JR. AVE SE
WASHINGTON DC 20032

OUTLINE

- Project Overview
- Schedule & Cost
- Structural Analysis
 - Green vs. White Roof
- Energy Analysis
 - Green vs. White Roof
- Recommendation
- Roofing Industry
- Questions

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CLIENT INFORMATION

- Department of Mental Health (DMH)
- St. Elizabeth's Hospital Complex
- New Psychiatric Hospital
- Criminal /Civil Patients
- Broke ground in December 2006

Overview

- Schedule & Cost
- Structural
- Energy
- Recommendation
- Roofing



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3-D MODEL



PROJECT INFORMATION

- Gross Area: 448,190 ft^2
- Assignable Area: 349,730 ft^2
- Amenities and Building Support: 99,460 ft^2
- 3 Stories: 2 Occupied, 1 Mechanical
- Footprint 251,000 ft^2

HOSPITAL FOOTPRINT



Overview

- Schedule & Cost
- Structural
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ST. ELIZABETH'S SCHEDULE SUMMARY

Task ID | Task Name | Start | Stop

1 | Site Preparation | 10/1/07 | 10/15/07

2 | Foundation | 10/15/07 | 10/30/07

3 | Structural | 10/30/07 | 11/15/07

4 | Mechanical/Electrical | 11/15/07 | 12/1/07

5 | Interior Finishes | 12/1/07 | 12/15/07

6 | Exterior Finishes | 12/15/07 | 1/1/08

7 | Final Construction | 1/1/08 | 1/15/08

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(5) YEAR PROJECT
\$ 140 MILLION

Overview
 Schedule & Cost
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DIVISIONAL COST BREAKDOWN	TC (\$)	CC (\$)	Cost/SP (\$)
Division 1 General Requirements	600,000	-	-
Division 2 Site Construction	14,175,000	-	-
Division 3 Concrete	9,276,000	6,076,000	18,000
Division 4 Masonry	15,813,473	15,813,473	50,000
Division 5 Metals	10,200,000	10,200,000	24,000
Division 6 Woodwork/Plastics	2,700,000	2,700,000	-
Division 7 Thermal and Moisture Protection	6,500,000	6,500,000	-
Division 8 Doors and Windows	6,800,000	6,800,000	-
Division 9 Finishes	9,000,000	9,000,000	18,000
Division 10 Signage	680,700	680,700	-
Division 11 Equipment	3,737,000	3,737,000	-
Division 12 Refrigeration	112,000	112,000	-
Division 13 Special Construction	6,810,000	6,810,000	-
Division 14 Controlling Systems	1,000,000	1,000,000	-
Division 15 Mechanical	26,000,000	26,000,000	54,000
Division 16 Electrical	12,240,000	12,240,000	50,000
Totals	110,911,500	110,911,500	
Building Size: 445,000 SF			
Cost/SF	249,000	249,000	

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ANALYSIS 1

*GREEN ROOF STRUCTURAL
 COMPARISON & CO₂ IMPACT*

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OVERALL PROBLEM STATEMENT

Are there **greener** options than a **green** roof?

GOAL

To analyze the environmental and economical impacts of installing a white roof over that of a green system



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- Vegetation
- Soils
- Protection Course/Root Barrier
- Drainage/Water Storage/Aeration
- Insulation/Air Barrier
- Roofing Membrane
- 4\" Composite Slab

CURRENT ROOF DESIGN:

Hydro-Tech Garden Roof® Assembly

GREEN ROOF BENEFITS

- Overview
- Schedule & Cost
- Structural**
- Energy
- Recommendation
- Roofing

- Storm water management
- Reduction of the "heat island" effect
- Very good thermal properties
- GHG regulation
- Organic material usage

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COMPONENTS

- 50 Mil. Polyvinyl White Membrane
- 5\" Polyiso Insulation
- 22G. B-WR. Roof Deck

PROPOSED ROOF DESIGN:

Duro-Last Cool Zone® Assembly

WHITE ROOF BENEFITS

- Overview
- Schedule & Cost
- Structural**
- Energy
- Recommendation
- Roofing

- High Thermal Reflectance
- Lightweight Construction
- Construction Cost
- Reduced Schedule

GREEN ROOF LOADS

Dead Loads	lb/ft ²
20G. Composite B-lock Deck	1.9
4" Lightweight Concrete Slab	29
Hydro-Tech Green roof Assembly	35
Ceiling	2
Utilities	10
Drainage	5
	82.9

Live Load	lb/ft ²
Snow load	25

Factored Load:
 $1.2(82.9) + 1.6(25) = 139.5 \text{ lb/ft}^2$

Line Load:
 $139.5 \text{ lb/ft}^2 (5') = 700 \text{ lb/ft}$

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STRUCTURAL COMPARISON

Green Roof vs. White Roof

WHITE ROOF LOADS

Dead Loads	lb/ft ²
22G. B-W.R. Roof Deck	1.7
5" Polyiso Insulation	2.5
50 Mil. Polyvinyl White Membrane	0.25
Ceiling	2
Utilities	10
Drainage	3
	19.45

Live Load	lb/ft ²
Snow load	25

Factored Load:
 $1.2(19.45) + 1.6(25) = 63.82 \text{ lb/ft}^2$

Line Load:
 $63.82 \text{ lb/ft}^2 (5') = 320 \text{ lb/ft}$

- Overview
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GREEN ROOF JOIST TONNAGE

Joist	L.F.	lb./lf	Tons
18K5	18	7.7	0.0693
24K7	22	10.1	0.1111
26K9	28	12.2	0.1708
28K9	30	13	0.195
16K7	16	8.6	0.0688
14K1	795	5.2	2.067
18K3	54	6.6	0.1782
22K5	90	8.8	0.396
26K7	136	10.9	0.7412
24LH06	995	16	7.96
24LH07	800	17	6.8
		Total Tonnage	18.8

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STRUCTURAL COMPARISON

Green Roof vs. White Roof

WHITE ROOF JOIST TONNAGE

Joist	New Joist	L.F.	lb./lf	Tons
18K5	14K3	18	5	0.045
24K7	16K3	22	6.2	0.0682
26K9	18K6	28	8.5	0.119
28K9	20K6	30	8.7	0.1305
16K7	12K1	16	5	0.04
14K1	10K1	795	5	1.9675
18K3	16K2	54	5.5	0.1405
22K5	16K4	90	6.9	0.3105
26K7	18K6	136	8.5	0.578
24LH06	26K6	995	8.5	4.22875
24LH07	28K8	800	9.9	3.96
		Total Tonnage		11.6

- Overview
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Member	L.F.	lb./lf	Tons
W16X31	294	31	4.557
W16X26	159	26	2.067
W10X12	232	12	1.392
W12X19	44	19	0.418
W12X16	202	16	1.616
W12X14	28	14	0.196
W12X22	24	22	0.264
W24X62	60	62	1.86
W24X55	56	55	1.54
W24X68	56	68	1.904
W16X26	26	26	0.338
W16X31	20	31	0.31
W21X44	24	44	0.528
W18X35	20	35	0.35
W30X90	32	90	1.44
W30X99	94	99	4.653
W27X84	34	84	1.428
Total Tonnage			24.9

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OVERALL LOAD REDUCTION (LB/SF)
 (63.82 lb/sf)/(139.5 lb/sf) = 457
54.3% lb/sf Overall Roof Load Reduction

ASSUMED W-SHAPE REDUCTION
 30% Assumed W-Shape Reduction
 24.3% Re-design Cushion

TOTAL REDESIGN W-SHAPE TONNAGE
 7(24.86) = 17.4 Tons

- Overview
- Schedule & Cost
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	Old	New
Joist Tonnage	18.8	11.6
W-Shape Tonnage	24.9	17.4
Total Tonnage	43.7	29

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OVERALL STEEL REQUIRED FOR WHITE ROOF:
29 TONS
34% DESIGN REDUCTION

- Overview
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Duro-Last Cool Zone® Assembly GHG Savings:
 Concrete: 310 Tons
 Steel : 29.4 Tons
Total : 339.4 Tons



12 Times





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GREEN ROOF GHG EMISSION IMPACTS:

- Steel Production
2 Tons CO₂ / 1 Ton of Steel
- Concrete Production
1 Tons CO₂ / 1 Ton of Concrete
- Soil Heat Treatment
- Insignificant CO₂ Sequestering

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Construction Days



Roof Type	Construction Days
White	30
Green	17

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SCHEDULE IMPACT
 Green Roof vs. White Roof

Duro-Last Cool Zone® Assembly Schedule Savings:

Elimination of Composite Slab : -10 Days
 Elimination of Green Assembly : -5 Days

(3) Week Savings

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GREEN ROOF CONSTRUCTION COST

Structural Component	Total (\$)
Steel Joists	16,920.00
Structural Steel	60,482.10
Composite Deck & 4" Slab	90,737.50
Green Roof Assembly	427,000.00
	\$595,139.60

COST ANALYSIS

WHITE ROOF SAVINGS

\$375,971.10 which is a 63% reduction

WHITE ROOF CONSTRUCTION COST

Structural Component	Total (\$)
Steel Joists	10,044.00
Structural Steel	43,479.00
20 G' Metal Roof Deck	45,048.00
Cool Roof Assembly	120,200.50
	\$219,117.50

Overview

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Roofing

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ANALYSIS 2

GREEN VS. WHITE ROOF
ENERGY COMPARISON

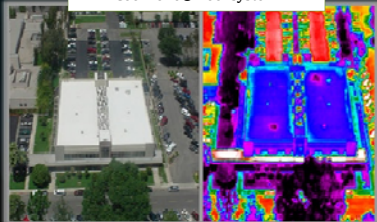



Duro-Last Cool Zone® Assembly Properties

- 50mil
- 2 Layer Polyvinyl Construction
- 86.5% Reflective
- 100% No Waste
- 5" Polyiso Foam Insulation

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Thermal Imaging of a Duro-Last Cool Zone® Roof system





ENERGY - 10 COMPARISON

Green Roof vs. White Roof

Overview

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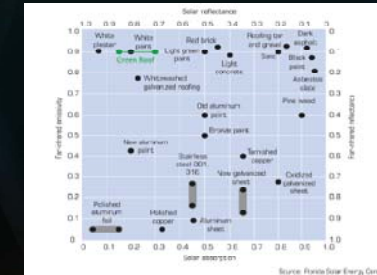
Recommendation

Roofing

What level of reflectance is needed by a roof material to mimic the surface temperature of a green roof?

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Thermal Imaging of a Duro-Last Cool Zone® Roof system



ENERGY - 10 COMPARISON

Green Roof vs. White Roof

“equivalent albedo” of a green roof is between **70-85%**

Overview

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Roofing

New Project Information

Location
 Weather File: STERLING1
 City: STERLING
 State: VIRGINIA

Utility Rates
 Elec Rate: 0.12 \$/kWh
 Elec Demand: 2.00 \$/kW
 Fuel Cost: 1.45 \$/therm

Zone 1
 Building Use: Office
 HVAC System: VAV DC cooling w/ Gas W/air sep
 Floor Area: 27,350 sq ft
 Number of Stories: 1

Zone 2 (if applicable)
 Building Use: [blank]
 HVAC System: [blank]
 Floor Area: 0 sq ft
 Number of Stories: 0

Shoebox Geometry
 Zone 1 Zone 2
 Aspect Ratio: 1.000
 Libray to use: ARCHIVELIB

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ENERGY - 10 COMPARISON
 Green Roof vs. White Roof

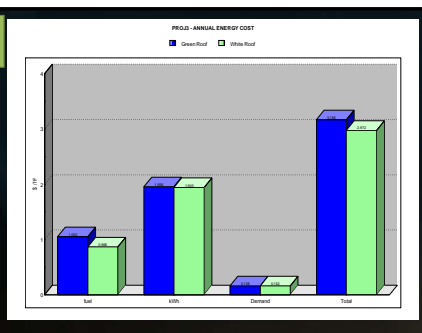
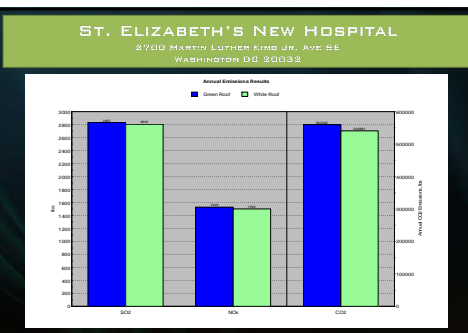
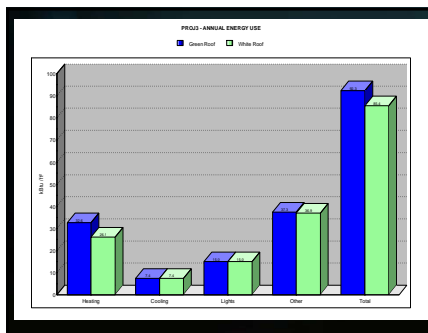
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OTHER SOFTWARE INPUTS

- Wall Composition
- Roof Assembly Composition
- Surface Reflectance

Roof Construction - Study 2 Settings

Roof Type	Area	U-Value	R-Value	Roof Type	Area	U-Value	R-Value
Green Roof	27,350	0.12	8.33	Green Roof	27,350	0.12	8.33
White Roof	27,350	0.12	8.33	White Roof	27,350	0.12	8.33
Total	54,700	0.12	8.33	Total	54,700	0.12	8.33



Annual Energy Use (kBtu/ft²)
 Heating - White - 20%
 Cooling - 0%
 Other - White - 1%
Total - White - 7.4%

Annual Energy Cost (\$/ft²)
 Fuel - White - 17.7%
 kWh - White - .7%
 Demand - Green - 2.4%
Total - White - 6.13%

Emissions (lbs.)
 SO₂ - White - 1.2%
 NO_x - White - 1.8%
 CO₂ - White - 3.5%
Total - White - 6.5%

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ENERGY - 10 COMPARISON
 Green Roof vs. White Roof
 Results

WHITE ROOF THERMAL SAVINGS

Hospital Energy cost :
 \$4.00/sf

Savings:
 \$.25/sf

\$5300.00/yr.

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Avg. Monthly Precipitation (in.)
 Washington D.C.

Month	Precipitation (in.)
January	3.21
February	2.63
March	3.6
April	2.77
May	3.82
June	3.13
July	3.66
August	3.44
September	3.79
October	3.22
November	3.03
December	3.05

Total Annual rainfall: 39.35

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RAINWATER HARVEST INVESTIGATION

ANNUAL ROOF CAPTURE:
 523,047 gal.

LAUNDRY WATER AND ELECTRICAL DEMANDS

	Qty.	Cycles/Yr	Hours/Cycle	Water Use/Cycle (gal.)	Water Use/Year (gal.)	kW	kWh/Yr
COMMERCIAL							
Washers	24	1300	0.5	14.0	433680	5	78000
Dryers	12	1300	0.666	-	-	21	213181.6
RESIDENTIAL							
Washers	2	1300	0.5	10	26000	1	1300
Dryers	2	1300	0.833	-	-	2	4331.6
				Total	459,680	Total	301,813

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Rain Water Recovery System Components

- Darco Inc. 10,000 gal. Fiberglass Tank — \$17,599 (Mat. & Lab.) & Plumbing Hookups
- ½ HP Shallow Well Jet Pump
- Sediment Filter
- CAIT 10 Filter w/ 5 Micron Filter
- 6 gal. Pressure Tank
- Power Star Endless Water Heater

} \$4,600 (Mat. & Lab.)

Total Up-front investment = \$22,199

HOLDING TANK/PUMP/FILTRATION DIAGRAM



Laundry System Water Usage

- Annual Laundry 1st-0 Usage: 624,320 gallons
- Annual Rainwater Capture Capability: 523,017 gallons
- Water Rate \$2.14 per CCF (WASA)
- 1 US gallon = 0.13368 ft³

$(459,689) \times (0.13368 \text{ ft}^3) = 61,460 \text{ ft}^3$

$61,460 \text{ ft}^3 / 100 = 614.60 \text{ CCF}$

$(614.60 \text{ CCF}) \times (\$2.14) = \boxed{\$1315/\text{year}}$

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SYSTEM DEMAND REQUIREMENT:

301,813 kWh/year

Capitol Sun Group

Photovoltaic Estimate

Laundry Demand: 301,813 kWh/year

Size of System Required: 223kW

System Coverage: 19,800ft²

20° Panel Orientation

Total Material & Installation:

\$1,780,000

PHOTOVOLTAIC INVESTIGATION

COST ANALYSIS OF PHOTOVOLTAIC SYSTEM

(301,813 kWh/year) \$.12kWh = \$36,218/year

\$1,780,000 / \$36,218/year = **49 year payback**

Overview

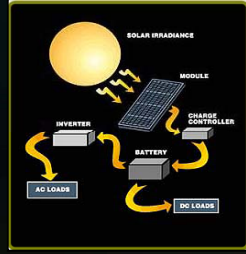
Schedule & Cost

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BOTTOM LINE COST BREAKDOWN OF WHITE ROOF INSTALLATION					
Duro-Last Cool Zone® Construction Savings:	\$380,022.00	<p style="text-align: center;">RECOMMENDATION:</p> <p><i>X Hydro-Tech Garden Roof® Assembly</i></p> <p><i>✓ Duro-Last Cool Zone® Assembly</i></p> <p><i>✓ Rainwater Harvest</i></p> <p><i>X Photovoltaics</i></p>		<p>Overview</p> <p>Schedule & Cost</p> <p>Structural</p> <p>Energy</p> <p style="color: green;">Recommendation</p> <p>Roofing</p>	<p>Ultimately, the Duro-Last Cool Zone® and rainwater harvesting system is a more environmentally and economically sustainable design both in construction and lifecycle as compared to the Hydro-Tech Garden Roof®.</p>
Rainwater Harvesting System Cost:	-\$22,200.00				
TOTAL:	\$357,822.00				
Annual Projected Lifecycle Savings					
Energy:	\$5,300.00				
Water:	\$1,315.00				
Maintenance:	-\$500.00				
TOTAL:	\$6,115.00				
SCHEDULE ACCELERATION	(3) Weeks				



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RESEARCH TOPIC

*WORKFORCE DEVELOPMENT:
THE ROOFING INDUSTRY*



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*CONSTRUCTION LABOR PROBLEMS
&
INDUSTRY TRADE ISSUES*

- Negative Industry Perception
- Higher Education
- Recruiting/Retaining Domestic Hires

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**Did You Seriously Think of Quitting
During the First Four Weeks on the Job?**



Response	Percentage
No	59%
Yes	41%

NRCA Survey

Relative Opinion of Various Occupations

Occupation	Percent With Very High/Moderately High Opinion
Carpenter	84%
Mechanic	82%
Machinist	80%
Welder	78%
Plumber	78%
Painter	65%
Concrete foundation	64%
Plasterer	59%
Landscaping	58%
Roofing	43%
Assembly line	43%
Asphalt paver	43%

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ROOFING DISSATISFACTION

Category	Percent Dissatisfied
Vacation Time	35%
Advancement-Pay	27%
Benefits	25%
Can't determine own schedule	21%
Pay	20%
Lack of steady work	19%

NATIONAL PUBLIC PERCEPTION

- National avg. roofing wage at **\$16.99**.
- A **66% increase** over the national minimum wage of \$5.85.
- Yet this industry struggles to maintain a steady influx of domestic hires.

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ROOFING CERTIFICATION

Would Training Courses/Certification Make Others Respect Roofing Jobs More?

Response	Percentage
Yes	81%
No	19%

"Do you think the establishment of specific training courses and levels of certification would make others respect roofing jobs more?"

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NEW TECHNOLOGIES

"Green Collar"

DOMESTIC SOLUTIONS AS DISCUSSED WITH INDUSTRY MEMBERS

- Technical Education
- New Marketing Angle
- "Inspire Professionalism"**
 - Clear Promotional Outline
 - Attractive Wage Incentives
 - Benefit Packages
 - Certification
 - Technology

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HISPANIC LABOR FORCE

- Ready & Willing To Work In Construction
- Many Already Have Trade Experience
- Great Work Ethic
- Already Extremely Dependant on this Labor Pool

FOREIGN LABOR POOL

Foreign-born workers in 2007 were more likely than their native-born counterparts to be employed in natural resources, **construction**, and maintenance occupations (**16.4 versus 9.7 percent**)

Overview

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Language Issues

Work With Those Not Speaking One's Language

Response	Percentage
No	63%
Yes	37%

Difficulty of Communication

Difficulty Level	Percentage
Very	15%
Somewhat	80%
None	24%

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3 MAIN INDUSTRY CONCLUSIONS

1. Benefits Need to be Addressed
2. Technology will Gradually Aid Image
3. *Pour Resources into the Hispanic Labor Force*

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QUESTIONS?

