South Campus Neighborhood Project

Complete Streets

CONCEPTS

Prepared By

Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Department of Civil Engineering, College of Engineering,

Computer Science & Construction Management

California State University, Chico

Resilient Cities Initiative
Institute for Sustainable Development
California State University, Chico

The South Campus Neighborhood Project

The South Campus Neighborhood Project is an award-winning neighborhood improvement planning effort coordinated by the Resilient Cities Initiative at California State University, Chico and the Public Works-Engineering Division at the City of Chico, CA. The project is focused on the public rights-of-way in Chico, California's South Campus Neighborhood, a six by seven square-block area bound by 2nd Street to the North, 9th Street to the South, Orange Street to the West and Salem Street to the East. Immediately adjacent to both downtown Chico and the University, it is Chico's oldest residential neighborhood and was laid out by the town's founder, John Bidwell, in the 1860's.

The neighborhood today is densely populated with university students and is also home to a number of small businesses, restaurants, bars, churches, community organizations, a school, a fire station, a police station, a railway station and transit center. Given its location, population and mixed uses, the neighborhood faces a unique set of circumstances and challenges. This three-year project aims to assess existing conditions and to develop and refine neighborhood improvement concepts to address a range of identified issues. The neighborhood improvement planning process is focused on concepts for complete streets and public works that will enhance public health and safety, quality of life, sense of place and environmental sustainability.

☛ *More information can be found online at http://scnpchico.com/*

RCI

City of Chico Public Works-Engineering

The overall Mission, Vision and Goal of the City of Chico Public Works Department is to provide the best possible Quality of Life through our abilities to protect, plan, construct and maintain the physical assets of the City. This is achieved through teamwork, integrity, professionalism, innovation, respectful customer service, value to the citizens of Chico, accountability and stewardship of the City's infrastructure and public resources. We serve the public in a manner that supports the rich heritage of Chico, as well as progressing into future improvements desired by the community in a sustainable manner. We continue to look for new technology that assists in meeting these goals so that we can operate at the most efficient level and continue to be at the leading edge of modern standards.

Our Mission, Vision and Goals include ensuring public safety through detail oriented and strategic improvements to mitigate unsafe operation and use of our Public property; Providing safe, sustainable, integrated and efficient transportation systems to enhance the City of Chico's economy and livability for all modes of transportation; Efficiently and effectively providing a reliable, sustainable and cost effective sanitary sewer and storm water collection system for our residents and businesses in-line with our overall Mission and Vision. We are stewards of the natural environment and through responsible practices, we construct and maintain our natural environment to the highest of standards. We will continue to make the City of Chico a leader in sustainable and clean practices so that our residents can experience the quality of life that is desired for an infinite length of time.

The Resilient Cities Initiative

The Resilient Cities Initiative (RCI) is an interdisciplinary university-community partnership program established by the Institute for Sustainable Development at California State University, Chico in 2016. The RCI connects real-world community sustainability projects— identified and funded by partner agencies— with faculty expertise and student innovation from departments and disciplines across the University's academic colleges. The RCI recruits partner agencies through a competitive selection process and matches projects with existing courses across the university's curricula. Partner agencies are able to harness incredible momentum for their projects in large part because the partnership is realized on a bigger scale than more typical one-off university-community projects. Faculty are able to opt-in and augment their existing curriculum with real-world projects that have been identified, funded and supported by the leadership and staff of the partner agency— ultimately delivering their students' work for consideration and implementation. The RCI is a member of the Educational Partnerships for Innovation in Communities (EPIC) Network, a nationwide network of over 25 universities that have replicated the highly successful Sustainable City Year Model that was established at the University of Oregon in 2009. The model is based on university-community partnerships with a defined geographic and temporal scope, focused on advancing sustainability and the social good, leveraging the multidisciplinary knowledge and capacity of the university to 'move the needle' on pressing community issues. The RCI directly engages hundreds of CSU, Chico students each academic year, providing impactful opportunities for them to put theory to practice in their own community and region, connecting them with decision-makers in practitioners in their fields of study, and helping develop the next generation of workforce professionals and leaders.

Course Participants

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017 | Dr. Pablo Cornejo

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South Campus Neighborhood Project

Complete Streets Concepts

Resilient Cities Initiative
Institute for Sustainable Development
California State University, Chico

Public Works-Engineering
City of Chico, California

Prepared by Sam Forsberg, Alejandro Valadez, Rafael Cervantes, Jonathan Campos, Ivan Juarez, Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

1. Implement a roundabout and several new and improved light fixtures to improve safety and also aesthetics while keeping cost in mind.
2. Problem Definition: Unsafe pedestrian and cycling conditions due to lack of luminance as well as lack of proper street infrastructure. Unsafe yield signs at intersections with blind spots, no reserved safe space for cyclists anywhere on the road, and unpreserved road.
3. Goal: To provide a pedestrian-safe design while keeping a retro-look that complements the city of Chico.
4. Functional Unit: Single intersection and surrounding roads over a period of 20 years

Sustainability Metrics

1. Triple bottom line:
   - Environmental: CO_2 emissions is developed due to construction/Operation & maintenance. Electricity is the main contributor as a result of the length of time of use.
   - Social: Safety is our priority for our design. This design will reduce the amount of accidents for both drivers and bicyclists.
   - Economic: Cost is based on the material gathered for Life Cycle Inventory from commercial equivalents

1. LCA was calculated with the use of SimaPro. We used a table we found fit for our project boundaries which created each individual input. We created an assembly and ran TRACI to obtain a detailed explanation of effects. As a result, it gave us the largest contributor to carbon footprint which was electricity.
2. Economic impacts was based on cost expressed as net present worth. We used these equations to convert future and annual costs into present worth:

$$P = A\left[\frac{(1+i)^n - 1}{i(1+i)^n}\right]$$

$$P = F(1+i)^{-n}$$

Life Cycle Inventory

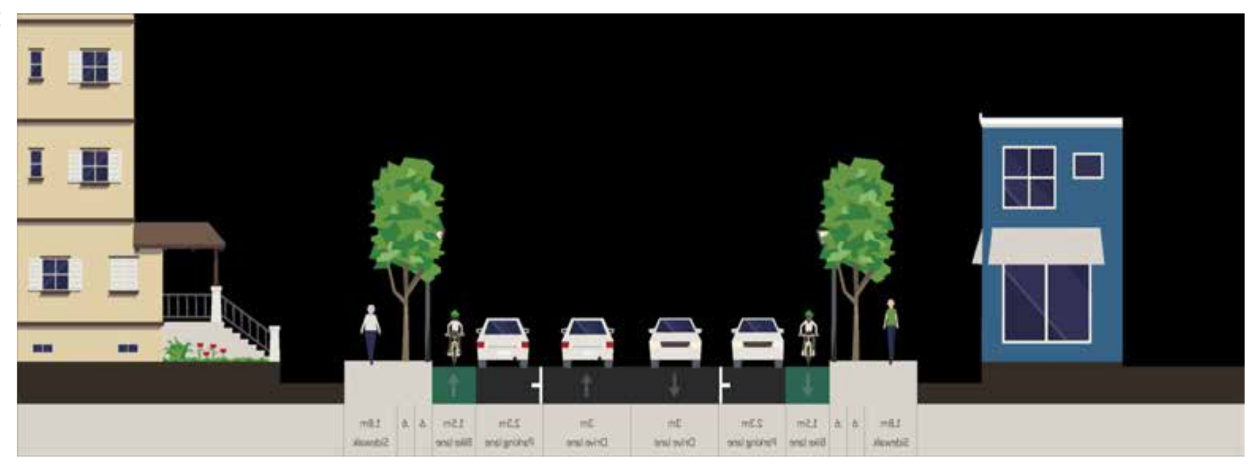
Lifecycle Stage	Description	Item	Avg	Units
Construction	Roundabout	Concrete	77	ft^3
	Light Posts	Aluminum	1041.76	lb
		LED	0.27	lb
	Yield Sign	Galvanized Steel	0.98447	ft^3
	Bike Lanes	Paint	16	gallons
Operation and Maintenance	Light Post Operation	Electricity	28295	kWh
	Transportation	Transport by Truck	3	tkm

Data based on our functional unit of a single intersection and surrounding streets over a period of 20 years.

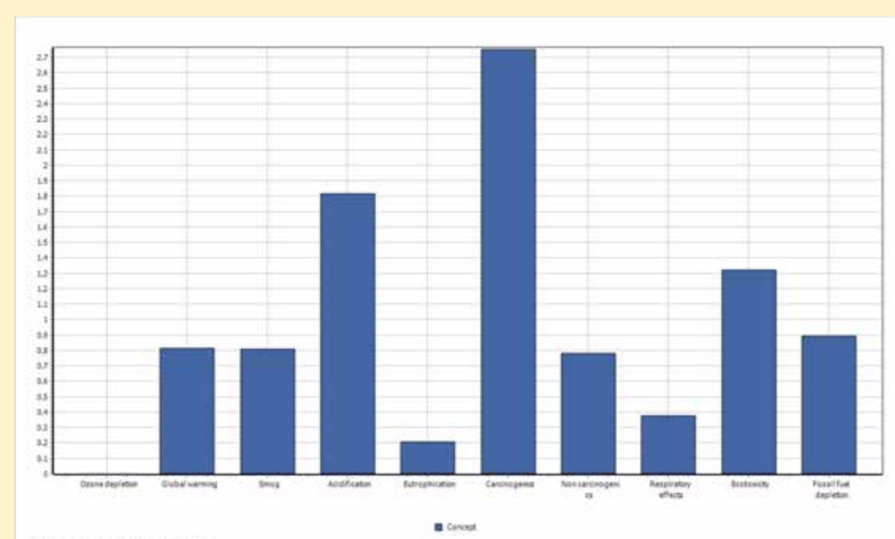
1. Social Impacts
   - Improved safety
   - Aesthetics

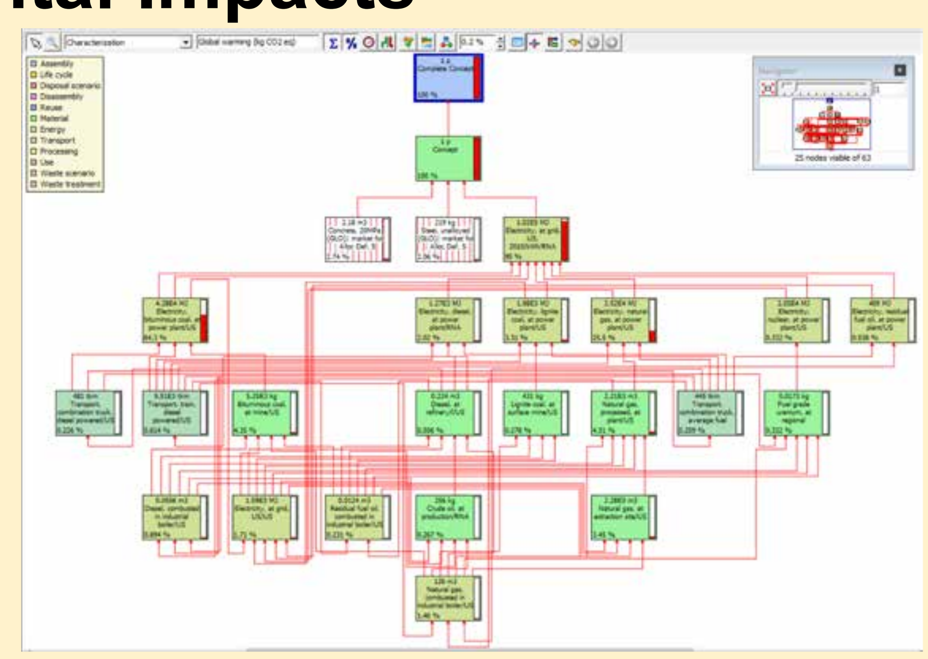
Chestnut & 7th Modifications

1. Intersection of interest: Chestnut and 7th
2. Complete Streets Concept: A team that establishes transportation designs that will ensure the safety of the public when dealing with pedestrians, bicyclists, and any motor vehicle on the road.
3. Proposed street design: Chestnut and 7th is a very busy road that has plenty of unnecessary yield signs that can cause for many accidents to motorists, bicyclists, and pedestrians. So we decided to add a bicycle lane, a roundabout, and lights to enforce the protection and safety of others.
4. Design concept:



Environmental Impacts





These show the results of our life cycle assessment. They demonstrate that electricity use over 20 years is the biggest contributor to carbon footprint.

Economic Impacts

	Initial Capital Costs
Light Posts	27,030
Bike Lanes	336
Yield Signs	980
Roudabout	350,000
Total Initial	378346
	Replacement Costs
Light Posts	27030/10 years
	Annual Costs
Electricity	170/year

- Bike lane and yield sign costs based on material cost and is negligible
- Light post cost based on commercially available products with an estimated life span of 10 years
- Roundabout cost based on reported averages for installation of similarly sized ones
- Electricity based on estimated annual usage from light posts

- Costs were expressed as net present worth in order to get an estimate of the total cost of our functional unit of a single intersection over a period of 20 years in terms of present dollar amounts. Interest rate was assumed to be 6%
- Total cost expressed as Net Present Worth: $403,800

Final Recommendations

1. In conclusion, this intersection has the most potential for improvement due to its high level of perceived danger, level of traffic on road, and inadequate lighting.

1. Results of Metrics:
   - Environmental: Low impact, mostly from electrical use
   - Economic: Average costs for refurbishment of this size, may save money through decreased accidents
   - Social: Will Improve safety and ease of use for pedestrians, bikers, and drivers

1. Possible sources of funds:
   a. Raising parking meters by 5-10 cents
   b. Increase taxes by .01%
   c. Create new environmental tax

Our study shows the many benefits of implementing our concept, due its low environmental and economic impact, and large increased in the safety of the intersection.

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South Campus Neighborhood Project

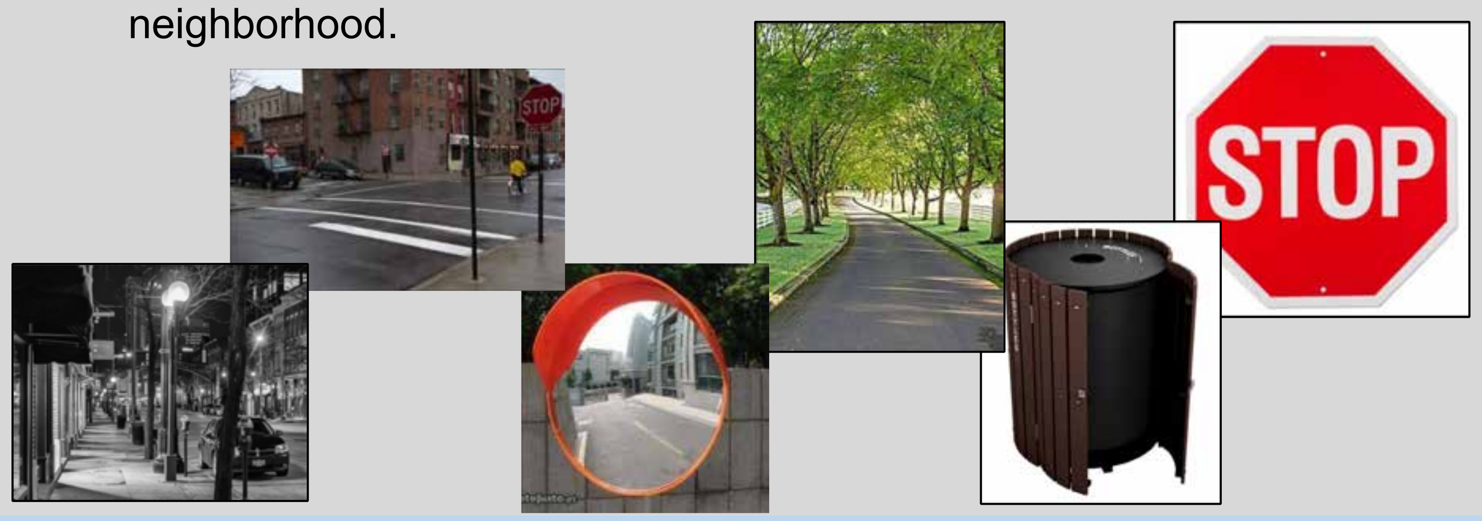
Complete Streets Concepts

Prepared by Zack Cavender, Charles Johnson, Xochitl Ramirez, Jorge Romero, Kate Worcester, Dr. Pablo Cornejo
Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Public Works-Engineering
City of Chico, California

Project Goals & Scope

1. Generate eco-friendly and financially feasible plans for bettering the South Campus Neighborhood.
2. The South Campus Neighborhood within Salem St and Orange St, and 2nd St to 9th St.
3. Address the problems of inconsistent lighting, unintuitive and unsafe traffic control, overgrown tree canopies, excessive litter, and poor road conditions.
4. The goal is to positively increase the community view of the neighborhood.



Sustainability Metrics

For each concept, we applied a triple bottom line approach, although our primary and secondary concepts are not directly comparable.

1. Environmental Metrics
   - CO_2 Emissions
   - Global Warming Potential (GWP)
   - Proper disposal and recycling of waste
   - LCA was performed using Traci (US, 2008) in SimaPro
2. Economic Metrics
   - Construction and Operation & Maintenance Costs
   - Equivalent Uniform Annual Worth (EUAW)
   - Net Present Cost (NPC)
   - P=F(P/F,i,n) A=P(A/P,i,n)
   - P=Present Cost, F=Future Cost, A=Annual Cost, n=number of years, i = interest
   - i=7% (historical average return for S&P 500, adjusted for inflation)

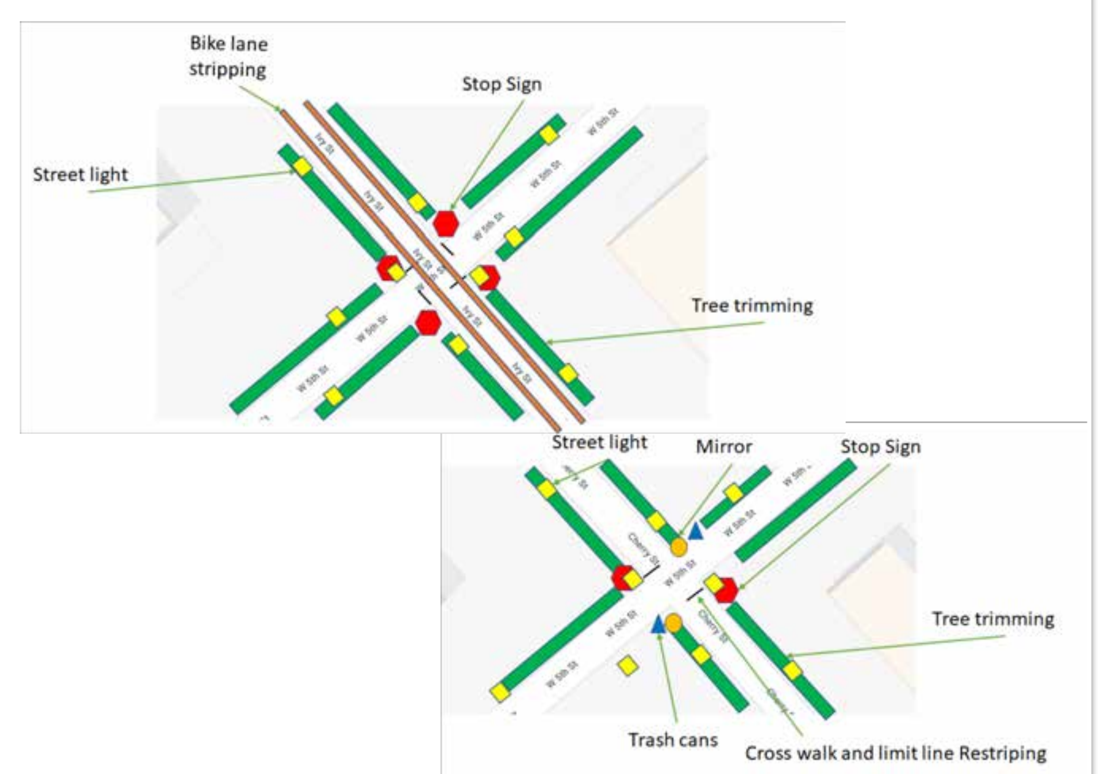
1. Social Metrics
   - Do pedestrians and bicyclists view the improvements as safer
   - Compare traffic accident rates before and after improvements

Primary Concepts

Concepts that are simple and efficient to implement quickly, but improve neighborhood characteristics

Key Design Components

- Through Streets (Ivy and 5th)
- Using Mirror to improve line of sight on through streets
- Four-way Stops (it's a neighborhood)
- Reduce Littering with additional trash cans
- Trimming the Trees to reduce interference with lights, power lines, and pedestrian walkways.
- Additional Lighting
  - Fixture on power poles
  - Black Acorn Style Lights

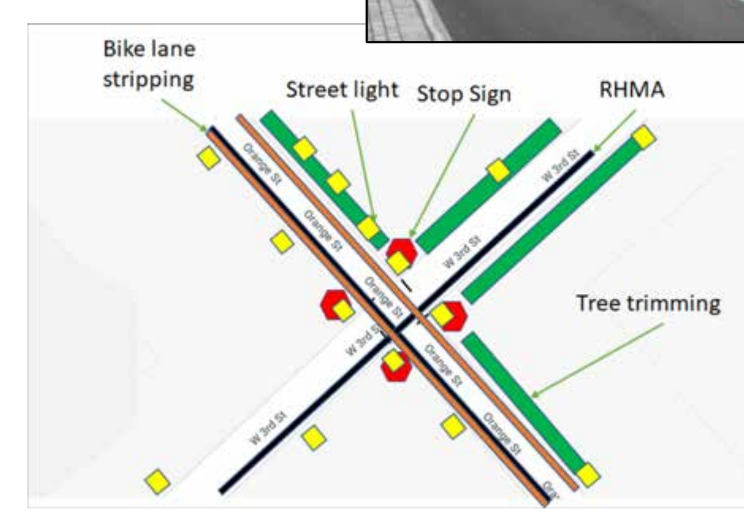


Secondary Concepts

Concepts that require more time, money,and planning to implement, but would have a lasting effect on the community

Key Design Components

- Recycled Hot Mix Asphalt (RHMA)
- Recycled Asphalt Pavement (RAP)
- Re-striping limit lines, crosswalks, and
- ng for trash pickup



Economic Impacts

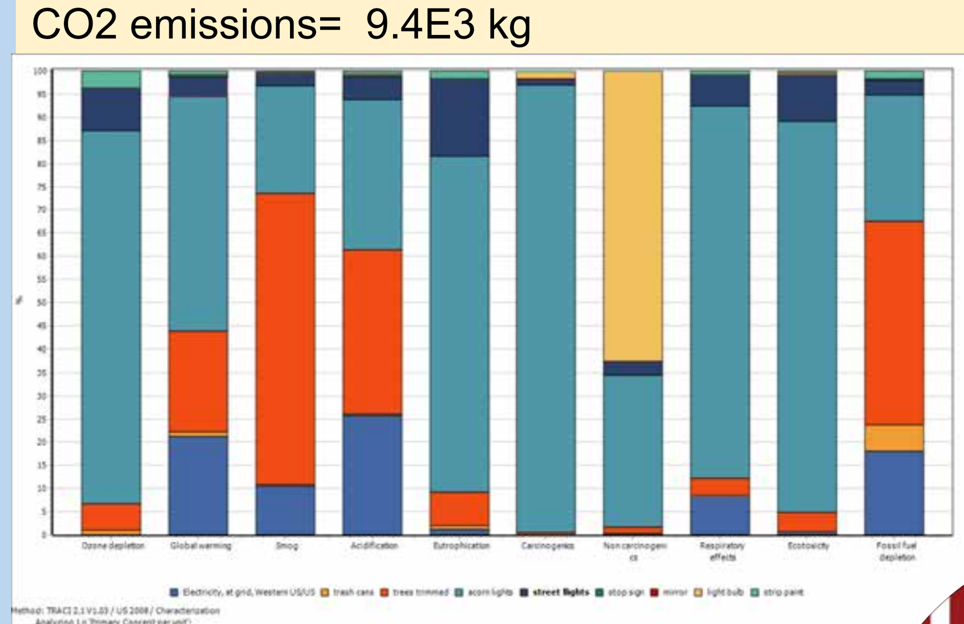
1. **Primary Concept**
   - EUAC - $1,500,000
   - NPC - $15,500,000
1. **Secondary Concept**
   - EUAC - $3,100,000
   - NPC - $6,800,000

Item		Amount	Units	Cost Per Unit		Lifespan
		Primary concepts				
Stops Signs		3	pfu	$	24.00	10 years
	Aluminum	7.38	lb			
Through Street signs		2	pfu	$	40.00	10 years
	Aluminum	3.69	lbs			
Tree Trimming		22	trees pfu	$	1,500.00	1 year
	Gas	5	gallons			
	Motorvehicle	3	vehicles			
	Electric engine	2	pfu			
Mirrors		2	pfu	$	500.00	10 years
	Glass	4	lbs			
	Stainless steel	9	ft^2			
Trash Cans		2	pfu	$	695.00	20 years
	Polyethylene	62	lbs			
	Stainless Steel	7	lbs			
Re-Striping						10 years
	Electro static paint	634	oz			
Acorn lights		10	pfu	$	524.00	10 years
	Cast iron	600	lbs			
	Glass	20	lbs			
	Corgated Board Box	26	g			
Street light Fixtures		8	pfu	$	135.00	10 years
	Glass	5	lbs			
	Aluminum	40	lbs			
Light Bulbs		18	pfu	$	53.00	4 years
	Glass	5	lbs			
	Mercury	0.003	kgs			
	Electricity	80	Watts			
		Secondary Concepts				
RHMA		Entire Neighborhood		4.1 million		15 years
	Recycled Aggregate	20000	tons			
	Binder	12200	tons			
	Tire waste	2800	tons			
Parking Restriction Signs		0.5	pfu	$	20.00	10 years
	Stainless steel	1	ft^2			
	Parking	42	1			
Bike Lane		1	linear ft	$	13.56	10 years
	Green Electro static paint	634	oz			
	*pfu	per functional unit				

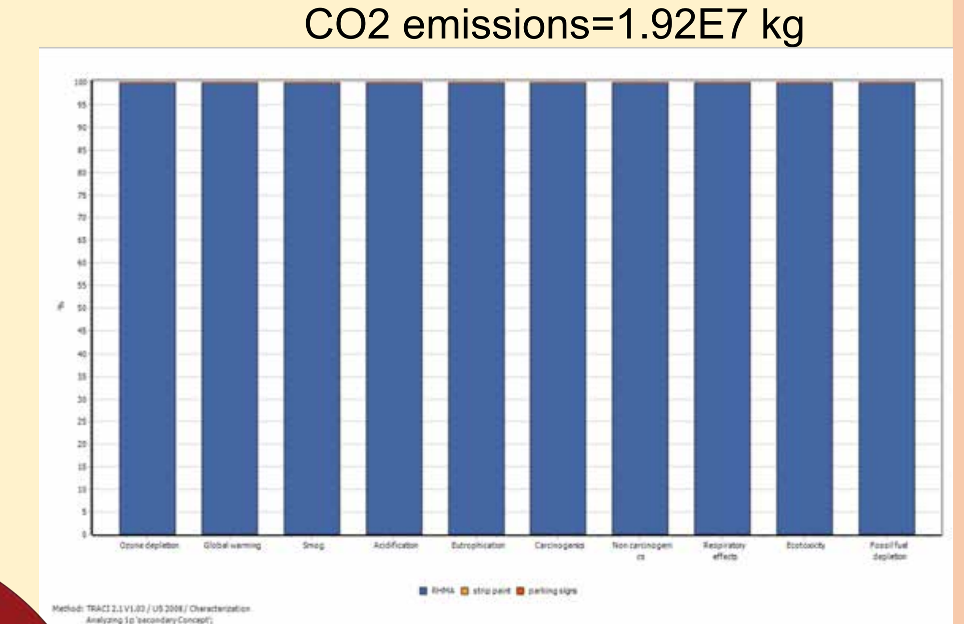
Environmental Impacts

SimaPro - TRACI US 2008

Primary
CO_2 emissions= 9.4E3 kg



Secondary
CO_2 emissions=1.92E7 kg



Final Recommendations

Two separate concepts

Simple quick solutions that can be implemented within a year

Long term solutions that will have a lasting effects on the community

Refer to the tables below for the list of potential benefits for each of the concepts

primary

Section	Importance to Neighborhood	Regular Maintenance	Qualifications	Bulk Options
Stop Signs	Replacing the stop signs would allow for more consistent traffic control and to increase the safety on streets, whether for vehicles and or for pedestrians crossing streets.	No	MUTCD	Yes
Cross Traffic Signs	We want to replace and or add clearly labeled signs to increase the control of traffic and street safety of both motorists and pedestrians.	No	MUTCD	Yes
Trash Cans	Trash cans would be added to help avoid littering and help in beautifying the South Campus neighboorhood to increase its aesthetic view.	Yes	No	Yes
Tree Trimming	Tree trimming semi- annually, would reduce the amount of trees blocking powerlines/ poles and street lights. It would also increase pedestrian visibility as the trimmed canopy wouldn't be blocking any light.	Yes	No	No
Mirrors	Mirrors would enable better line of site for motorists and pedestrians at difficult intersections on Ivy Street. This is great as it wouldn't reduce parking around the neighborhood as well.	Yes	No	No
Additional Lighting	Adding lighting to existing poles would provide more safety at night when it is dark and lower crimes. It will also increase visibility and pedestrian and motorist safety, which would decrease the amount of accidents.	Yes	No	Yes

secondary

Section	Importance to Neighborhood	Regular Maintenance	Qualifications	Bulk Options
RHMA/ RAP	RHMA/ RAP would help improve the road and drive quality for vehicles.	No	DOT	No
Bike Lanes	Finishing the existing bike lane on Salem St. would help improve the safety of bicyclists when driving near and around motorists by making it visible with green paint.	No	MUTCD	No
Additional Bike Lane	Adding a complete bike lane on Orange St. would help improve the safety of bicyclists to use as an alternative from the existing one on Ivy St. and Salem St. It would enable a better cyclist traffic control.	No	MUTCD	No
Re- Striping	Re- striping limit lines and crosswalks would reinforce traffic control and be more visible as some existing ones look invisible. It would make pedestrians safer and create a more controlled area.	No	MUTCD	No
Restricting Parking Signs	No parking signs would help give easy access for weekly trash pick up during certain times on a given day. It would also help keep the neighborhood clean.	Yes	No	Yes

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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

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City of Chico, California

Project Goals & Scope

As it stands, Orange street is in terrible shape: the road surface is in deplorable condition, the lighting is effectively non-existent, and absolutely no considerations are made for bike transit. Through most of Orange there is little consideration for parking and often there is no clear delineation between the street and the shoulder. This project focuses on redesigning a section of Orange St. ranging from the intersection of 2nd to the intersection of 7th with the goal of increasing safety for all vehicles, cyclists, and pedestrians while simultaneously generating green electricity and improving the overall quality of the roads and neighborhood.

Alternatives Considered	Function	Functional Unit	Key Inputs	Key Outputs	Environmental Impacts Assessed
Resurface & Repair	Create safe, complete streets	One intersection (Orange and 7th) for 20 years	Asphalt, paint, energy, metals	Emissions, runoff from asphalt	Carbon emissions
Solar Roadways			Glass, plastics, electrical components, energy	Emissions, green energy	Carbon emissions

Table 1: Alternatives

Sustainability Metrics

Our triple bottom line approach came down to: damage to human health, safety, and net present worth. **Safety**: the light provided by both streetlights and tiles allows complete visibility of any oncoming traffic/pedestrians. **Economic**: by doing an NPW analysis it allowed us to choose the most cost effective alternative that will be less harmful to the community in a 20 year lifespan. **Environmental**: by adding solar roads, the tiles will create a surplus of energy that is redirected back into the grid thus reducing Chico's greenhouse emission.

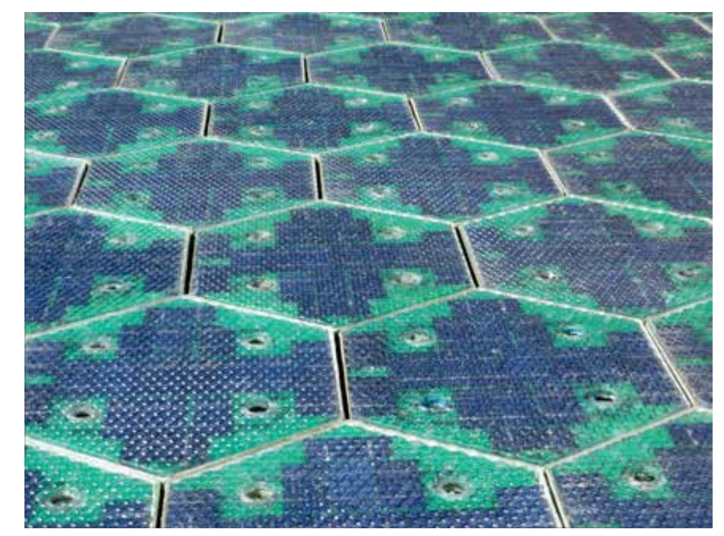
By using the environmental impact tool TRACI to calculate our environmental impact alternatives we were able to compare both of the alternatives; solar tiles and repaving/resurfacing the roads. In a 20 year lifespan, it is both economically and environmentally safer to repave/resurface the tiles as indicated on the graphs in the right section.

Our NPW for both alternatives is shown on the top right section and indicates the number of product needed, cost of maintenance, yardage needed, etc. Everything was taken into account thoroughly, to produce the most cost effective, yet best outcome.

Safety was the only Social aspect considered, Orange Street is marked as an extremely hazardous road for means of transportation. All of our alternatives combats that dilemma and provides solutions; Panel sensors allows commuters to know when someone or something is approaching them, streetlights allows vehicles, pedestrians, and cyclist to be seen easily at night, and resurfacing and repainting reduces the amount of potholes and cracks in the asphalt that can cause problems for commuters.

Solar Roadways: Dream or Reality?

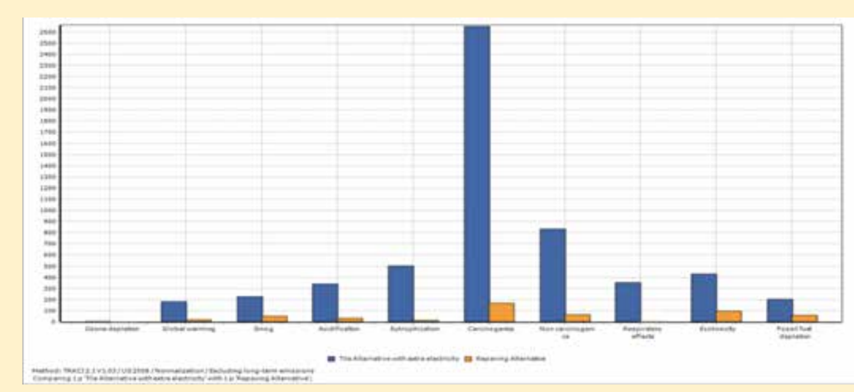
The focus of our design is a series of interlocking, solar panel tiles that form a programmable, solar roadway. These pressure sensitive panels permit on the fly redesigns for streets and are even capable of detecting the weight of a pedestrian, and as all panels are equipped with embedded L.E.D.'s to provide maintenance free, high visibility road markings, are then able to illuminate the pedestrian for drivers. Additionally these smart panels are immune to potholes due to their impact resistant, glass surface, contain integrated heating units to eliminate black ice or the need to plow/salt roads, and are modular permitting effortless, quick road work, all while still generating green electricity for the community.



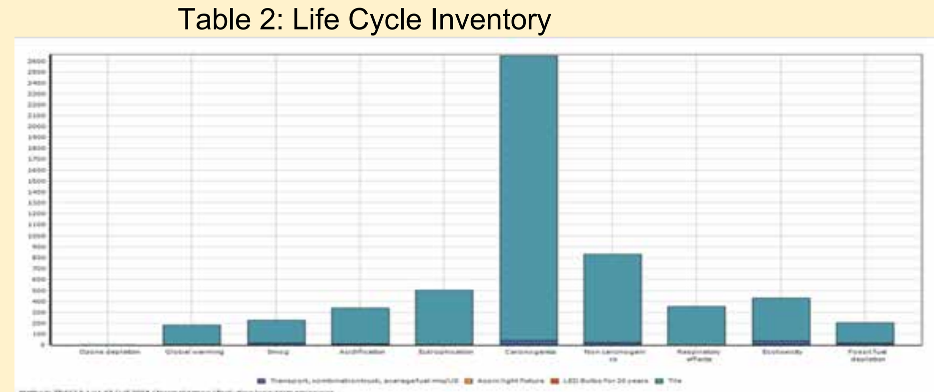
Environmental Impacts

Life Cycle Stage	Item	Average	Units
Construction	LED	13587456	diodes
	Recycled Tempered Glass	66345	ft^2
	Solar Panel	58250.91	ft^2
	Recycled Plastic	66345	ft^2
	Heating Element	13269	element
Operation and Maintanence	Transport by Truck	800	miles
	Electricty Cost	21,024.00	kWh/20 years
	Electricty Produced	1,920,000.00	kWh/20 years
	Electricty Surplus	1,898,976.00	kWh/20 years

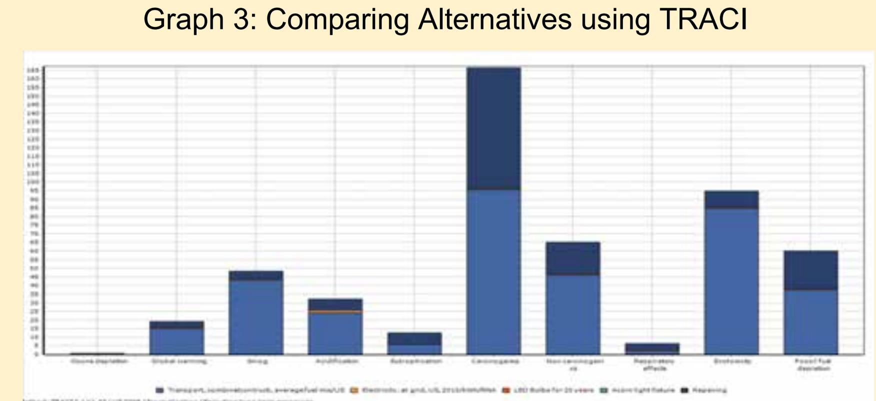
Table 2: Life Cycle Inventory



Graph 3: Comparing Alternatives using TRACI



Graph 1: Solar Tiles Alternative Analysis using TRACI



Graph 2: Repaving Alternative Analysis using TRACI

Estimated Economic Impacts Based on NPW Calculations

Tile Alternative

Tiles								
	Area to be Covered (sq. ft.)	Area of One Tile (sq. ft.)	Number of Tiles	Cost Per Tile	Total Cost			
	53073	4	13269	$ 80.00	$1,061,520.00			
Concrete Ditch								
	Volume of Concrete (cubic yard)	Cost per Cubic Yard	Total Cost					
	855	$ 100.00	$ 85,500.00					
Acorn Lighting								
	Light Fixtures	Cost of Fixture	Led Lamps	Cost of Lamps	Cost	Cost with Tax		
	8	$ 1,061.10	8	$ 43.20	$ 8,488.80	$ 9,146.68		
	Cost	Cost of Replacement at year 10	Total Cost for 20 years					
NPW of LED Lamps	$ 372.38	$ 207.94	$ 580.32					
Electricity								
	Electricty Needed (kWh)	Electricty Produced (kWh)	Electricy Surplus (kWh)	Cost of Electricity	Money Saved from Electricity Production	Price PG&E pays for Electricity Surplus	Money Earned from Electricity Surplus	
	21,024.00	1,920,000.00	1,898,976.00	$ 0.14	$ 267,375.82	$ 0.03	$56,969.28	
Total	$ 832,401.90							

Table 3: Total Cost of Tile Alternative

Repaving Alternative

Acorn Lighting							
	Light Fixtures	Cost of Fixture	Led Lamps	Cost of Lamps	Cost	Cost with Tax	
	8	$ 1,061.10	8	$ 43.20	$ 8,488.80	$ 9,146.68	
Repaving							
	Area to be Covered (sq. ft.)	Cost per Square Foot	Cost	Cost of Replacing at Year 10	Lifetime Cost (Equivalent Replacement at Year 10)		
	53073	$ 2.24	$ 118,883.52	$ 66,383.94	$ 185,267.46		
Repainting							
	Center line Length	Line Cost per Foot	Stop and Crosswalk Line	Stop/Cross line cost per line	Parking Spots	Parking Spot Cost per Line	Cost
	600	$ 0.30	8	$ 30.00	64	$ 4.50	$ 708.00
Bike Lane							
	Lanes	Linear Footage (ft)	Cost Per Foot	Cost of Painted Lanes	Biker Stencil	Cost per Stencil	Cost
	2	600	$ 3.60	$ 4,320.00	4	$ 1,000.00	$ 8,320.00
	Cost	Cost of Replacement at year 10	Total Cost for 20 years				
NPW of LED Lamps	$ 372.38	$ 207.94	$ 580.32				
NPW of Repainting	$ 708.00	$ 395.34	$ 1,103.34				
NPW of Bike Lane	$ 8,320.00	$ 4,645.84	$ 12,965.84				
Total	$ 209,063.65						

Table 4: Total Cost of Repaving Alternative

Final Recommendations

Our final recommendation is to use the solar smart road system to replace the existing roads. This option, despite having a large upfront cost, has an increased lifespan and the potential to generate copious green power in perpetuity for the city. This option will also greatly increase general safety for pedestrians and bicyclists while simultaneously allowing better solutions for traffic, blockages due to external factors and general road conditions.

The impact socially is a road that feels safer to travel on so people will actually want to use it. As it stands, at night the street looks more like a good way to get a knife in the ribs or discover a new pothole by breaking your car on it. With a better road surface and lighting, the street will feel safe to traverse, meaning people, especially those who live close can now take a more direct route instead of having to rely on Ivy being the one reasonably lit street.

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South Campus Neighborhood Project

Complete Streets Concepts

Prepared by Luke Baptista, Jimmy Draper, Ted Hunter, Karen Martinez, Jesus Ramos, Dr. Pablo Cornejo
Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Public Works-Engineering
City of Chico, California

Project Goals & Scope

Problem Definition:
Beautiful trees, green area, and walkability are the city's most likeable aspects. Whereas dangers from car traffic and crime are the least liked ones. For this reason, we have decided to put special emphasis on simple, yet economic solutions to these issues.

Goal:
To make the Chico South Campus Neighborhood streets safer by replacing 4-way yields with 4-way stops, adding more lighting to poorly lit streets, and repainting street intersections and curbs.

Scope:
From 2nd St, to 9th St; and Salem St. to Orange St.

To calculate environmental impact of adding more stop signs, street lighting, and repainting.

Sustainability Metrics

Overview:
During this project our group focused simple and easy solutions that would make a big impact in the safety and functionality of the south campus neighborhood. We used the Triple Bottom Line metric which focuses on environmental, economic and social impacts will have on our community.

Metrics:
The environmental metrics we measured are the atmospheric pollution of particulates (PM) in the air per cubic meter, carbon footprint (kg*CO2eq/block), and energy used (kWh) during operation. The economic metrics were construction cost, and operation and maintenance cost calculated using present worth analysis.

Environmental Impacts:
We used SimaPro to calculate Environmental Impacts such atmospheric pollution, carbon footprint, and energy used during operation. (See *Environmental Impacts* for more detail).

Economic Impacts:
We used present worth analysis A=P(A/P,i,n) to calculate the yearly payments required per functional unit. (See *Economic Impacts* for more detail).

Social Impacts:
The social metrics we measured are whether our complete streets are pedestrian and bike safe/ friendly, safe for drivers, and its visual appearance. This measured using personal opinions from our peers and community members.

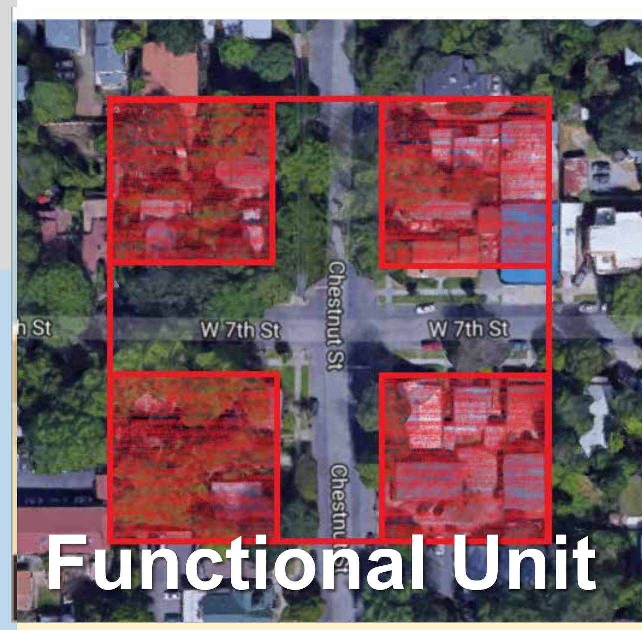
Stop Signs for a Safer Tomorrow

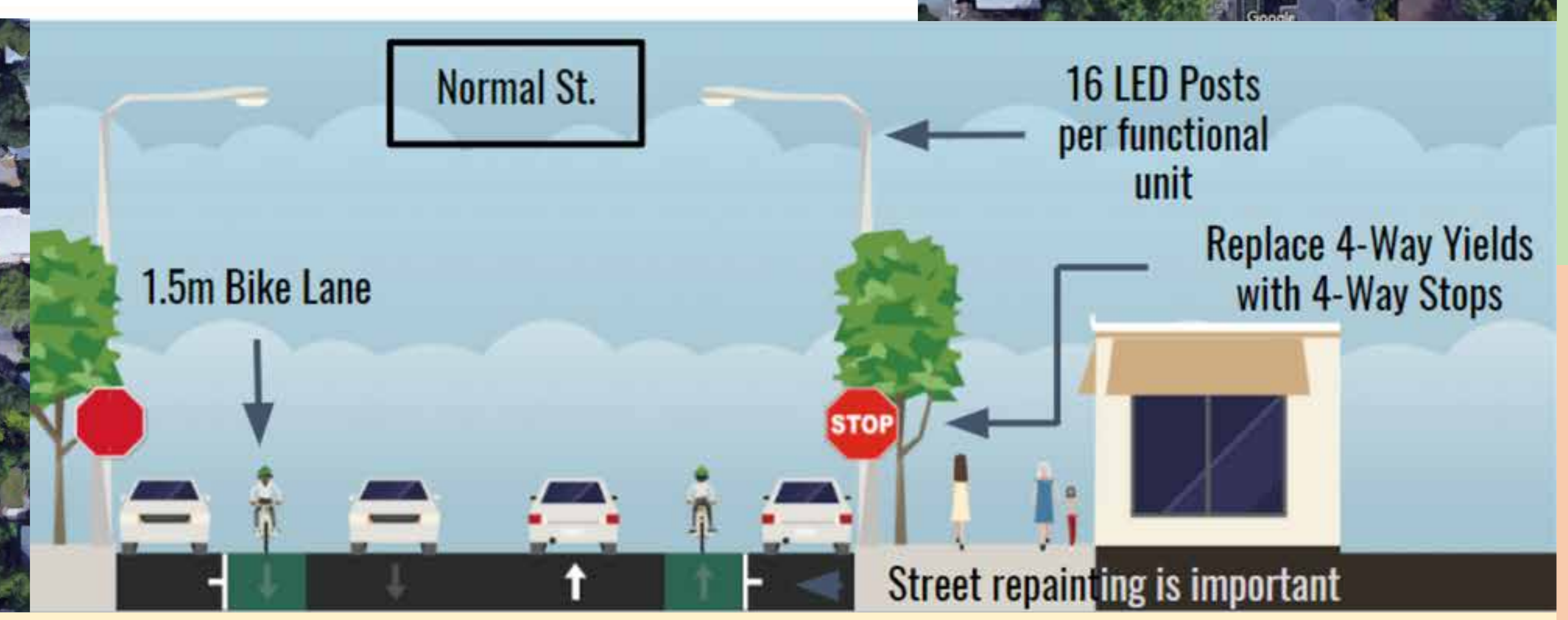
Intersection of Interest:
4th and Normal St.

Complete Street Concept:
The complete street design for streets that run parallel to Normal St. is very similar in essence. Ideally, you want two bike lanes on each side of these streets with a minimum width of 1.5m. The total average width of these streets is ###, so by repainting the dividing line between lanes, this can be achieved.

The complete street design also includes 16 LED posts per functional unit.

Lastly, the image below shows stop signs replacing previous yield signs to aid with the walkability of the neighborhood.





Environmental Impacts

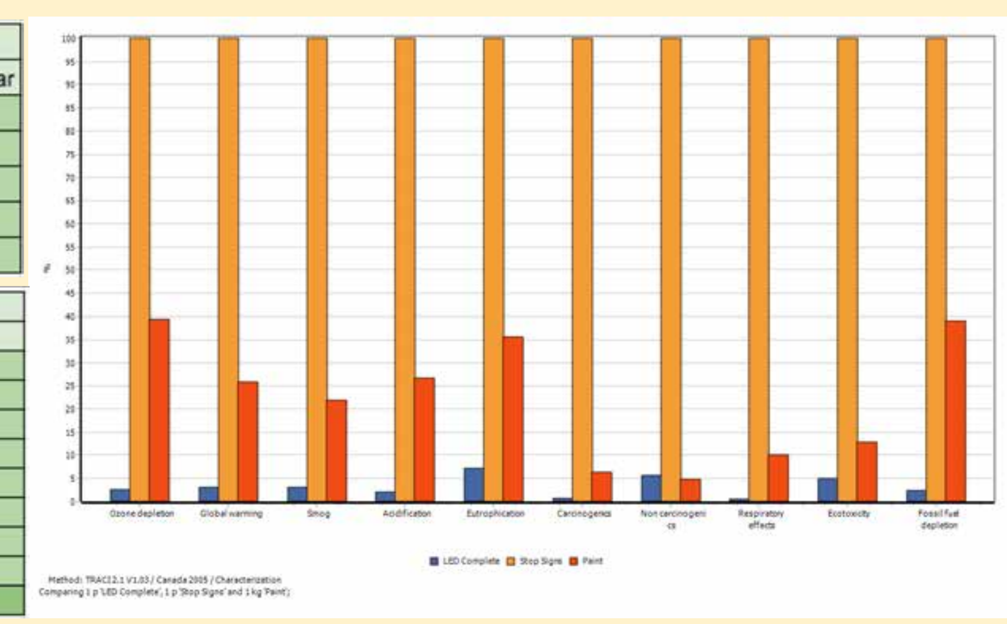
LCA Results:
Stop signs have the worst effect on the environment, paint has the second worst effect, and lastly the LED lights. LCCA Total: $27,678.30. See table below for inventory.

Lifecycle Inventory over a 20-year lifespan per street

Item	Costs	Installation Costs per functional unit	Unit	Replacement Costs per year
Street Lights	$1500 x2	$2,200.00	1 light post	$115.64
Delineator Post	$125 x2			$200.00
Aluminum	$25 x2	$250.00	per sheet/per post	$50.00
Paint	$3.4 x60	$500.00	Sq. Ft.	$30.00
Concrete	$9.53 x250	$1,000.00	cubic yd.	$90.00

Lifecycle Inventory over a 20-year lifespan per street

Lifecycle Phase	Description	Unit Process	Items	Avg	Units
Construction	Infrastructure	Sidewalks	Concrete	400	m^3
		Street Lamps	LED Lights	23.6	g
			Light Posts	2825.88	g
		Transport Products	Diesel	300	mpg
	Materials	Curbs	Paint	4	gallon
		Urban Forest	Trees	20	trees
		Stop Signs	Stop Signs (Aluminum)	18597.3	g
			U-Channel Delineator Post	3048.141	g
Operation and Maintenance	Street Lighting	Street Lamps	Electricity	13	kWh



Economic Impacts

Analysis Period:
According to our Life Cycle Cost Analysis table, we analyzed the costs based on a 20-year life span.

Findings:
We found that concrete and paint were less expensive when buying and replacing, while the other main items needed for our project were a bit more pricy.

We found street lights to be the most expensive route to go with, although based on our LCA it shows that LED lighting has the 3rd worst effect on the environment which would be worth it in the long run.

In terms of replacement costs, stop signs are the most expensive to replace (per year) both delineator and aluminum combined.

Conclusion:
Our calculations state that the total annual cost would not exceed $1,000 and neither would our construction costs which are the two main issues our city would have to worry about in terms of funding and contracting.

Final Recommendations

Finalized Concept:
All intersections with yield signs will be replaced with either a 2 way or 4 way stops, depending on the intersection. Several 2 way stops will be changed to 4 way stops as well.

Additionally, cross walks, limit lines, and bike lanes will be repainted. Low level LED street lights will also be added to every other street.

Social Implications:
Adding stop signs will slow down traffic and make intersections safer to walk and bike across. Requiring cars to come to a full stop will also help mitigate the dangers of poor cross traffic visibility, without reducing the number of already limited parking spots.

Better lighting will further improve the neighborhood's walkability, and pedestrians and bikers will be more visible to cars.

Repainting the streets is an easy way to uplift the neighborhood's image while also aiding with traffic control.

Conclusion:
Overall, these additions will contribute to a much safer and more vibrant south campus neighborhood.

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South Campus Neighborhood Project

Complete Streets Concepts

Public Works-Engineering
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Prepared by Muhanad Alharbi, Trevor Clark, Drake Landy, Dylan Landy, Ashley Santuyo, Ebba Tadesse, Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

1. Problem Definition: In the South of Campus community there is a low perceived level of safety due to the lack of lighting. The presence of low, thick canopied trees block light from traditional street lamps at night and create blind intersections.
2. The goal of this of project is to determine the environmental, social, and economic impacts the proposed complete street project would have.
3. Scope Definition:
   - A. Function: To provide better lighting and roadway safety.
   - B. Functional Unit: 1 Block (four low lamps, two benches, 1794 ft of road striping paint) *see **Figure 1**.*
   - C. System Boundary: Manufacturing, distribution, construction, O&M, end use
   - D. Inputs: Steel, thermoplastic paint, glass, fuel, electricity
   - E. Outputs: Emissions, light, wastes, energy

Sustainability Metrics

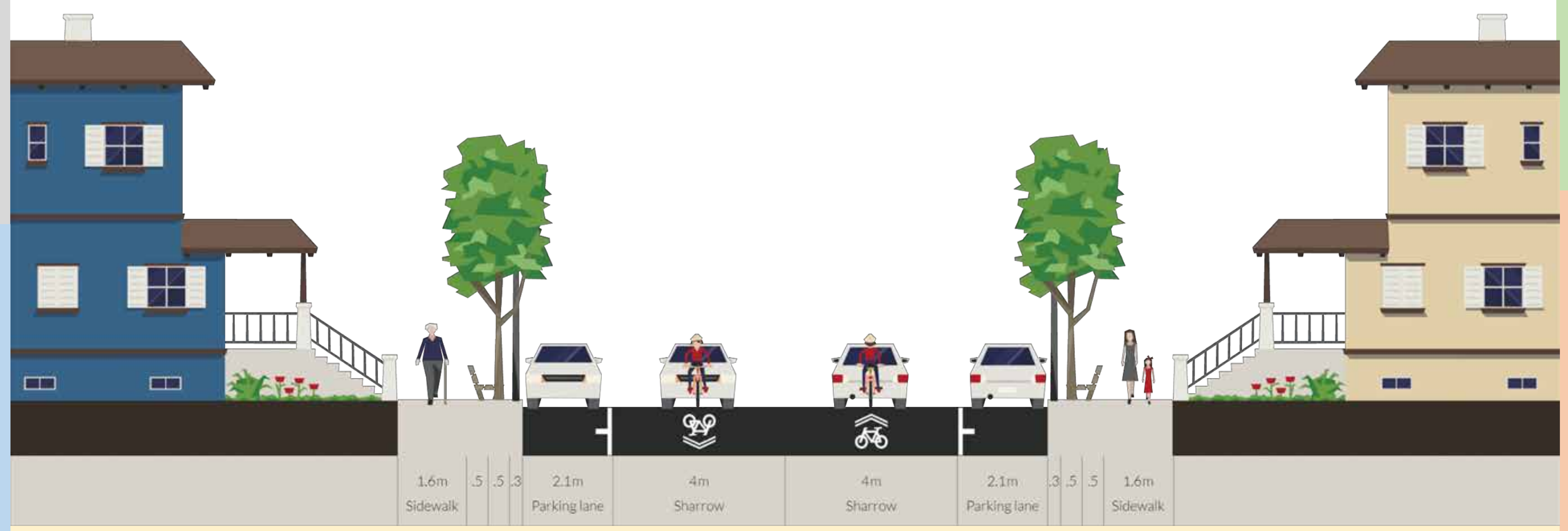
1. Three areas that will be considered to gauge the success or failure of this project would have are: environmental, economic, and social.
2. To determine the environmental impacts of this project due to global warming, the life cycle inventory was entered into a process using SemiPro a LCA focusing on carbon footprint was conducted using the Traci 2.1 method.
3. The upfront cost of materials, annual O&M and electricity costs, and salvage value of material at the end of life were researched and calculated. Series present worth *(P/A,i,n)* and single present worth *(P/F,i,n)* equations were used to bring the future costs back to present worth at a 6% interest rate over 10 years.
4. The social impacts considered were safety, human health, participation.

Hazel at W 7th

1. Intersection at Hazel and W 7th
2. Four light posts on each corner of the intersection with two benches opposite of each other, road layout is shown in the Street Mix View below.
3. Lamp post locations are indicated by blue circles and bench locations by red rectangles.

Figure 1: Functional Unit

Hazel at W 7th



Environmental Impacts

Process	Item	Amount	Units	Cost	Lifespan
Lamp Post	Aluminum	62.28	lbs	$1551.00	10 yr
	Glass	5	lbs		
	LED	1	lbs		
	Electricity	525.6	kWh	$63.07	10 yr
Line Striping	Thermoplastic	75.6	lb	$610	10yr
Park Bench	Aluminum	20	lb	$999	10 yr
	Steel	150	lb		

Table 1: Life Cycle Inventory

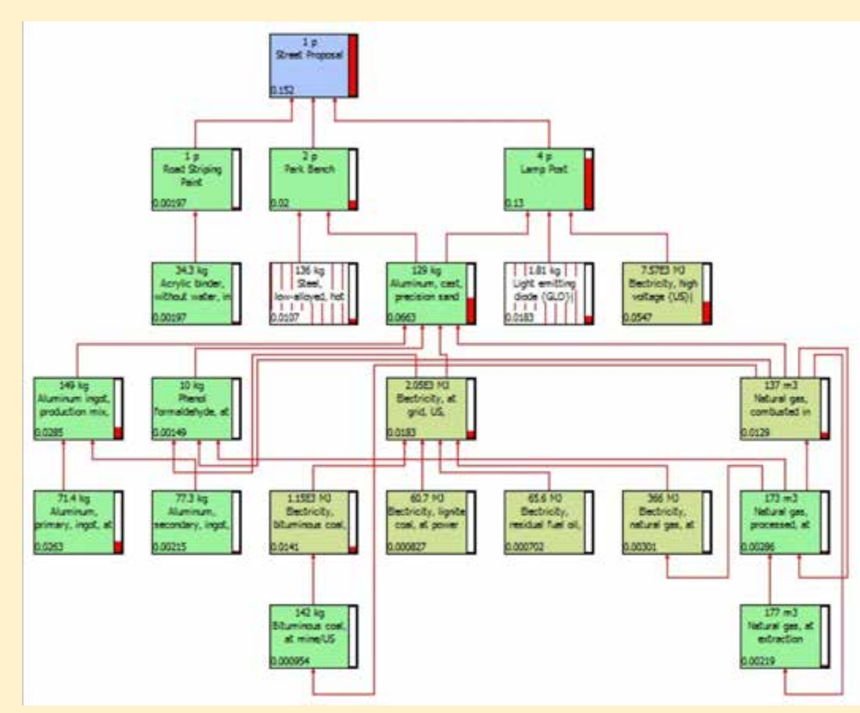
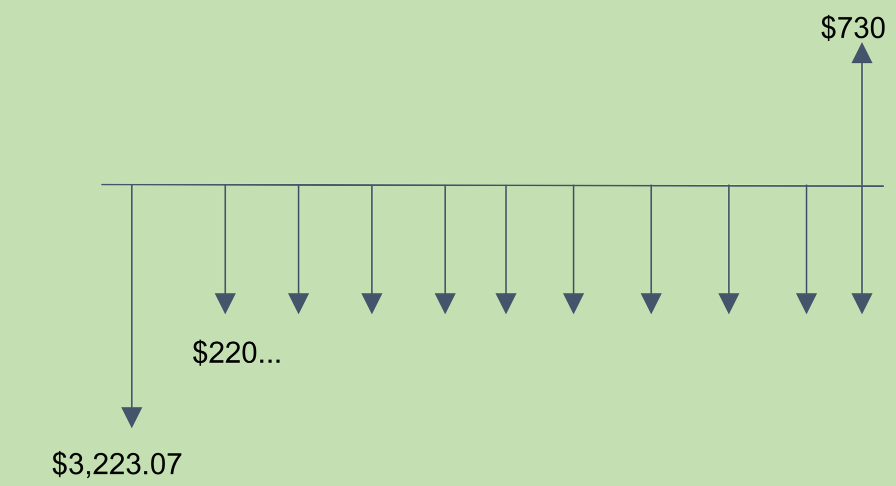


Figure 2: Global Warming with LCA Results

Economic Impacts



- Total upfront cost (lamp post, line stripping, bench) = $3,223.07
- Annual maintenance cost = $220
- Salvage value = $730

Present Worth Benefits
= $730 (P/F, 6%, 10)
=$730 (0.5584)
=$407.63

Present Worth Costs
= $3,223.07 (P/A, 6%, 10)
=$3,223.07+$220 (7.360)
=$4842.27

Present Net Worth = Present Worth Benefits - Present Worth Costs
= $407.63 - $4,842.27
= -$4,434.64

Final Recommendations

This project set out to implement improvements to the flow of traffic, pedestrian safety, and cyclist safety without burdening the environment. With the simple addition of low lamp posts, visibility at night would significantly increase along the sidewalks present at the intersection. By including two benches the need within the community for more public seating areas is addressed and lastly, new road striping would applied to the pavement clearly defining parking boundaries, limit lines, yield indicators, and bike lanes.

According to the LCA conducted, given the included Life Cycle Inventory, the main contributor to the project's carbon footprint is the electricity used by the four LED lamps. In the future these lamps could be replaced with battery powered LED lamps capable of being charged using mounted solar cells where space and sunlight permit use.

Possible social issues that may arise from the project is local resident objection to installing the lights and benches as this could change the aesthetic of the neighborhood. Also residents may not take kindly to having construction delays for the period of time required to install the units, remove and reapply new road striping.

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South Campus Neighborhood Project

Complete Streets Concepts

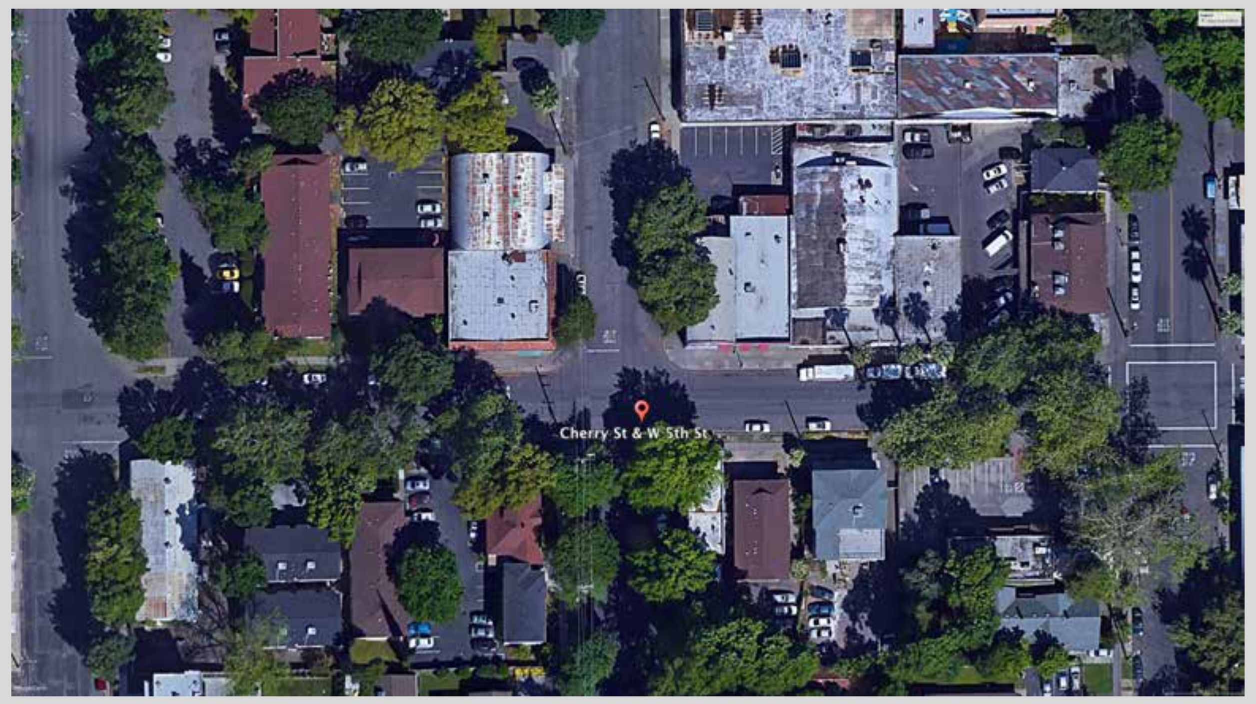
Public Works-Engineering
City of Chico, California

Prepared by Alexander Miller, Brandon Evangelista, Davis Walker, Mohammad Al-Hussein, Oscar Rodriguez, Ramon Huerta, Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

- The goal of our project is to modernize the neighborhood in order to make it safer and more efficient for everyone.
- The boundary condition for our project is 1 square block with the intersection of W 5th & Cherry St.



Sustainability Metrics

- 1 - To assess how these changes would affect the neighborhood we focus on three key sustainability metrics: social, environmental, and economical.
- 2 – Our Triple Bottom Line approach indicates the level of sustainability by measuring the impact of our proposed alternatives including its social, economic and environmental aspects.
- 3 - For environmental, we focused on carbon footprint and conserving water.
- 4 - For economical, we focused on costs and maintenance utilizing Net Present Worth (NPW) to evaluate the feasibility of alternatives.

Present Cost as a function of Series Cost

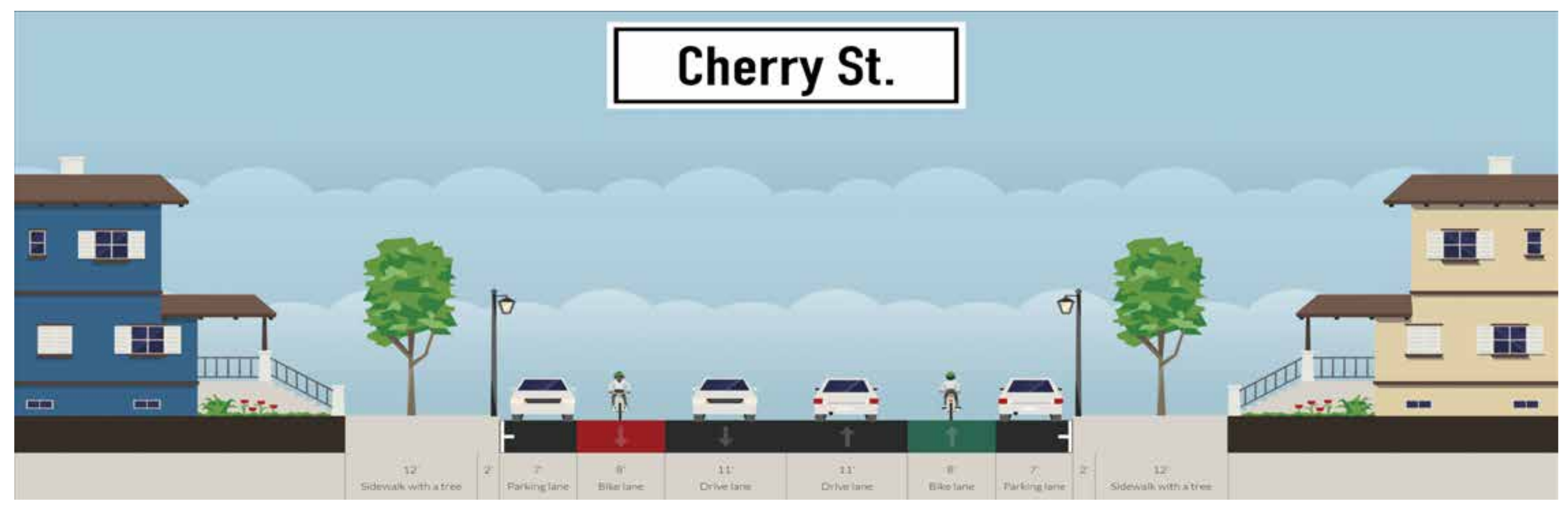
$$P = A \cdot \left[\frac{(1+i)^n - 1}{i \cdot (1+i)^n} \right]$$

5 - For the social metric we focused on pedestrian safety and lowering crime. To increase safety, we proposed street lights to increase visibility at night. We proposed adding bike lanes to increase the safety of bicyclists.

Cherry Street Refinement

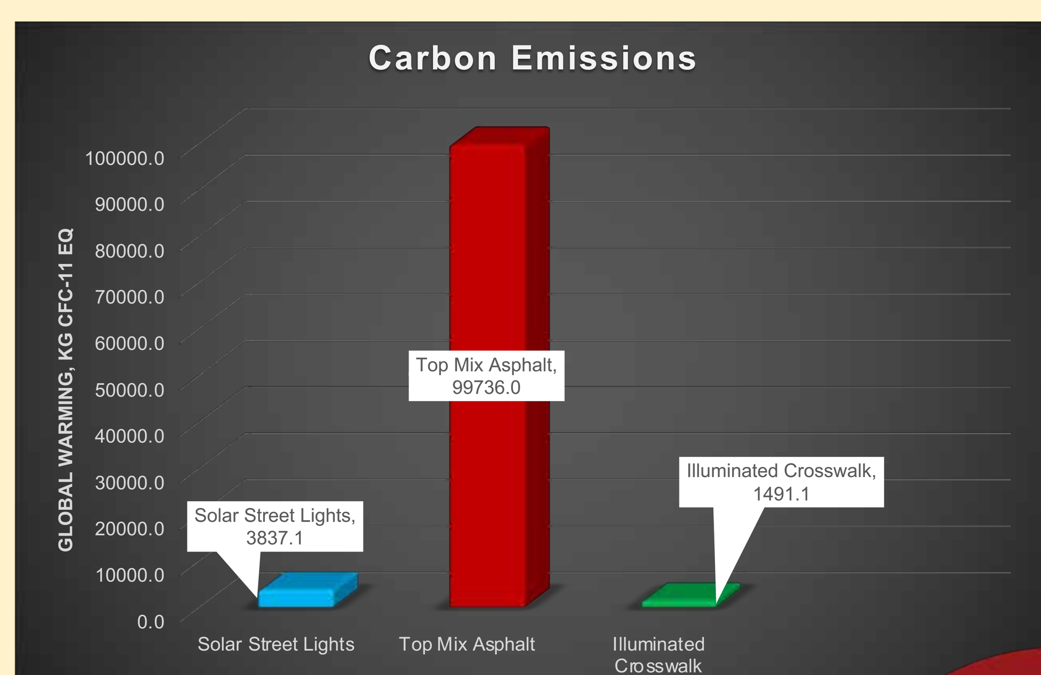
- Cherry Street and West 5th Street in Chico, CA
- Caltrans defines a Complete Street as

  "a transportation facility that is planned, designed, operated, and maintained to provide safe mobility for all users, including bicyclists, pedestrians, transit vehicles, truckers, and motorists, appropriate to the function and context of the facility. Every complete street looks different, according to its context, community preferences, the types of road users, and their needs."
- Key Concepts of Complete Street Design
  - Offer a safe and efficient transportation system.
  - Provide a pleasant environment free of crime.
  - Present a unique living space that community members can take pride in.



Environmental Impacts

- The study method used in our LCA was TRACI 2.1 US 2008. We isolated data regarding global warming to see each alternative's carbon emissions over 20 years.

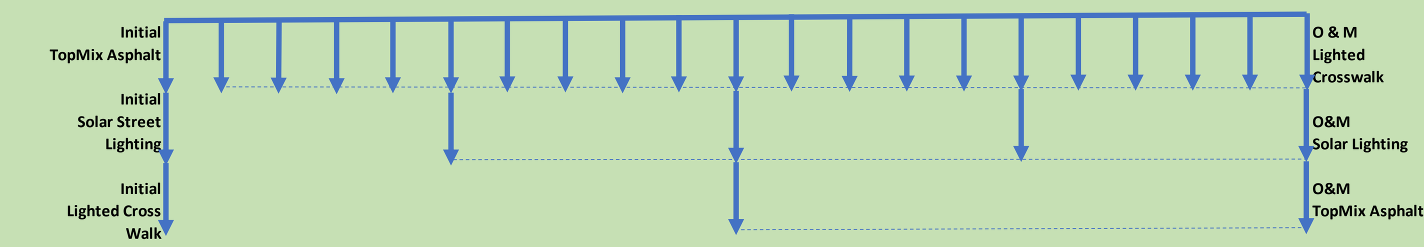


System	Item	Amount	Units	Cost/Unit in dollars	Cost at Installation	Lifespan in Yrs.
Top Mix Asphalt Alternative	Asphalt	159	ton	75	11925	20
	Water	4500	kg	0.04	180	20
	Paint	6.018	lb.	40	240.72	10
	Diesel	1500	kg	2.75	4125	20
	Lightweight Concrete	50	ton	185	9250	20
	Steel, Low alloyed	1.25	ton	1200	1500	20
	Inert Filler (Sand)	12.5	Ton	35	437.50	20
	Geotextile Fabric	82000	sqrt	130	21320	20

System	Item	Amount	Units	Cost/Unit	Cost at Installation	Lifespan in Yrs.
Illuminated Crosswalk	Acrylic	15	gal	23.3	349.50	20
	Rubber based Seal	10	lb.	0.99	9.90	20
	Lumistar VI Lighting fixture	20	Piece	350	15000	10
	Pre-fabricated Button Activation	4	Piece	485	1940	20

System	Item	Amount	Units	Cost/Unit in dollars	Cost at Installation	Lifespan in Yrs.
Solar Street Light	Solar Panel Fixture	4	Piece	1499.99	5999.96	20
	Pole	4	Piece	700	2800	20

Economic Impacts



Proposed Alternative	Estimated Cost
TopMix Asphalt	$207,349.61
Solar Street Light	$30,395.32
Solar Lighted Crosswalk	$47,500.89
TOTAL ESTIMATED COST	**$285,245.82**

- **Less use of costly emergency services due to increased safety.**
- **Diminished energy costs for the city.**
- **Contracting with local construction firms can help stimulate the Chico economy.**
- **Raise Property values of nearby residences.**

Final Recommendations

- The renovations done to the intersection of Cherry and 5th will increase the overall safety of the area, primarily for commuters.
- Pedestrians will have more visibility at night with strategically placed solar powered overhead lights and lighted crosswalks. This would help to increase safety and reduce energy consumption.
- Bike lane markings will provide a safe, clear path for bicyclists to stay on and the bright markings will deter vehicle traffic.

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South Campus Neighborhood Project

Complete Streets Concepts

Public Works-Engineering
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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

1. Problem Definition

South campus neighborhood is old and outdated

- Street lighting is either blocked by trees or is not adequate
- Streets are in bad condition and not safe for users
- Trees are damaging streets and some streets have sparse trees

1. Define Goal and Scope
- Goal: Create an updated neighborhood that is safer and more environmentally friendly
- Scope:

Function: Create a complete street on one block/intersection in the neighborhood

Functional Unit: Calculate the amount of carbon dioxide emitted by one block over 20 years.

System Boundary: One intersection and bike lanes, sidewalks, lights, and plants/trees on both sides

Sustainability Metrics

1. To evaluate the sustainability of our designs, we used the triple bottom line approach, evaluating key environmental, social, and economic metrics.

- *Environmental*: Using low power LED lights combined with solar-generated electricity will lower the total CO_2 emissions from running the lights.
- *Social*: The installation of improved lighting and safer, more visible bike lanes in the neighborhood should reduce accident and crime rates
- *Economic*: The use of solar panels, along with the possibility of having local businesses help pay for them in order to share some of the power generated, will save money from having to pay for electricity to run the lighting.

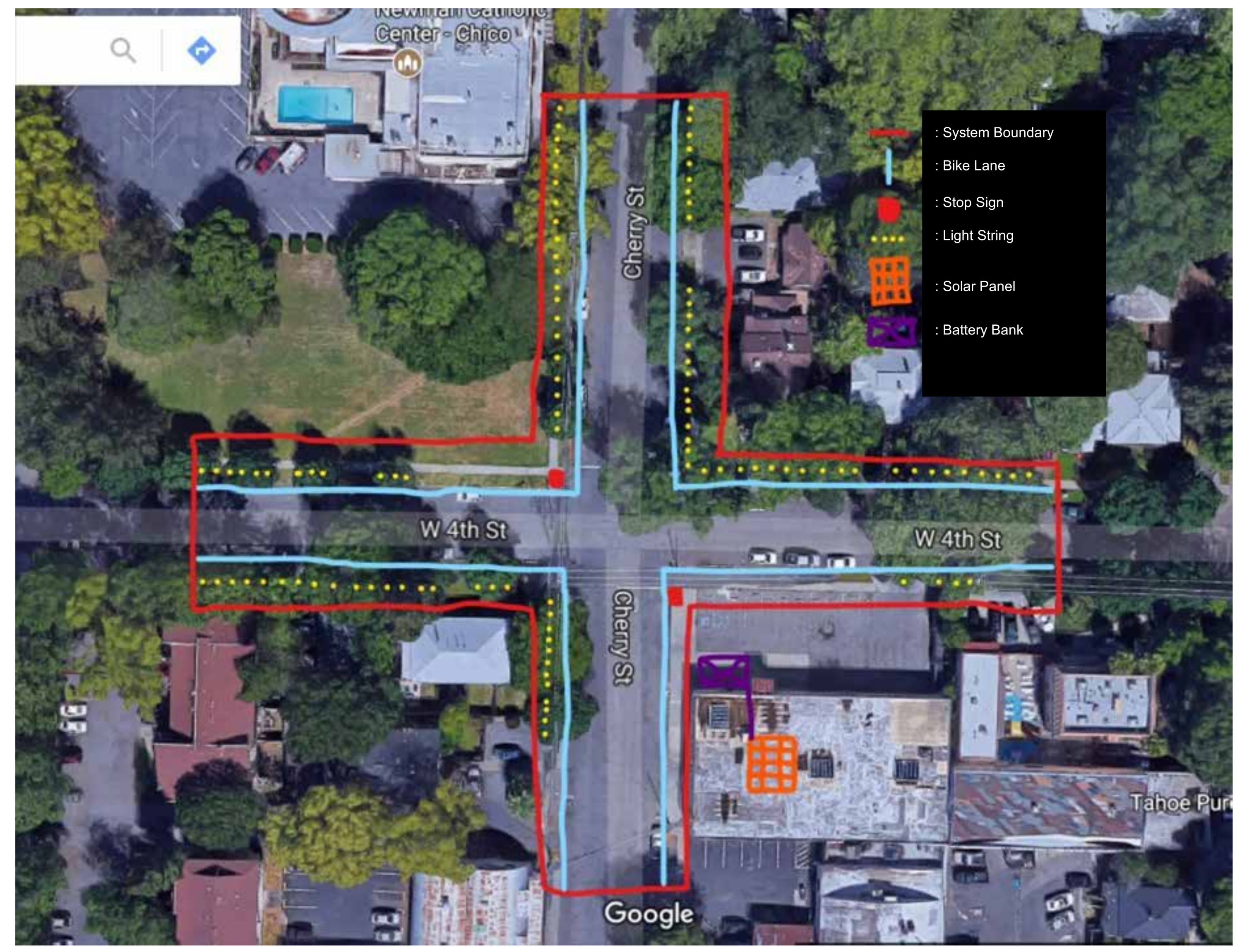
1. To evaluate our environmental impacts, we did a Life Cycle Assessment (LCA) using the program SimaPro, the results of which can be seen in the Environmental Impacts section.
2. For our social impacts, we considered safety in the neighborhood the main priority, as we want people to not only be safe, but also feel safe.
3. To evaluate our economic impacts, we compiled cost data for the materials needed for our design, and calculated the Net Present Worth (NPW) of each of our alternatives, the results of which can be seen in the Economic Impacts section.

South Campus Improvement Project

Intersection: 4th & Cherry Street

The concept of a complete street is a street designed that is designed for safe use and access by all users, from pedestrians to motorists which include aspects like:

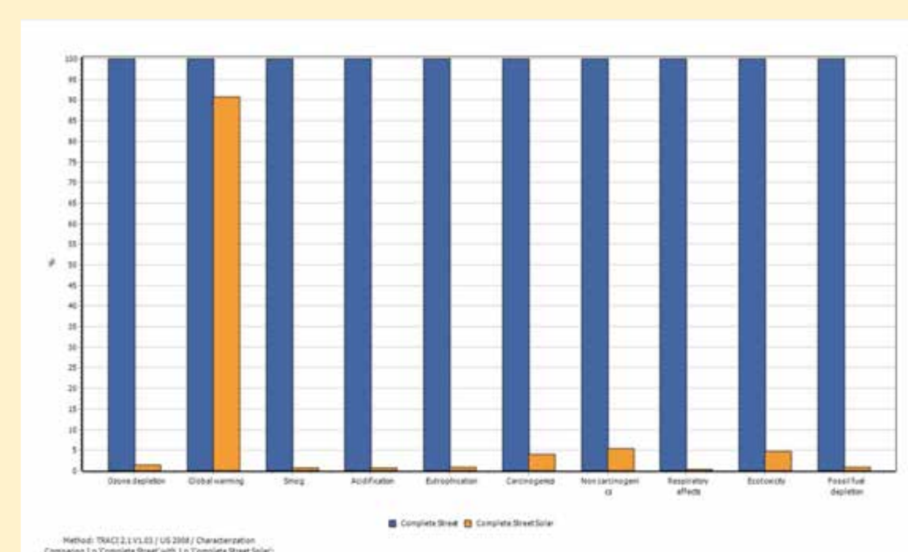
- Alternative 1:
  - Repainting streets
  - New stop signs
  - Rumbles strips to separate bike lane from vehicle lane
  - LED lights strings around trees
  - Planting of additional trees if needed
  - Solar panels to power lights
- Alternative 2:
  - Repainting streets
  - New stop signs
  - Rumbles strips to separate bike lane from vehicle lane
  - LED lights strings around trees
  - Planting of additional trees if needed
  - Grid electricity to power lights



Environmental Impacts

1. The inventory data used to evaluate the environmental impacts is included in the table in the economic impacts section.
2. The graph to the right compares the environmental impacts in various categories of each of our alternatives.

- Clearly our first alternative, the use of solar panels to generate electricity, has less of on impact on the environment when compared to using traditional grid electricity.



Economic Impacts

1. To compare the economic impacts of our alternatives, we calculated the Net Present Worth of each.

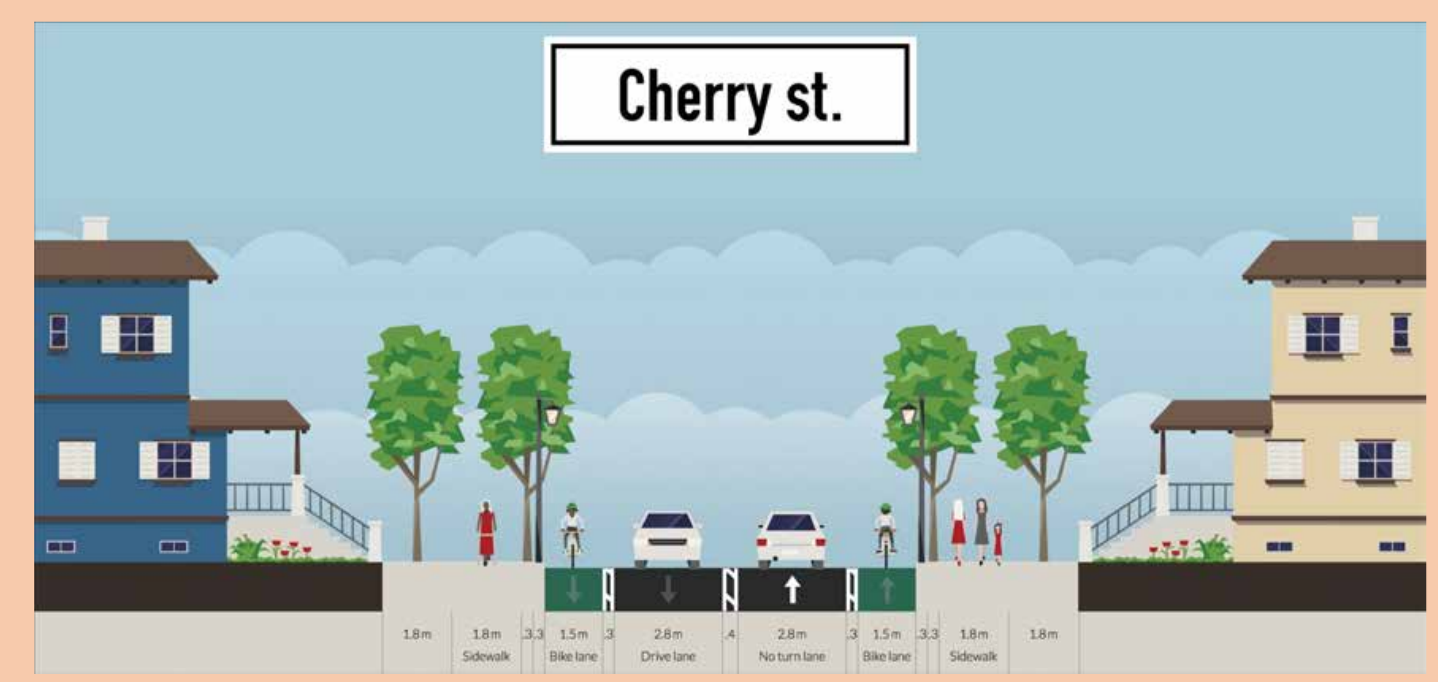
- *Alternative 1*: NPW = PWb - PWc = \$0 - \$15,900.00 = -\$15,900.00
- *Alternative 2*: NPW = PWb - PWc = \$0 - \$15,904.80 = -\$15,900.80

	Alternative 1				Alternative 2			
LCI	Item	amount	units	Cost	Item	amount	units	Cost
construction	led lights (strand)	600	linear ft	$ 600.00	led lights (strand)	600	linear ft	$ 600.00
	street paint	4	gallons	$ 200.00	street paint	4	gallons	$ 200.00
	concrete	100	yd^3	$ 10,000.00	concrete	100	yd^3	$ 10,000.00
	dirt	10	yd^3	$ 300.00	dirt	10	yd^3	$ 300.00
	oak tree	2	amount	$ 200.00	oak tree	2	amount	$ 200.00
	solar panels	3	amount	$ 200.00	solar panels	0	amount	$ -
	battery	12	amount	$ 1,000.00	battery	0	amount	$ -
operation/ maintenance	system maintenance	20	years	$ 3,400.00	system maintenance	20	years	$ 400.00
	eletricity	21024	kw/h	$ -	eletricity	21024	kw/h	$ 4,204.80
	truck transport	20	tkm	$ -	truck transport	20	tkm	$ -
	Co2 to air	150.95	metric tons	$ -	Co2 to air	150.95	metric tons	$ -
Total Cost:				$ 15,900.00				$ 15,904.80
Net Present Worth:				$(15,900.00)				$(15,904.80)

Final Recommendations

1. For our project, we have two alternatives that, while they both have the same street design, rely on different power sources: one with solar power, the other from the local power grid. Based on our analysis, we think that the solar alternative is the best way to go.
2. Discuss social implications of your design

With the solar alternative, we can incite local businesses to set up solar panels to power the lights.



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South Campus Neighborhood Project

Complete Streets Concepts

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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Public Works-Engineering
City of Chico, California

Project Goals & Scope

The goal is to promote a sustainable design that helps understand the importance of our environment. The city of Chico has partnered with the Civil Engineering 302: Engineering Risk & Economic Analysis class to produce a complete street prototype. It will use sustainable methods to re-design the downtown area. The prototype plans focuses on correcting three main issues with the current roads: traffic and safety, flooding, and pollution.

- Traffic and safety will be viewed as one problem. The current system has a serious lack of parking, and no protection for bike lanes that causes traffic to slow and build up.
- Flooding during the winter in downtown is horrible. Cars park in full gutters and people must step out into small ponds. This significantly impacts bikes as well, because they are not boats.
- The final issue of Chico's streets is pollution. The oil on roads leaks into the green spaces or out in the gutters and pollutes the environment.

Sustainability Metrics

- The triple bottom line approach was used throughout our analysis. This framework takes environmental, social, and economic factors all into consideration for the most optimal design.
  - Environmental Metrics: Flooding, Carbon Footprint
  - Social Metrics: Urban Forest, Safer Walking/Driving Conditions
  - Economic Metrics: Less Material, Low Power Use
- A Life Cycle Analysis (LCA) program, Sima Pro, was used to compare the environmental impacts of our proposed design. The four main criteria used for comparison were Equivalent Eutrophication, Equivalent Fossil Fuel Depletion, Equivalent Global Warming, and Equivalent Ozone Depletion.
- Porous Asphalt
  - P = [165350 + 400(P/A, 6%, 30) + 165350(P/F, 6%, 15)] = $239,856
- Conventional Asphalt
  - P = [109000 + 250(P/A, 6%, 30) + 3333(P/A, 6%, 30) + 16.7(P/A, 6%, 30) + 3125(P/F, 6%, 30) + 32000(P/F, 6%, 30)] = $173,206

Porous Asphalt and Divided Roadway

- A complete street design is meant to provide safe mobility for all users, which encompasses bicyclists, pedestrians, passenger cars, truckers, and motorists.
- Main components of our design
  - Porous asphalt roadway design
  - Dedicated bike lanes with short dividers
  - Lighting fixtures on dividers to promote safety

Environmental Impacts

Economic Impacts

Processes	Project	Ingredients	Details	Amount/Qty	Unit	Weight (lbs)	Cost [$]
Construction	Roads	Porous Asphalt	Type 4 sand (Silica)	74.87	m^3	262028	$3,369
			#9 Binder	156.00	m^3	624002	$93,600
			#5 Base	233.95	m^3	1199642	$4,585
			42-A Rock Mix	467.91	m^3	1820940	$30,956
		Road Paint	Paint	0.04	m^3	140	$245
		Reflectors	Reflective Plastic	0.11	m^3	312	$294
		Street Signs	Galv Aluminum	0.00	m^3	28	$135
	Lighting	Street Poles	Galv Steel	9.60	m^3	170371	$3,200
		100 Watt LED Bulbs	Glass (13%)	299.60	grams	1	$640
			Aluminum (44.7%)	1033.20	grams	2	^
			Acrylic, polycarbonate (13.1%)	302.40	grams	1	^
	Sidewalk	Concrete (CEM III/B)	Portland Cement (PC)	124.04	m^3	2190300	$52,926
			Blast Surface Slag (GGBS)	289.44	m^3	Above is total for both	^
	Green Space	Benches (Q = 2)	Quickrete 5000 Mix	0.56	m^3	84	$72
			rebar	0.00	m^3	6	$5
Operations	Transportation	NA	NA	213092.16	t*mi	NA	
	Electricity	Electricity, At Grid	For 10 Years	350400.00	kWh	NA	$35,040
					Totals:	**6.27E+06**	**$225,068**

Final Recommendations

- The final conceptual design that we would recommend for the south of campus area focuses on safety, lighting, pollution and the urban forest. Safety is increased in our street design by implementing a bicycle divide and moving the light poles off of the sidewalk and onto to the bicycle divide. This move will allow for the lighting to be lower than the urban forest crown which will let the light propagate more effectively to the road and bike lanes where it is needed. To help reduce pollution and flooding in the area we decided that we would have permeable pavement that keeps pollutants in place, captures heavy metals and recharges ground water more effectively.
- The added safety features in our complete street design would also have improved social implications. We believe that our lighting system would help deter theft and encourage walking and bicycling. The added ground water from the porous road would also help to promote healthy trees and reduce the risk of having standing dead trees in that area.

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South Campus Neighborhood Project

Complete Streets Concepts

Resilient Cities Initiative
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Public Works-Engineering
City of Chico, California

Prepared by Bryna Frace, Michael Mekuria, Noah Macias, Kathryne Tetreault, Anis Barchini, Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

Suggested alternatives to the problems involved with the south side of Chico.

Problem Definition

5th and Cherry Street is near Chico State University and is commonly used by cars, bikes, and pedestrians Being right next to the Recreation Center and a parking structure the street is a popular route for the Chico Community; improvements should be made. Improvements include: lighting, traffic safety at intersections, creating space for bikers, and add to green spaces.

Goal and Scope

The goal is to increase safety, reduce environmental impacts, and improve aesthetics for the scope of 5th and Cherry Street.

Sustainability Metrics

We used the Triple Bottom Line approach to create key sustainability metrics for environmental, social, and economic.

Key Metrics:

Environmental: Energy, Carbon Emissions, and Pollutants from runoff

Social: Sense of Safety, Sense of Community, and Aesthetics

Economic: Net Present Worth

- The main environmental impacts of the project involve the initial costs of construction and maintenance. This data was collected in the inventory section of research.
- Using the inventory table and the lifespan of 25 years, the Net Present Worth was calculated by summing the data of each recommendation.
- Social Impacts define below:
  - **Sense of Community**: Design a street where people want to be outside and be involved
  - **Sense of Safety:** Design a street where people feel safer
  - **Aesthetics**: Design a street to be visually appealing.

5th and Cherry Street Design

The scope of the Complete Street Design is the intersection of 5th and Cherry approximately 20 ft out in all directions. We came up with six recommendations to increase traffic safety, Lighting, and Aesthetics of the street. The recommendations include: Solar Street Lighting, LED Parking Meters, Natural Drainage Landscaping, Convex Mirrors, Sensor and Lights, and Bike Lanes.

***Figure 1**: System Boundary and Overview of 5th and Cherry St.*

Environmental Impacts

Problem	Alternatives Considered	Function	Functional Unit	Key Inputs	Key Outputs	Environmental Impacts Assessed
Lighting and Safety	Tall Solar Street Lights	Providing a well-lit community after dark	12 lights/ intersection/25 years	Aluminum, Silicon, Glass	Light	kg CO2eq/ intersection/ 25 years
	Parking Meter with LED Fixture	Provide lighting and parking	24 meters/ intersection/ 25 years	Aluminum, Plastic, LED, Ceramic	Lighting and Profit	kg CO2eq/ intersection/ 25 years
Traffic and Safety	Traffic Sensors	Provide safety on intersectioons	2 Traffic Sensors/ intersection/ 25 years	Li-ion Battery, Glass, Silicon, Solar Glass	Safety	kg CO2eq/ intersection/ 25 years
	Mirrors	Provide safety at intersections	8 mirrors / intersection/ 25 years	Stainless Steel, Aluminum	Safety	kg CO2eq/ intersection/ 25 years
	Bike Lanes	Provide safe commute for bikers	30,360 square feet/25 years	Asphalt, Paint	Safety	kg CO2eq/ intersection/ 25 years
Green Spaces	Natural Drainage Landscaping	To treat wastewaster at the source	Total volume of 2400 cuft / intersection / 25 years	Concrete, Structural Soil, Mulch, Native Plants	Natural Drainage Landscape	Pollutants to drain/ intersection/ 25 years

***Figure 2:** LCA Table of Functional Alternatives*

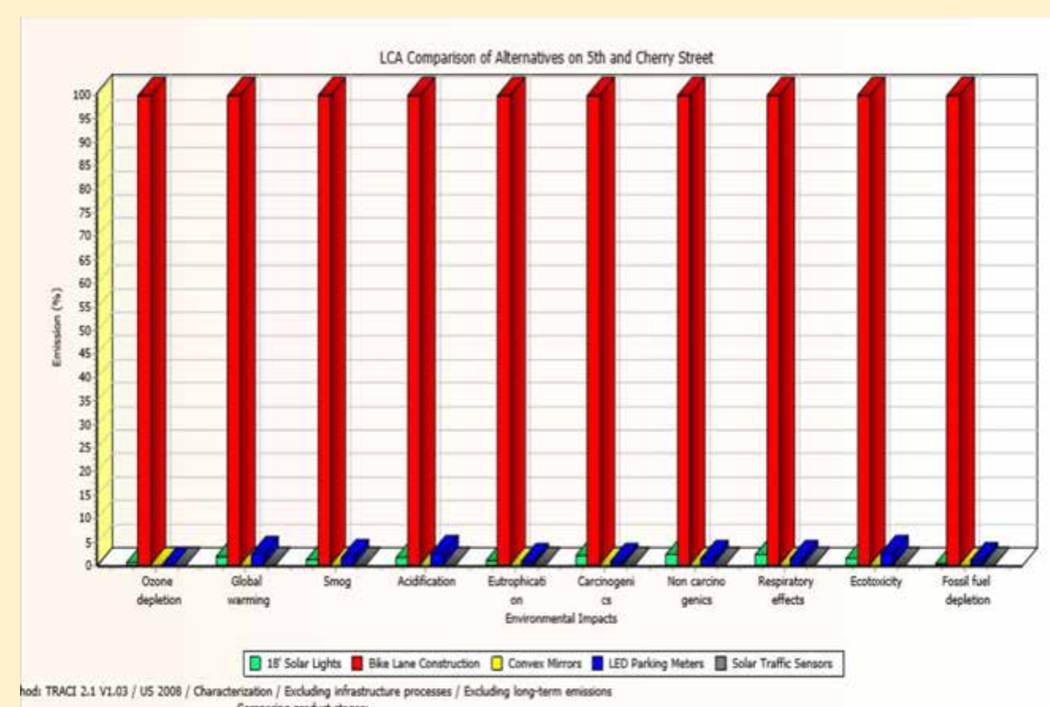


***Figure 3:** LCA Comparison of Environmental Impacts from the six alternatives*

Economic Impacts

Results of economic analysis.

- *Solar Street Lights:* **$32,829**
- *LED Parking Meters*: **-$2,939**
- *Green Spaces*: **$74,513**
- *Traffic Sensors and Mirrors*:**$750**
- *Bike Lanes*: **$201,527**

TOTAL: $306,679

Life Cycle Cost Analysis

	Tall Street Lights	Parking Street Lights	Bike Lanes w Repavement	Sensors	Mirrors	Bioswale	TOTAL
Initial Cost	$ 18,516.00	$ 3,809.73	$ 174,333.78	$ 302.00	$ 260.00	$ 68,656.00	$ 265,877.51
Replacement Cost	$ 18,516.00	$ 1,301.76	$ 2,344.39	$ 42.97	$ 200.00	$ -	-
Annual Revenue	$ -	$ 401.50	$ -	$ -	$ -	$ -	$ 401.50
Annual O&M Cost	$ -	$ -	$ 1,300.00	$ -	$ -	$ 300.00	$ 1,600.00
Lifetime	13	9	13	13	13	25	
TOTAL NPW	$ 32,829.47	$ (2,939.68)	$ 201,526.56	$ 335.22	$ 414.61	$ 74,513.04	$ 306,679.21

***Figure 4:** Life Cycle Costs Analysis for a 25 year life span.*

Final Recommendations

5A. Solar Street Lighting

Tall solar street lights by Sunna Design will provide lighting at no cost due to its efficiency.
**Image from Sunna Design Co.*

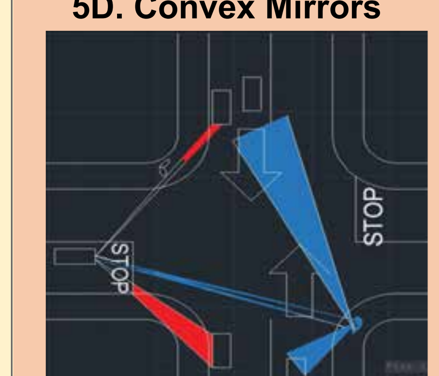
5B. LED Parking Meter

Modification to the current Parking Meter design with a lighting fixture installed on top.
**Lighting Fixture designed by Kathryne Tetreault*

5C. Natural Drainage Landscaping

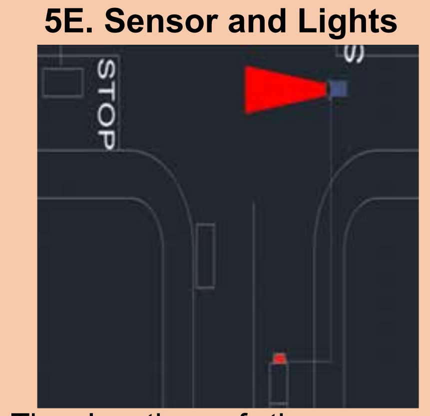
Natural Drainage Landscape design goal is to increase the permeability of the landscape and increase aesthetics of Cherry Street.
**Original photo and design by Bryna Frace.*

5D. Convex Mirrors



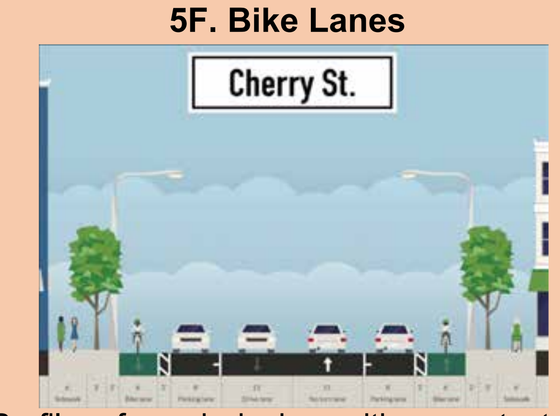
The best location of the mirrors, and how they would help to prevent accident.
**Convex Mirror drawing designed by Anis Barchini.*

5E. Sensor and Lights



The location of the sensor and the light and how they would work.
**Sensor and Lights designed by Anis Barchini.*

5F. Bike Lanes



Profile of road design with a protected bike lane. Not pictured is the 2 feet buffers will be lined with delineator posts every 20 feet.
**Image produced through streetmix.net.*

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South Campus Neighborhood Project

Complete Streets Concepts

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Public Works-Engineering
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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Project Goals & Scope

1. The purpose of this project is to implement complete street principles focusing on the south campus neighborhood. More specifically creating safe bike lanes, parking, lighting, and overall street improvements.
2. Problem Definition: Area is not safe for drivers or pedestrians, and the urban Forest needs to be maintained and edited for sustainability purposes.
3. Goal and Scope: To consider the different methods of rebuilding the neighborhood in order to make the neighborhood a safer, more sustainable area for all stakeholders.

Sustainability Metrics

1. Using the triple bottom line approach we accounted for the social, economic, and environmental metrics. For example safety of all stakeholders, affordable building materials, and low carbon emissions.
2. We used the SimaPro database to calculate the carbon footprint of all materials used.
3. To calculate the economic impact we used the Future Worth, given Present Cost, equation: F = P(F/P,i,n)
4. For the social criteria of our project we considered the safety of the area, accessibility for all motorists and pedestrians.

Complete Street Concept Design

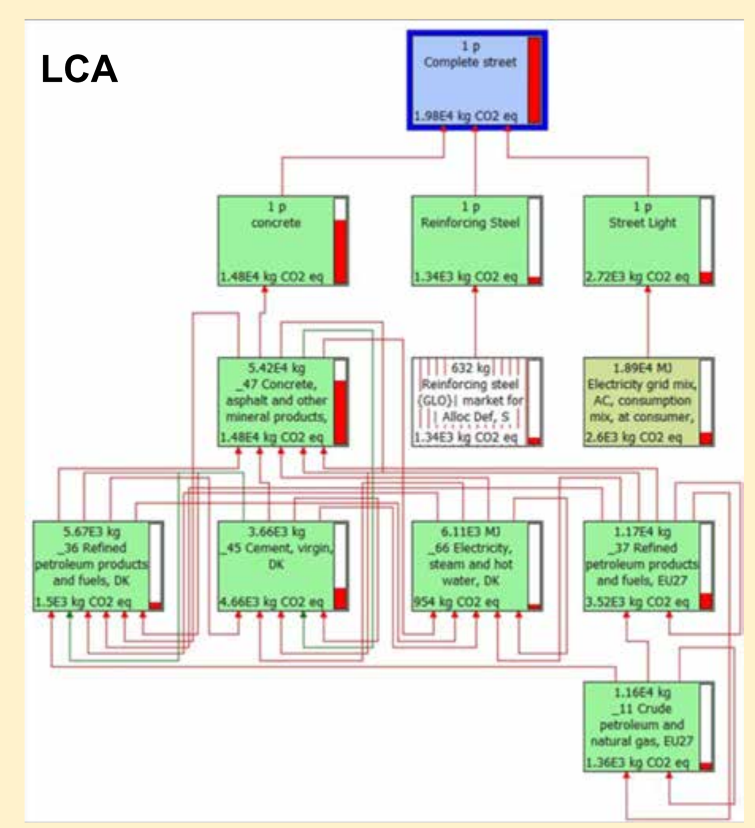
1. We considered a system boundary of Hazel St between 6th St and 7th St, including one intersection.
2. In our project we used the CalTrans Complete Street design template as our main reference.
3. Our complete street concept includes inserting bike lanes, removing yield signs and replacing them with stop signs, environmentally friendly street lights, visible road striping, and enhanced parking.
4. Below is a street view and an overhead view of our conceptual design highlighting some of our key changes to the existing street:

1. Key components of our Complete Street Design include narrowing the green space in some areas to create more room for parking and bike lanes, enhancing street striping, and implementing cost effective street lights. Our sleek curb design weaving around existing trees will minimize maintenance costs and create a sharp appearance to the complete street.

Environmental Impacts

LCCA

Item	Amount	Unit	Unit Cost (Per Unit)	Lifespan(Years)
Concrete	26.00	yd^3	$ 90.00	20
Reinforcing Steel	1,393.60	lbs	$ 1.12	20
Mastic Asphalt	5.23	tons	$ 79.92	20
Street Lights	8.00	lights	$ 1,551.00	20
Paint	4.00	Gal	$ 39.94	20
Electricity	42,048.00	kWh	$ 0.12	20
		Total Cost	$ 21,932.09	



Economic Impacts

To find how cost effective our chosen alternative is we used the Future Worth Given Present Cost shown below. This equation helps us calculate the compound amount after a number of years (20 in our case). This value is a good indication on how feasible this alternative is from an economic standpoint.

For the calculations we know the present cost of the materials we will use, we also know the number of years we need to account for. Finally since we cannot say the exact interest rate of future years, we assumed a 6% interest rate to help us accurately come up with a future value.

$$F = P(1+i)^n$$

$$i = 6\%$$

$$n = 20$$

$$P = 21{,}932.09$$

$$F = \$21{,}932.09(1+.06)^{20}$$

$$F = \$70{,}339.18$$

Final Recommendations

1. After due consideration, we have determined that it is within the community's best interest to improve the existing traffic pattern into a sustainable environment for motorists and pedestrians alike.
2. Socially, our design will make the South Campus Neighborhood easily navigated for homeowners, business owners, students, and members of the community. This will help eliminate accidents, crime, and create a more desirable place to live and will lead to a stronger sense of community.
3. Another social advantage of using the materials we are proposing, is that it will show how environmentally friendly alternatives usually cost more upfront. However due to the energy saving capabilities of these materials we lower the total cost over a 20 year period. Therefore alerting and educating the community of the advantages of these materials. Hence creating the foundation of a "Green Community".

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South Campus Neighborhood Project

Complete Streets Concepts

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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

Public Works-Engineering
City of Chico, California

Project Goals & Scope

- How to make streets more friendly for pedestrians without being detrimental to vehicular traffic flow or safety.
- The goal is to maintain or increase the traffic flow while also increasing the ease of pedestrian crossings at these streets:
  - a) Highway 32, known as 8th and 9th Street.
  - b) Cross-section Between Salem and Orange St.

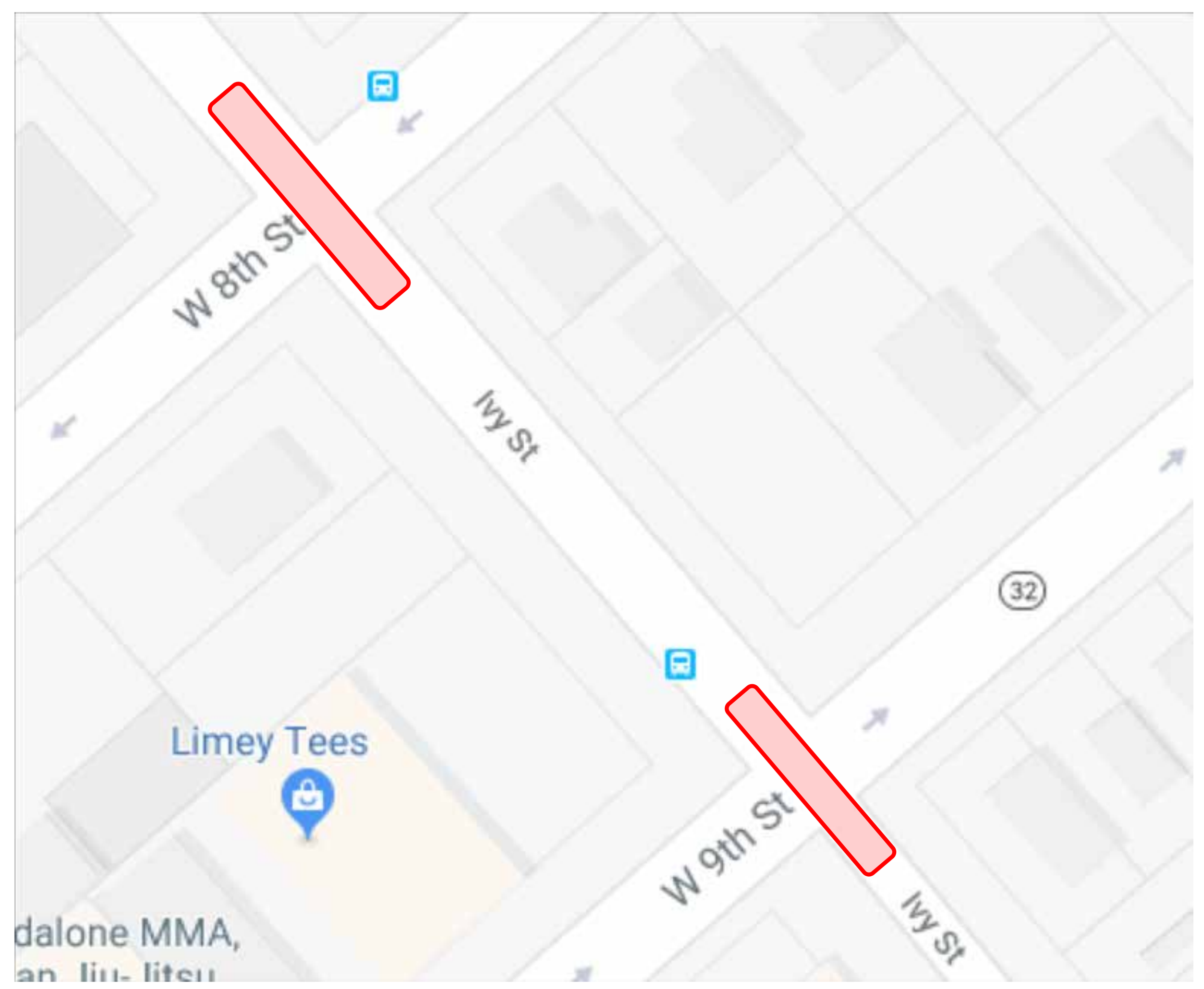
Sustainability Metrics

- **Environmental metrics**: Where we look into material of the initial build, construction, maintenance and repair of the bridge
- **Economic metrics:** Where our life cycle cost will be analyzed through construction, operations, modifications, maintenance, and deconstruction of the bridge.
- **Social Metrics:** Will include pedestrian friendly attributes such as energy efficient lamps for good lighting at night, open space to be visible from all angles, and include home-like features such as local art to add Chico character to the bridge.

1. We used SimaPro TRACI analysis to determine the environmental impact of our project
2. To evaluate the Economic Impact of the proposed project, we used Net Present Worth. This economic metric was chosen as to have every cost during the bridge's long lifespan accounted for and easily understood in terms of the present day value of the United States Dollar.
3. We take into consideration lives saved, accidents avoided from less street pedestrian traffic, pedestrian and driver wait times, and traffic flow.

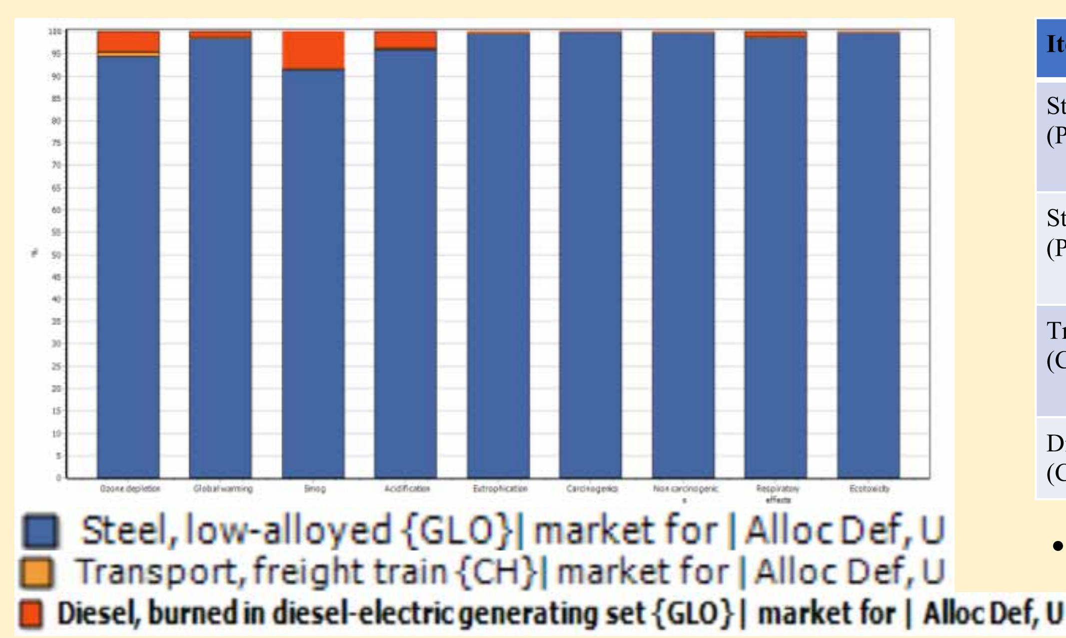
Pedestrian Bridge

1. CA Highway 32 (8th &9th St.) and Ivy St.
2. Describe the complete street concept
3. The complete street concept is a pedestrian overpass between the boundaries discussed. This boundary was determined by the highest traffic points for both vehicular and foot traffic. LCA analysis and Preliminary Economic Analysis will be used to determine the feasibility of this project.
4. Highlighted streets and concepts:



Proposed Location of Bridge

Environmental Impacts



Item	Amount	Units	Cost	Lifespan	Source
Steel (Production)	120	ft^3	$147,000	50 years	Metalset Inc. Bay Area Fabrication
Steel Railing (Production)	30	ft^3	$300	50 Years	Metalset Inc. Bay Area Fabrication
Transportation (Construction)	283	km	NA	NA	Metalset Inc. Bay Area Fabrication
Diesel (Construction)	50	gal	$175	NA	NA

- Highest % environmental impact: Steel production

Economic Impacts

1. The economic cost of this project is minuscule when analyzed with the number times it would be used by residents.
2. The initial cost is estimated to $219,812.81 with a total maintenance cost of $238,434.06 in current USD over the bridge's 50 year lifespan. Thus the estimated total project cost is $458,246.87
3. The estimated number of times that intersection is crossed per day is 375. Over the lifespan of the bridge, it is estimated to be used 47,949,200 times.
4. Using the two figures above, the total cost per use can be calculated by dividing the total cost by the estimated number of uses of its lifetime.

Cost Per Use: $0.0095

For less than a penny, a student can cross

the most dangerous intersection in Chico Safely!

Final Recommendations

1. Our recommendation is to buy two pre-manufactured steel bridges to increase the flow of traffic for 8th and 9th St while increasing pedestrian safety on Ivy.
2. Based on a 2012 report done by the city of Chico for the top 100 most dangerous intersections Ivy St & W 8th St was rated the most dangerous intersection, we took this into consideration and feel that a pedestrian bridge would be the most effective way to increase pedestrian safety

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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

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Project Goals & Scope

1. In this project, we are to completely re-design not only an intersection, but also half of the adjoining streets to that intersection. This intersection must be contained within the boundaries of 2nd street to 8th street and Orange to Salem.
2. The issue within the south campus neighborhood is that there are problems with safety due to poor lighting and cracked sidewalks. Not only that, but more issues with safety arise from the lack of consistency of stop/yield signage, street parking, bike lanes, and crosswalks, all of which make this area unsafe both day and night.
3. We are looking to improve the street lighting and the warped and cracked sidewalks that haunt the downtown area, as well as make traffic and pedestrian safety a number one concern by incorporating clear signage at downtown intersections, and reducing the trash that litters the sides of the street.

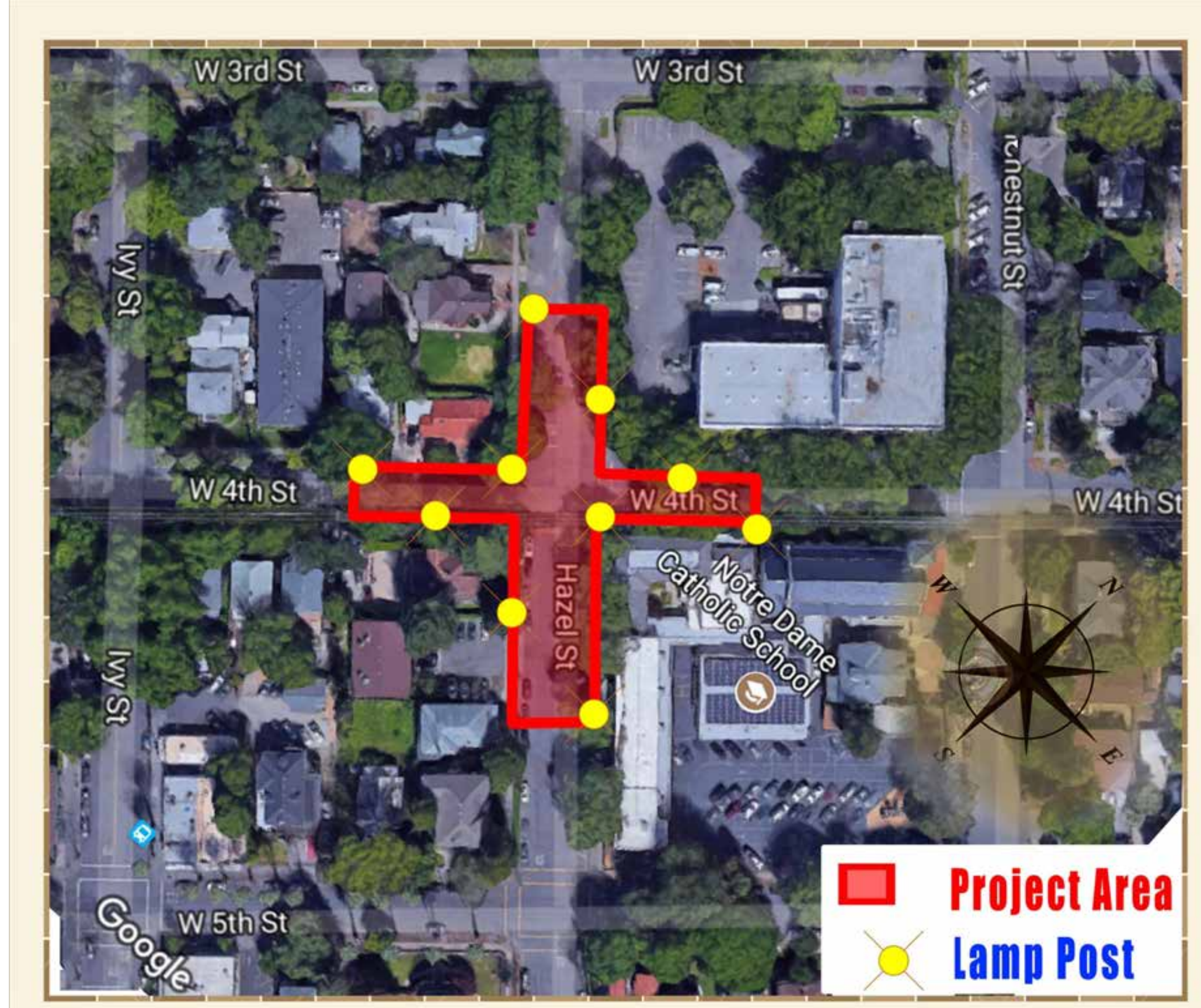
Sustainability Metrics

1. Environmental Metrics: Maximize air quality, water quality and minimize ecological impact.
   a. We chose to minimize the impact on the local green spaces to preserve the historic features of downtown.
1. Social Metrics: Safety of pedestrians.
   a. By improving the lighting, widening the bike lanes and clearly marking intersections pedestrians will have a safer commute which will encourage environmentally friendly means of transportation.

1. Economic Impacts: Minimize maintenance costs to the city.
   a. A stronger sense of community will encourage residents to maintain their property and surrounding areas.

Project Hazel

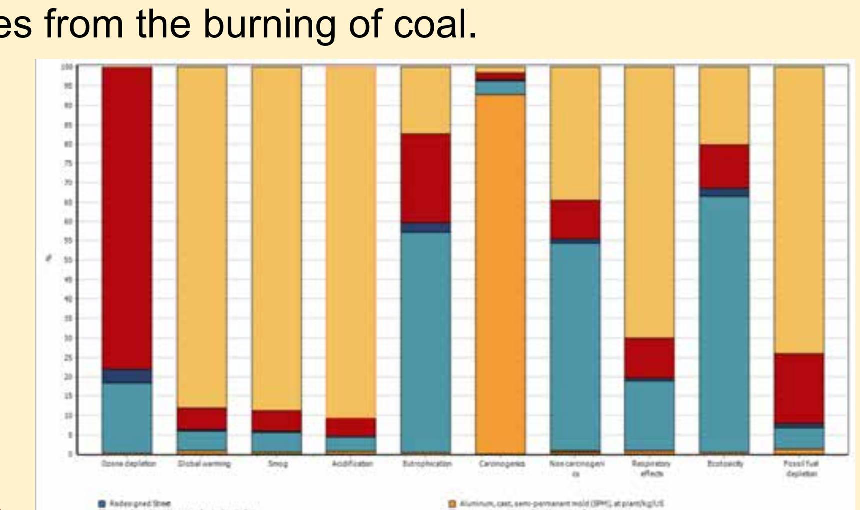
1. Intersection of 4th and Hazel
2. Our complete street concept involves moving the bike lanes up next to the sidewalks and using parked cars as a barrier between drivers and bicyclists to create a safer road for bicyclists.
3. Lighting is also vastly improved by increasing the number of street lights at each intersection on Hazel St.



Environmental Impacts

1. We calculated the environmental impacts of the Construction and Operation of our proposed concept for a 20 year lifetime.
2. Our LCA shows that the electricity used by our project would be the leading contributor to global warming and fossil fuel depletion due to the fact that a lot of our electrical power comes from the burning of coal.

Life Cycle Stage		Item	Amount	Unit
Construction	Lighting	Cast Aluminum	252	lbs
		Glass Fibre	56	lbs
		LEDs	52.8	lbs
		Copper Wire	4.5	lbs
	New Road	Asphalt	60,000	lbs
		Electrostatic Paint	34	gal
Operation	Power	Electricity US Grid	157,680	kWh



Economic Impacts

1. Show results of economic analysis

Cost Calculation

Length of Analysis: 20 years

Alternatives	Details	Quantity	Unit Cost	Operations	Lifespan (years)	# of Life Cycles	Total Cost	Present Worth
Bikes Lanes & Offset Parking & crosswalk lines	Paint	34	$123.00		10	2	$8,364.00	$11,672.00
Crosswalk Signs	Metal Signs	4	$103.25		20	1	$413.00	$413.00
Additional Street Lights/Lamps	Lights	12	$60.00	$18,600.00	11	2	$34,272.00	$50,530.00
	Posts	12	$1,186.00		20	1		
Road Improvments	(1/4" Slurry Coat)	3333	$2.50		6	4	$33,330.00	$60,706.00
Total							**$76,379.00**	**$123,321.00**

Calculations for Net Present Worth Values:

Road Improvements: $8,333 for 3,333$m^2$ of Slurry Coat
Lifespan: 6 years PW_{Cost} = 8333 + 8333(F/P, 6%, 6) + 8333(F/P, 6%, 12) + 8333(F/P, 6%, 18) = $60,706

Additional Street Lighting: $14,232 for 12 Light Posts Lifespan > 20 years
$720 for 12 Light Bulbs Lifespan: 11 Years, $930 per year for electricity costs
PW_{Cost} = 14232 + 720 + 930(F/A, 6%, 20) + 720(F/P, 6%, 11) = $50,530

Bike Lanes, Offset Parking, and Crosswalk lines: $4,182 for 34 gallons of street paint. Lifespan: 10 years
PW_{Cost} = 4182 + 4182(F/P, 6%, 10) = $11,672

Final Recommendations

1. In conclusion, our complete street conceptual design will provide the city of Chico and its residents with safe and inclusive roadways for for all types of traffic. Increased staggered lighting and buffered bicycle lanes will not only be safe, but promote pedestrian and bicycle traffic. In return this will free up congested parking that the south campus area is known for. Downtown Chico will set a standard for complete streets and show that it is possible to safely manage automobile, bicycle, and pedestrian traffic.
2. Our design revolves around the safety of the community. Chico residents deserve to feel safe when walking at night and our staggered lighting design will provide adequate lighting for safe pedestrian traffic. We believe this design can further connect our downtown and make south campus an even more desirable place to live.

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Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

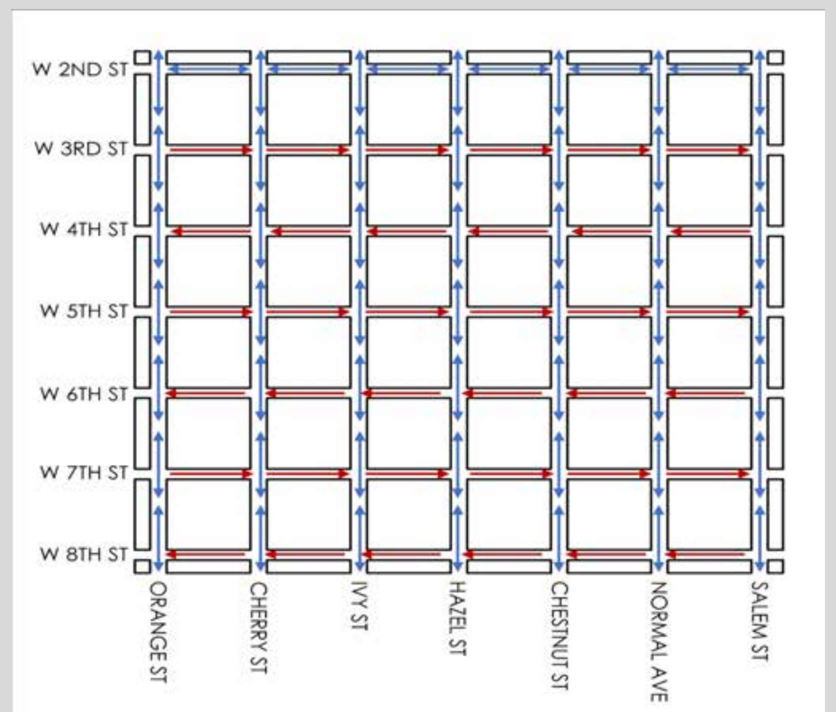
Project Goals & Scope

Goal and Scope:

The proposed renovation will cover the area from 2nd to 8th street and Salem to Orange. Our ideas revolve around making the street a safer, easier place to navigate for drivers, bicyclists and pedestrians alike.

Problem Definition:

At present, the streets have obvious hazards for pedestrians walking and biking through the area. These hazards include insufficient bike lanes and lacking protection from heavy traffic.



Sustainability Metrics

1. Research was conducted to determine how to create a complete street that would improve the safety and serviceability for all who live and travel through the South Campus Neighborhood.

2. The SimaPro software package was implemented to compare multiple environmental endpoint indicators using the TRACI method. Endpoint indicators included ozone depletion, global warming, and eutrophication.

3. Social impacts will be measured through the difference in reported crime and traffic incidents pre and post renovation. Surveys will be taken pre and post renovation to measure any change in overall happiness of residents. Traffic incidents are to be broken down into accidents involving pedestrians and accidents involving just motorists

4. We used equivalent uniform annual cost (EUAC) to compare the economic impacts of proposed alternatives.

A = Cost per unit

B = Quantity per system boundary

i = Interest rate (6% APR)

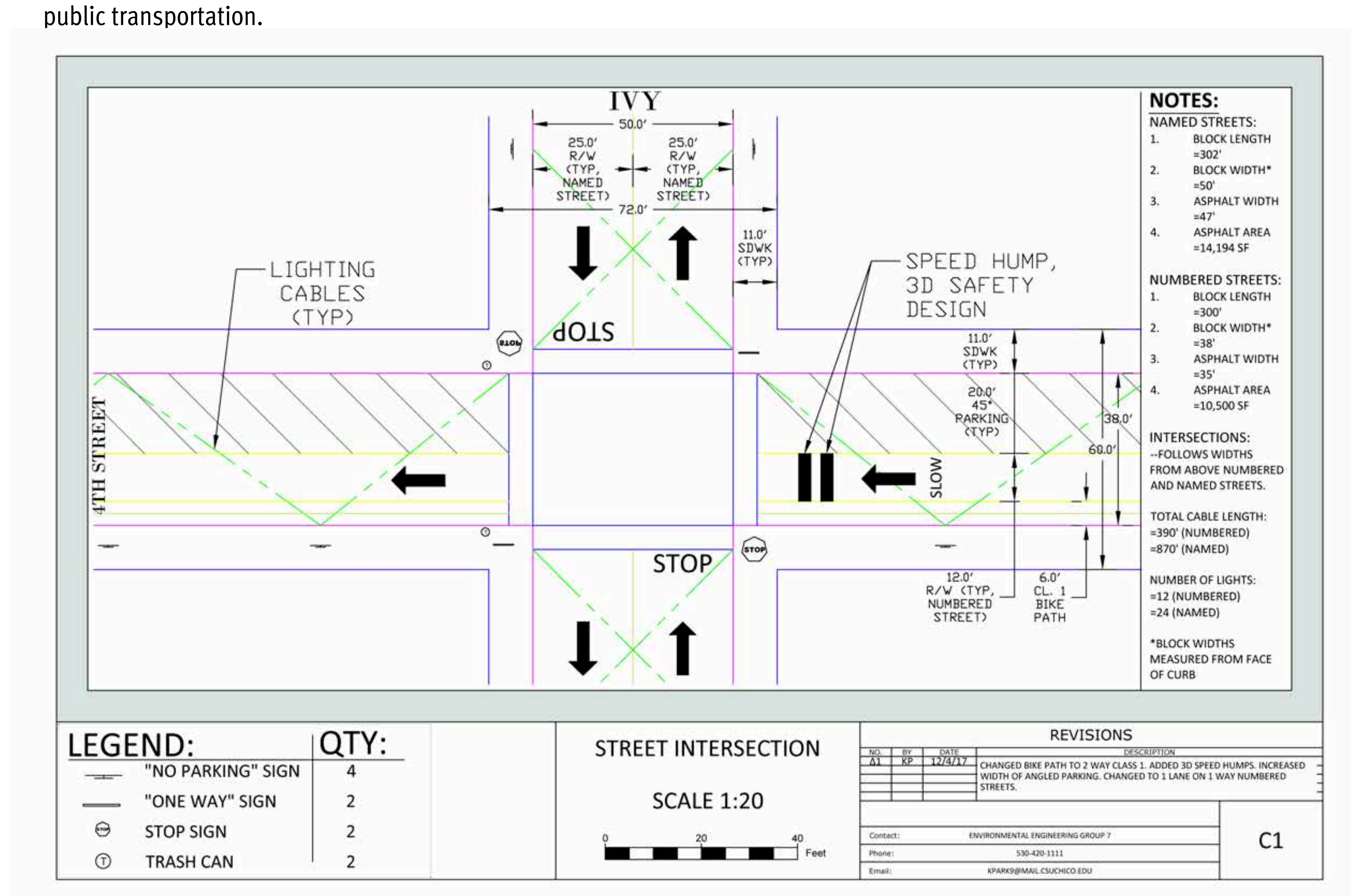
n = lifespan of item

$$EUAC = (A * B)\frac{i(1+i)^n}{(1+i)^n - 1}$$

Operation Thundergun: Make Chico Safe

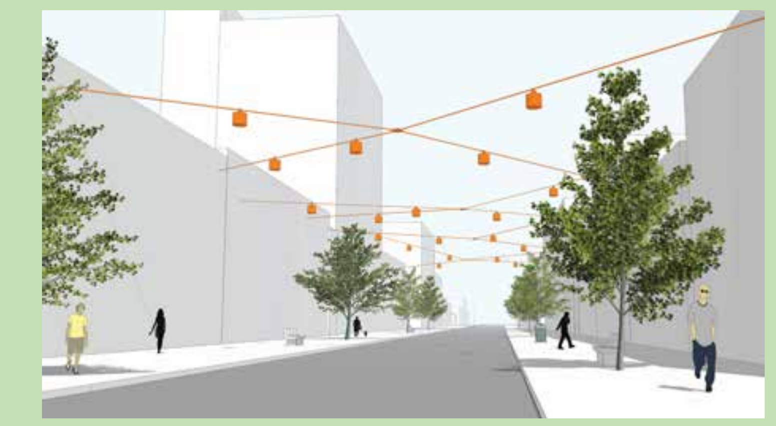
1. W 5th Street and Ivy Street

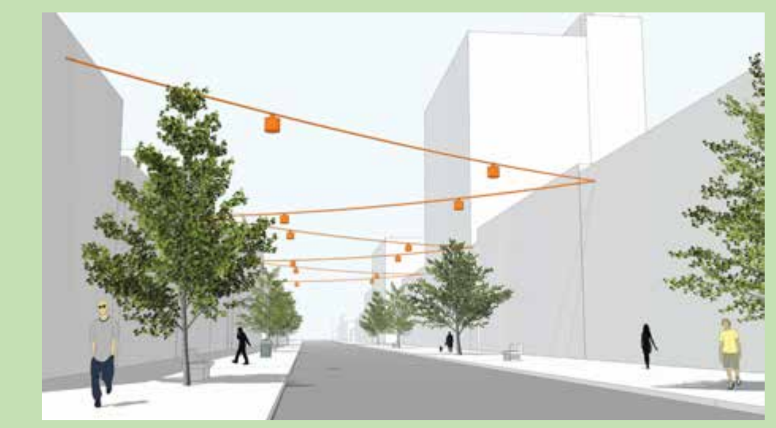
2. The goal of the complete street concept is to provide people, regardless of your age, ability, income, race, or ethnicity, a safe, comfortable, and convenient way to access community destinations and public places whether you are traveling by bike, car, foot, or public transportation.



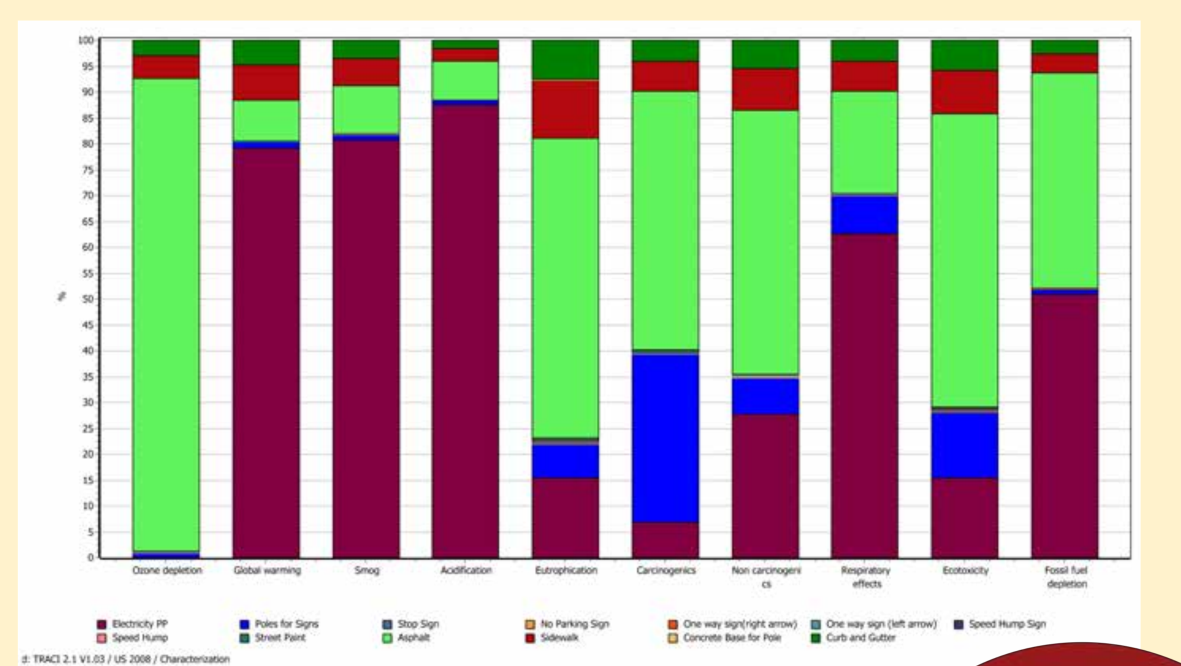
Economic Impacts

ITEM	Total EUAC per system
Poles for signs	$47.85
Attachment hardware	$0.63
Stop Sign	$15.88
No parking signs	$7.58
One way signs (right arrow)	$1.32
On way signs (left arrow)	$1.32
Speed hump signs	$5.15
Speed humps	$130.87
Trash Cans	$114.45
Street paint	$22.41
Lights	$747.41
Suspension cable (7mm)	$339.15
Asphalt	$1,872.28
Sidewalk	$696.61
Concrete base for poles	$2.85
Curb and Gutter	$473.65
Operation & Maintenance	$1,766.02
Total EUAC for all items in each system:	$6,245.44





Environmental Impacts

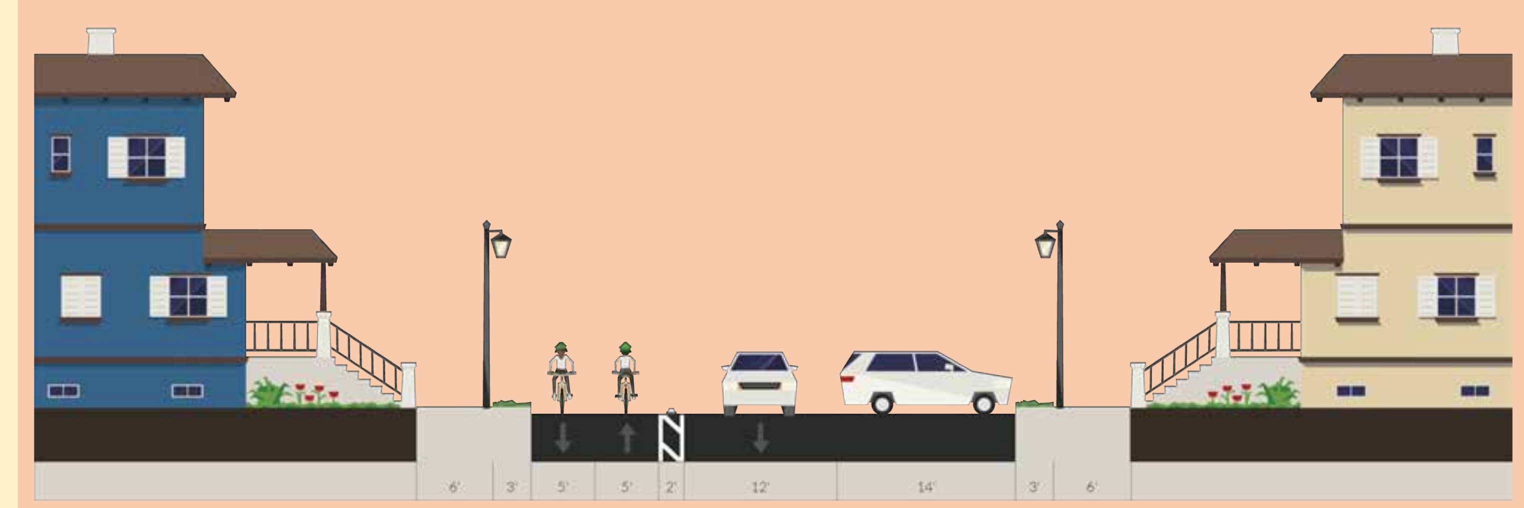


Item	Amount per system boundary	Units	Cost per unit (USD)	LIfespan (years)
Poles for signs	10	1 pole	72.00	40
Attachment hardware	10	1 kit	0.95	40
Stop sign	2	1 sign	58.45	10
No parking signs	4	1 sign	13.95	10
One way signs (right arrow)	1	1 sign	9.70	10
On way signs (left arrow)	1	1 sign	9.70	10
Speed hump signs	2	1 sign	18.95	10
Speed humps	6	1 hump (34lbs)	135.45	8
Trash Cans	2	1 can	861.00	40
Street paint	2.52	5 gallon	65.46	10
Lights	36	1 light	1000	22
Suspension cable (7mm)	1260	ft	4.05	40
Asphalt	199.45	tons	120	10
Sidewalk	112.04	yd³	98	50
Concrete base for poles	11.8	ft³	3.63	40
Curb and Gutter	76.18	yd³	98	50

Final Recommendations

1. We recommend that all streets in the area of interest receive a tenth of a foot cut and reseal. Lighting is to be improved by implementing a catenary lighting system with LED lights. The flow of traffic should be changed as indicated above. Speed bumps will be installed on numbered streets before intersections. Street layout will be changed as indicated in our street view cross sectional.

2. The proposed changes should decrease traffic incidents by creating an easy to understand grid of traffic flow. Speed bumps before intersections will lower traffic speeds to increase safety. Improved lighting will help to decrease crime and improve pedestrian safety. A dedicated, partitioned bike lane will make travelling by bicycle easier and safer.



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South Campus Neighborhood Project

Complete Streets Concepts

Public Works-Engineering
City of Chico, California

Prepared by Akayla Lipscomb, Katherine Gaffney, Mohammed Zainaldeen, John Vega, Suliaman Alsubaihi, Jeffrey Gutierrez, Dr. Pablo Cornejo

Engineering 302: Engineering Risk & Economic Analysis | Fall 2017

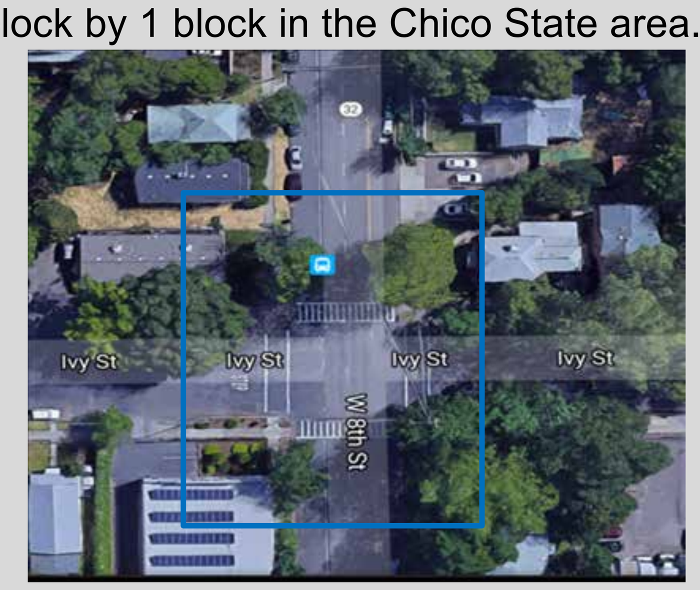
Project Goals & Scope

Project Goals:

- To create safe streets for Chico state students in the South side of campus from Chestnut to Orange, and 2nd to 9th street
- The plan is to make lighting sufficient and eco friendly and the streets more cyclist and pedestrian friendly
- Using solar power, batteries, Philips free street lights and smart crosswalks

Scope:

- Our scope is 1 block by 1 block in the Chico State area.



Sustainability Metrics

- How we did it:
  - Simapro
  - Excel
- While doing the research, we kept in mind the Triple Bottom line. Which means that we wanted to come up with alternatives that were had a positive social effect, environmentally friendly and economical.
- We used SimaPro to evaluate the environmental impacts that the alternatives had on the environment by measuring the carbon footprint
- We used Excel to calculate the cost of each alternative for the defined functional unit.
- Social Impacts:The health and wellness of the community. For example, how the project would affect Pedestrians, Motorists, and Bicyclists.

KEY SUSTAINABILITY METRICS

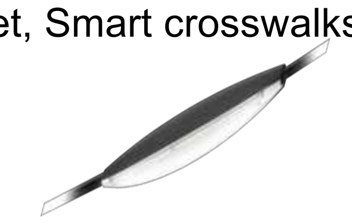
Economic	Social	Environmental
Operation Cost and Maintenance	Population Growth	Global Warming Potential kg-m^3 (CO2 to air)
Cost of Infrastructure and Construction	Health of the community	Energy Used
		The tree canopy and installation of newer, younger trees

A New Southside

A New Southside

- Our concept is to create a safe, noninvasive lighting system, with smart crosswalks and road repairs
- We have three main ideas involving our complete streets, Phillips free street, Smart crosswalks and refurbishing of city roads.

Philips Freestreet:



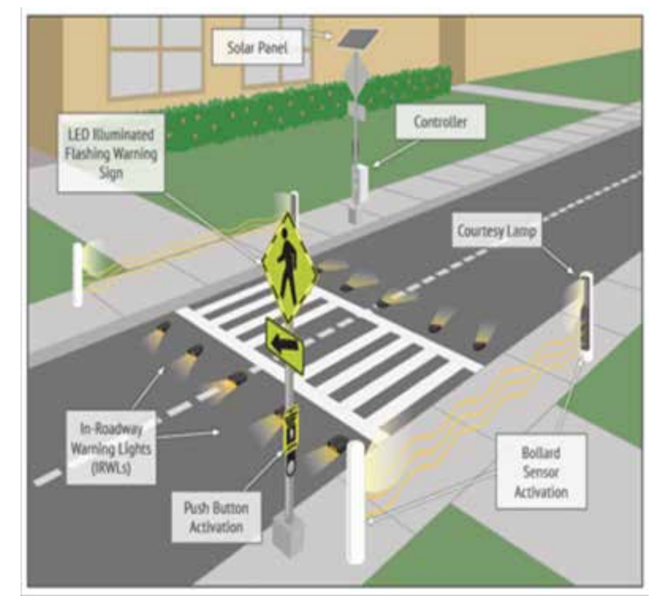
- The PFS will suspend the lighting on cords below the existing tree line
- The system will use solar power to charge batteries during the day
- We will raise the cords using 12 foot poles, 4 per block, running from pole to pole, then crossing the street lighting up the whole area.
- This platform will be less invasive, be more eco friendly than traditional lights, economically feasible, and light up chico in a unique way.

Smart Crosswalks:

- The smart crosswalks are manufactured by lightguardsystems.com
  - The crosswalk uses motion sensors, or physical buttons to alert the crosswalk to light up
  - After the crosswalk is activated, lights on both sides of the crosswalk and on the sign light up to alert cross traffic.
  - Our plan is to place these smart crosswalks on 8th and 9th for Ivy and

	Function	Key Inputs	Key Outputs	Environmental Impacts Assessed
Alternative 1	The function is to make safer, more accessible and lighting to the streets.	Energy Natural Resources	Air Emissions Waste	Global Warming Impact on Natural Resources
Alternative 2	The function is to make safer, more accessible and lighting to the street while reducing the cost from the first option.	Energy Natural Resources	Air Emissions Waste	Global Warming Impact on Natural Resources

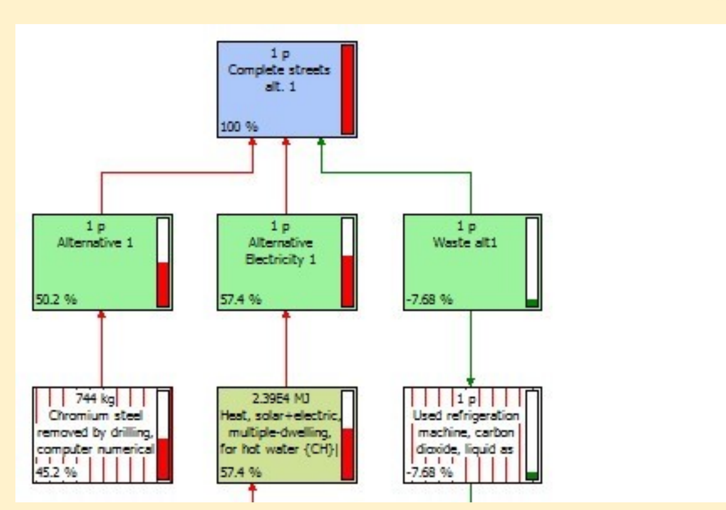
	Function	Key Inputs	Key Outputs	Environmental Impacts Assessed
Alternative 3	The function is to make safer, more accessible and lighting to the street while reducing the cost from the second option.	Energy Natural Resources	Air Emissions Waste	Global Warming Impact on Natural Resources



Environmental Impacts

SimaPro gave us results for , fossil fuel depletion, carbon footprint ,ecotoxicity, and five other categories that were analyzed through TRACI

SimaPro Network



Inventory Data

Alternative 1 (South Campus)					
Item	**Amount**	**Units**	**Cost**	**Lifespan**	**Source**
Streets					
Paint	400	ft^2	280$/container (5 gallons, covers 400 ft^2)	5-7 years	Paveman Pro Asphalt Kingdom
Potholes	20	unit	$40/unit	5-7 years	Governing.org
Signage					
Steel Posts	20		$8220	10-15 years	Light Pole Plus
Aluminum blanks	12	ft^2	$2.50	10 years	U.S. Standard Sign
Lighting					
LED light bulbs (free street)	384	units	$12.50/each	5-7 years	Philips
LED FreeStreet Housing	96	units	$25/each	5-7 years	Phillips
Stainless steel wire	2537	ft	$2.45	5-7 years	Web Rigging Supply
Energy					
Electricity (Solar Power)	6643.20	kWh	$0.10/kWh	20 years	Engoplanet
Solar Power poles	4	units	$1350.00/unit		Engoplanet
Battery	4	units	$500/unit	5-12 years	Kweight Power
Waste					
CO2 emissions		kg-m^3	NA		Simapro
Batteries	2	lb	$559.99	5-10 years	

Economic Impacts

Operation and Maintenance

Operation and Maintenance			
Task	**As Required**	**Monthly**	**Semiannually**
Inspect modules for damage			X
address array shading	X		
Adjust array tilt	X		
Inspect array mounting system			X
Inspect battery enclosure		X	
Inspect battery terminals and connection		X	
Equalize the batteries	X	X	
Load test batteries			X
Capacity-test batteries			X
Inspect and clean all electrical equipment			X
Monitor system for voltage and current	X	X	
The operartion and maintenance depends on the size of the system			

LCCA Alt. 1

Capital Cost				
Alternative 1				
Item	**Amount**	**Units**	**Cost**	**Total Cost**
Streets				
Speed Bumps	4	units	$2,500.00	$10,000.00
Asphalt	3.125	ft^3	$3.75	$11.72
T6 Automatic Activation Bollard	4	units	$550.00	$2,200.00
Potholes	20	units	$40.00	
Base Plates	10	units	$75	
Paint	1.5	ft^2	$280.00	$420.00
Signage				
Steel Post	20	units	$424	$8,480
System controller	2	units	$1,000	$2,000
Aluminum blanks	12	ft^2	$2.50	$30.00
Lighting				
LED FreeStreet Housing	96	untis	$25/each	$2,400.00
LED light bulbs	384	units	$12.50	$4,800.00
9X LED Light Star(road LED)	10	units	$10.00	$100.00
Stainless steel wire	2537	ft	$2.45	$6,215.65
Energy				
Electricity (Solar)	6643.20	kWh	$0.10	$664.32
Battery	4	units	$500	$2,000
Solar Power poles	4	units	$1,350.00	$5,400.00
Waste				
CO2 emissions		kg-m^3	NA	
Batteries	2	lb	$559.99	$1,119.98
Net Cost for the Functional Unit				$45,841.67

LCCA Alt. 2

Alternative 2				
Item	**Amount**	**Units**	**Cost**	**Total Cost**
Streets				
Asphalt	3.125	ft^3	$3.75	$11.72
Potholes	20	units	$40.00	$800.00
Speed hump	4	unit	$2,500	$10,000.00
Paint	1	ft^2	$280.00	$280.00
Signage				
Steel Post	20	units	$1,030	$20,600
Aluminum blanks	12	ft^2	$2.50	$30
Lighting				
LED light bulbs	384	units	$12.50	$4,800.00
Stainless steel wire	2537	ft	$2.45	$6,215.65
Energy				
Electricity (Traditional)	6643.20	kWh	$0.12	$797.18
Green spaces				
Redirecting sidewalk	20	ft	$9.53	$190.60
Waste				
CO2 emissions		kg-m^3	NA	
Net Cost for the Functional Unit				$43,725.15

Smart Crosswalk

Smart Cross walk				
Item	**Amount**	**Units**	**Cost**	**Total Cost**
Streets				
Asphalt	3.154	ft^3	$ 4.25	$ 13.40
Speed hump	4	Units	$ 2,500.00	$ 10,000.00
9X LED LightStar (road LED)	10	Units	$ 75.00	$ 750.00
Signage				
Crosswalk sign	4	Units	$ 100.00	$ 400.00
Automatic activation Bollard	8	Units	$ 350.00	$ 2,800.00
Control system				
System controller	2	Units	$ 500.00	$ 1,000.00
Waste				
CO2 emissions		kg-m^3	NA	
Net Cost for Functional Unit				$14,963.40

Final Recommendations

Our main goal for Safe Streets is to make it safer for all pedestrians, motorists, and bicyclists. Our team believes that

- **Alternative 1 without the smart crosswalk** would be the best option for the project.
- Triple Bottom line

This alternative is the most economical, socially beneficial, and environmentally friendly option. It is also the most innovative option

We also believe there will be important Social Impacts.

Our team believes that with the employment of PFS, revamping of green spaces, and general street resurfacing, it will increase accessibility and safety to all people in the area. Furthermore, with PFS we will be able to make people in the community feel more comfortable and safe.

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