Fall 2016

Whatcom transportation authority: WWU shuttle bus analysis

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WTA SHUTTLE BUS ANALYSIS

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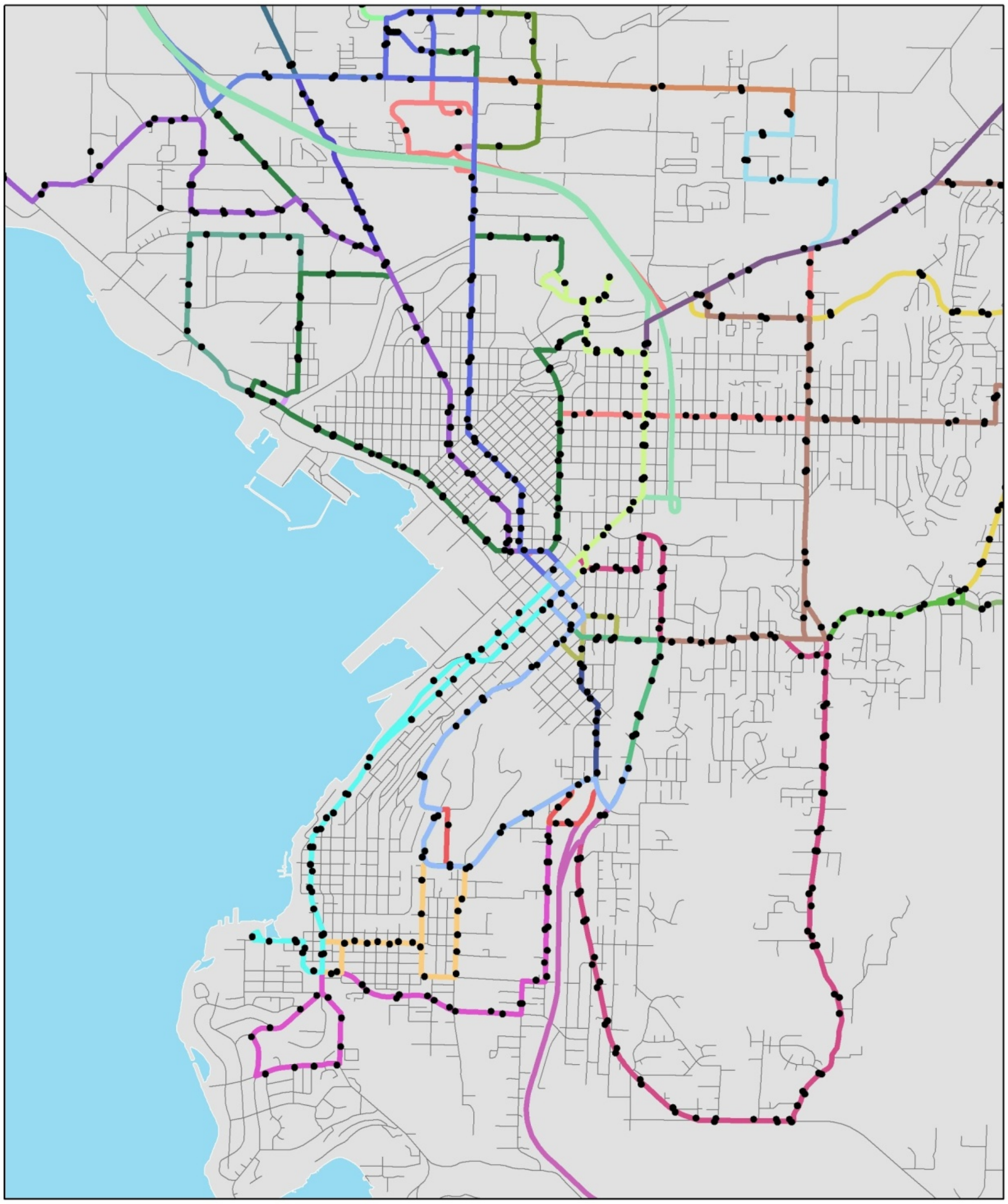

Huxley College of the Environment

Environmental Impact Assessment

Fall 2016

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Date 12/6/16

Dear Concerned Citizen,

The purpose of this Environmental Impact Assessment (EIA) is to assess the impact of added WTA shuttles on Western Washington University (WWU) bus routes. In 2007, students passed the Alternative Transportation Fee to support a transportation program that would benefit the students of Western. As a result, a reduced-fare, mandatory Whatcom Transit Authority (WTA) student bus pass was added to student fees at a cost of $26.50. The universal bus pass has been popular and students have placed such a demand on bus routes serving WWU, that WTA has added additional shuttles during peak times to address the increased ridership. The bus pass was intended for students who live farther away from campus, but high ridership demand has largely been seen by students who live within two miles or less of campus. These added shuttles have added economic and environmental costs, which are now being examined.

The goal of this EIA is to provide WTA with environmentally friendlier alternatives to the added shuttles. It does so by looking at the affected environments of this project which include: air, water, energy and natural resources, transportation, public services and utilities, and environmental health. Several alternatives under consideration are the gradual addition of electric buses into the WTA diesel fleet, adding a new fixed loop route through WWU that services high demand stops, and the removal of the universal bus pass.

In researching the shuttle buses, and the alternatives, we hope to deliver a more carbon-friendly option that benefits the environment. The Alternative Transportation Fee was originally created to provide students with greener ways of getting to campus, but seems to have had an unintended consequence of increasing environmental impacts and economic costs. Our goal is to find an alternative that reduces environmental impacts while still providing students with the transportation services they need.

Sincerely,

Shelby Kremenich ____________ Jocelyn Murphy ____________

Rachel Ohnemus ____________ Lucas Robinson ____________

Whatcom Transportation Authority: WWU Shuttle Bus Analysis

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Environmental Impact Assessment
ENVS 493
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Fact Sheet

Project Title
Whatcom Transportation Authority: WWU Shuttle Bus Analysis

Description of Project
Since the implementation of the “Alternative Transportation Fee” in 2007 at Western Washington University (WWU), the WTA buses servicing the campus have experienced significant increases in demand. Although the purpose of the fee was to create a more sustainable transportation option for students, the increase seen mainly at stops located within a mile of campus has resulted in the addition of shuttle buses on several routes at high-volume times to accommodate the demand. This project identifies and analyzes three alternatives the WTA and the university should consider to resolve this issue: 1) an electric bus fleet, 2) creating a fixed loop route, and 3) switching to an opt-in bus pass system for WWU students.

Location of Site
WTA Blue line routes in Bellingham, WA

Proponent
Whatcom Transportation Authority
4111 Bakerview Spur
Bellingham, WA 98226

Lead Agency
Whatcom Transportation Authority

Permits and Approvals
N/A

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Issue Date
December 5, 2016

Public Hearing:
Whatcom Transportation Authority
4111 Bakerview Spur, Bellingham WA 98226
Thursday, December 1 at 3:30 PM

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Glossary

Alternative Transportation Fee: Passed by WWU in 2007, required all students to pay a quarterly fee of $26.25 for access to an unlimited bus pass through WTA

Fallouts: When particulate matter is emitted as a gas and then falls back down to earth in liquid form

Fauna: The animals of a particular region or habitat

Flora: The plants of a particular region or habitat

Lentic Environment: A still freshwater environment (ex: lakes, ponds, swamps, etc…)

Lotic Environment: A moving freshwater environment (ex: rivers)

Nonpoint-source pollution: pollution from many diffuse sources

Particulate matter: the sum of all solid and liquid particles suspended in air many of which are hazardous

Permissible Exposure Limit: The maximum exposure limit that a worker may be exposed to a certain chemical or sound under OSHA regulations

Point-source pollution: pollution from a single identifiable source

Shuttle: An additional bus that is added to high-ridership routes, that trails behind other buses at high-ridership stops

Solute: A substance dissolved in a given (liquid) solution

Turbidity: A measure of water clarity that quantifies the amount of suspended material in a sample of water

Volatile Organic Compounds: organic compounds that easily become vapors or gases

Acronyms and Abbreviations

AQI: Air Quality Index
ATF: Alternative Transportation Fee
CAFE: Corporate Average Fuel Economy Standards
CO_2: Carbon Dioxide
CO: Carbon Monoxide
CTA: Chicago Transit Authority
DB: Decibels
EIA: Environmental Impact Assessment
EPA: Environmental Protection Agency
HCs: Hydrocarbons
Kwh: Kilowatt Hours
Lbs: Pounds
Mwh: Megawatt Hours
NOx: Nitrogen Oxides
pH: Potential of Hydrogen
SEPA: State Environmental Policy Act
USDOT: United States Department of Transportation
VOCs: Volatile Organic Compounds
WAC: Washington Administrative Code
WTA: Whatcom Transportation Authority
WWU: Western Washington University

1. Executive Summary

1.1 Purpose

The purpose of this environmental impact assessment is to evaluate the current conditions of WTA bus routes that service the Western Washington University campus. This assessment also weighs the impacts of alternatives to determine possible ways to address issues with the current conditions, and analyzes the affected environments concerning the existing conditions and alternatives, which include, but are not limited to air, water runoff, energy and natural resources, transportation, public services and utilities, and environmental health. The objectives of this project are to:

- Relieve congestion of WWU routes during peak hours,
- Reduce environmental impacts by finding greener alternatives to the added shuttle buses,
- Balance added economic costs between WTA and WWU, and
- Promote walking and biking as alternative forms of transportation.

1.2 Description of Problem

In 2007 the Alternative Transportation Fee (ATF) was approved at Western Washington University. The measure added a mandatory fee to students' quarterly tuition costs. The ATF enabled students to use their student ID as a bus pass through Whatcom Transportation Authority (WTA). While this measure has helped reduce the demand for parking, and made it easier for students to travel around town, it has had unforeseen consequences. The routes WTA runs through WWU's campus are known as the blue line, and since 2007 these routes have become inundated with students traveling to and from campus. The added pressure on these lines has caused WTA to run shuttles in addition to their regularly scheduled buses during peak times to help meet student demands. WTA is interested in the results of an environmental impact assessment to better understand the impact of these additional shuttles, as well as to explore alternatives to take pressure off their routes and promote other methods of green transportation.

1.3 Existing Conditions

Currently, all students pay a mandatory ATF of $26.50 per quarter, and in turn, each student receives a bus pass that can be activated on their student ID. The convenience of buses every fifteen minutes along the blue line that runs through campus, leads to overcrowded buses each morning and afternoon during peak hours. Students are often passed, and buses are frequently at capacity. Additional shuttle buses along popular routes have been added to meet high ridership demands.

1.4 Alternative Action One

The first alternative action is to replace the current fleet with electric buses. This would eliminate point source CO2 emissions from tail pipes, but would result in emissions from energy consumption used to the charge electric buses. The cost to purchase electric buses also needs to be considered.

1.5 Alternative Action Two

The second alternative action is the addition of a fixed loop route that services high demand stops. This action would reduce pressures on current routes, and free up space on buses. The fixed route would replace the shuttle buses, and reduce total mileage. Reduced mileage would decrease fuel usage and emissions.

1.6 Alternative Action Three

The final alternative action is to remove the mandatory student bus pass. This action would allow students to opt-in to paying the ATF. Given the opportunity to opt-out, students who live on or near campus would likely choose to walk or bike to school instead. Assuming ridership would decrease, the shuttle buses would no longer be needed. This would result in a decrease in emissions and fuel use. Potential consequence of this alternative is a decrease in accessibility for students who live on campus and/or do not have a car. Possible environmental impacts of this alternative include increased emissions from single occupancy vehicles, and higher likelihood of water runoff pollution from the higher volume of cars on the road and in WWU parking lots.

*Each Alternative will include an educational component that will aim to complement the overall objectives of this project (such as promoting greener forms of transportation).

1.7 Recommended Action

Our recommended action is alternative one, electric buses. We believe that converting the WTA’s fleet to electric buses will be economically beneficial to them in the long-run, while also having the greatest positive impact on the environment. Implementing a pilot program of four electric buses into WTA’s fleet may exemplify their positive effects and provide information for decision making.

2. Existing Conditions

2.1 Introduction
Since the implementation of the universal bus pass in 2007, some unforeseen consequences have resulted. One of the main goals of the Alternative Transportation Fee (ATF) was to provide a “greener” alternative to driving a car to campus, but this has not been the case. The convenience of taking the bus has encouraged students who would have previously walked or biked to class, to ride the bus instead. The high volume of student riders (particularly on the Blue Line) has resulted in overcrowded buses. In order to meet the demand of students, WTA has twelve routes that service campus, four of which have added shuttles. These additional buses have added economic and environmental costs.

2.2 Air

WTA currently has 58 fixed route buses:
- 40 - 40 ft diesel engine
- 8 - 40 ft hybrid engine
- 7 - 35 ft diesel engine
- 3 - 30 ft diesel engine

Diesel buses are powered by 280 horsepower Cummins 8.9L diesel engines, hybrid buses are powered by 280 horsepower Cummins 5.9L ISB engines. The specific emissions generated by these engines varies depending on the Corporate Average Fuel Economy (CAFE) standards of the year the engine was produced. Hybrid-electric engines result in reduced fuel use from the collection and re-use of kinetic energy, usually wasted in braking. Fuel is also saved by engine sizing down and partial electric operation, such as engine shutdown at idle. This results in 7% - 44% higher average fuel economy than a diesel bus of the same version (MJB & A, n.d.). Better fuel economy results in less tailpipe emissions. WTA’s diesel buses get an average of 5.10 mpg and the hybrid buses get an average of 6.37 mpg. Hybrid buses are used on all of WTA’s fixed routes, and no specific information on how frequently hybrid buses service blue line routes was available. Specific information on route mileage was also not available, but the 2015 total fixed route miles was 2,032,000.

According to the Environmental Protections Agency’s (EPA) Air Quality Index (AQI), Bellingham’s air quality is good. However, air pollution is being released from WTA’s fleet in the form of tailpipe emissions. Tail pipe emissions include carbon dioxide (CO_2), carbon monoxide (CO), hydrocarbons (HCs), nitrogen oxides (NO_x) and particulate matter. Particulate matter is composed of hundreds of chemical elements, including sulfates, ammonium, nitrates, elemental carbon, condensed organic compounds, and even carcinogenic compounds and heavy metals such as arsenic, selenium, cadmium and zinc (Union of Concerned Scientists, n.d.). Particulate matter irritates the eyes, nose, throat and lungs, which contributes to respiratory and cardiovascular illness and even premature death (see Environmental Health, section 3.7). Nitrogen and sulfur oxides can react in the atmosphere to form secondary particulates. Nitrogen Dioxide (NO2) contributes to the formation of ground level ozone, an irritant to the respiratory system that causes coughing, choking, and reduced lung capacity (see Environmental Health, section 3.7). In addition, NO2 also causes acid rain which increases the acidity of streams, rivers and lakes, and leads to nitrogen pollution.

CO2 is a powerful greenhouse gas that causes climate change. According to the U.S. Energy Information Administration, burning a gallon of diesel full releases about 22.38 pounds of CO2 (EPA, 2016). The total number of hybrid and diesel miles is not known, making it hard to determine how much CO2 is being emitted by WTA’s fleet. However, an approximation of 2015 CO2 emissions can be calculated from percentage of hybrid and diesel buses, total miles in 2015, average mpg, and CO2 emitted per gallon of diesel. Based off our calculations, WTA’s fleet emitted approximately 8,641 tons of CO2 in 2015.

2.3 Water Runoff

Water pollution is hard to quantify, since buses are a nonpoint source of pollution, but it is known that automobiles affect water pollution. Fallouts can occur, especially in areas with rainy conditions, where a known pollutant transitions from an airborne state towards a state of solute. These fallouts have a higher impact on lentic environments than lotic environments (Rodrigue, 2016). The most destructive fallouts are sulfuric acid, and nitric acid, produced by bus emissions, that alter the potential of hydrogen (pH) in water. This alteration of pH may increase acidity levels, affecting the local flora and fauna, and cause eutrophication. Other fallouts such as lead, HCs, and VOCs are poisonous, and can poison marine life (Rodrigue, 2016). Fallouts can also increase the turbidity of water.

Diesel and hybrid buses drip fluids, and auto fluids do not dissolve in water. Any fluid that is excreted from the bus, such as oil, antifreeze, and brake fluids contain metals, suspended solids, and HCs that can be carried off by water runoff and pollute local water sources (Victoria Transport Policy Institute,2015).

The weight of the buses affects water pollution. The average diesel transit bus can weigh from 20,000-33,000 pounds (lbs), and a fully-loaded bus can weigh anywhere from 30,000-44,000 lbs. (MORR, 2014). Compared to the average hybrid bus, which weighs about 30,000 lbs. (Intercity Transit, 2012) .The weight affects the tire wear significantly, and as the tire wears down, the rubber from the tire, and the other pollutants used to make the tire, are left to be swept away by water runoff and pollute the environment.

The maintenance and infrastructure of roads contributes to water pollution. Salting, sanding, and graveling roads (for buses) can affect water pollution when water runoff accumulates substances from these surfaces (Rodrigue, 2016). The dissolved substances are then carried off by the water. Maintaining and building roads also allows for the runoff of those infrastructure projects to affect local water environments. Runoffs from infrastructure can alter the turbidity, oxygen level, contaminate the food chain, and remove local habitats (Rodrigue, 2016).

2.4 Energy and Natural Resources

WTA's current fleet contains 8 hybrid buses (14% of the total fleet), and 50 diesel buses (86% of the total fleet). Hybrid buses get 6.37 miles per gallon (mpg), about 20% less than the standard diesel bus, which only gets 5.10 mpg. The total fixed route miles in 2015 was 2,032,000 (Bozzo, 2016). According to calculations, assuming hybrid buses make up 14% of the total fixed route miles, with diesel buses accounting for the rest, diesel buses used an estimated 387,310 gallons of fuel. Other natural resources are also used by the WTA to operate and maintain their services, but diesel is the most significant in terms of volume and energy extracted.

2.5 Transportation

Of all the routes that WTA provides, 12 of them service WWU's campus (14, 25x, 70x, 80s, 90a, 90b, 105, 107, 108, 190, 196, 197); 25x and 70x are county connectors, which head to Lynden and Blaine respectively. The 80s, 90a and 90b do not operate when WWU is not in session on weekends, or when summer quarter is in session, and the 196 and 197 only operate on evenings and Sundays. This leaves five routes that continuously service WWU's campus from morning to night, as well as the late night shuttle service that WWU offers for students while classes are in session.

Students have a variety of ways they arrive on campus each day. Some walk or bike, typically those who live in close proximity, while others may take the bus, park and ride, carpool, or drive alone. In 2007 the Alternative Transportation Fee was passed with the intentions of providing easier access to buses for students, as well as promoting greener forms of transportation.

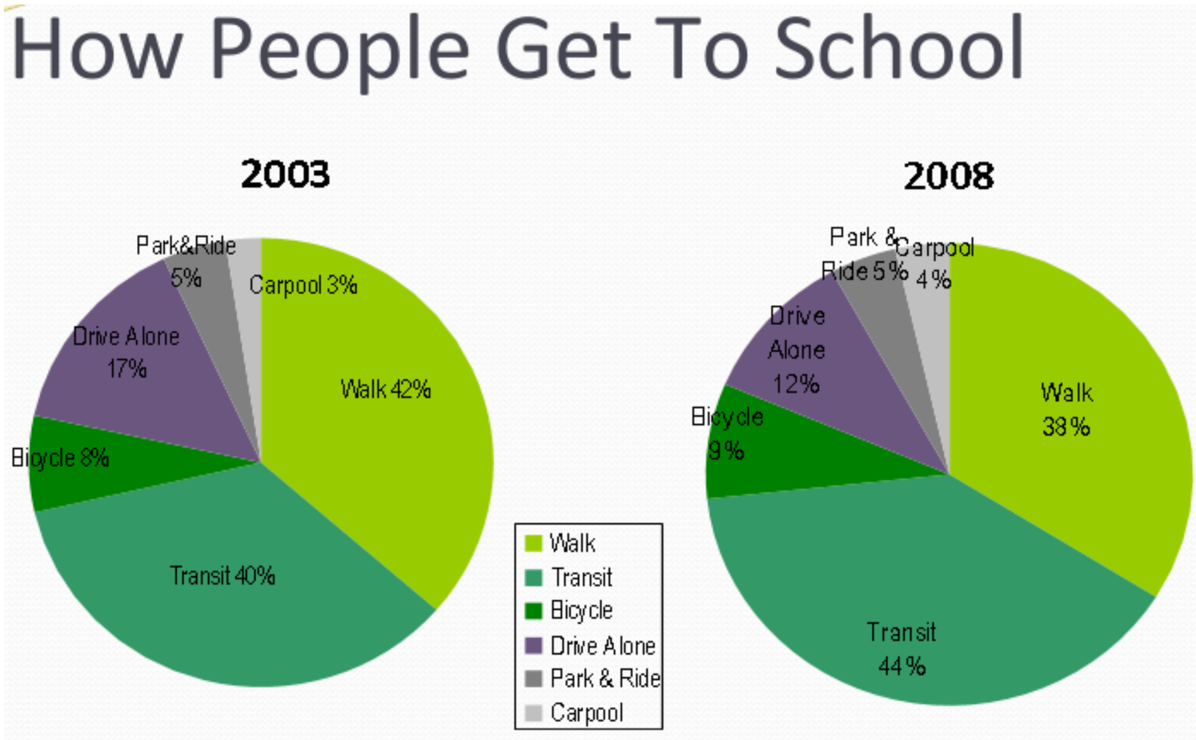


Figure 1. A comparison of the popular modes of transportation for students commuting to campus in 2003 (prior to ATF) and 2008 (post ATF) (Berry, 2009).

As Figure 1 shows, by 2008, a 4% rise in transit use was observed, which can likely be attributed to the drop in driving alone by 5%, or the drop in walking by 4%. While the implementation of a universal bus pass may have gotten people out of their cars, it is also possible that it got people off of the sidewalk. With the increased ridership, WTA added shuttles (extra buses on overcrowded routes) to help alleviate congestion. Currently, four shuttle buses operate on weekdays to help regular WTA buses, but this is a dynamic service that is updated as patterns change or additional help is needed. Though these shuttles are helping the problem of congestion, they are not solving it.

While it is hard to attribute this overflow to one factor alone, it is likely that students who used to walk or bike to campus each day are choosing the bus instead, since they now have a ‘free’ bus pass. With the addition of four shuttles servicing campus during peak times on weekdays, it seems as though the ATF is missing its goal of encouraging sustainable transportation. While WWU and WTA have an agreement for the cost each student pays for the bus pass, this was founded on a system that had not been employing a shuttle service. Now WTA is bearing the added cost associated with running four shuttles each weekday.

With additional shuttles come additional impacts to the environment. The ideal solution to this problem will lower the demand for shuttles, allowing them to be decreased or eliminated, while in turn lowering emissions and other harmful impacts on the environment.

2.6 Public Services and Utilities

WTA's mission is to deliver safe, reliable, efficient, and friendly service to the public. With the inundation of stops and routes around campus, the general public's access to WTA services has also been impacted. While hard to measure, it is possible that people who typically take routes running through campus may find themselves searching for alternate modes of transportation to the bus, which can result in more cars on the road, and a greater impact on the environment. WTA also has to put their resources into running these additional shuttles, which can be used on other services to the public, or upgrading their fleet to a greener standard.

Those with disabilities often rely on WTA for transportation, and for some it may be their primary mode of transport. Overcrowded buses can make it difficult for those in need to access transportation services and may deter them to different forms of transit, or not taking a trip at all. Whatever action is recommended to help solve the transportation problem around WWU, will need to take into account those with disabilities and their access to public services.

Surrounding campus there are two major fire stations, one located on the north side at 1111 Billy Frank Jr. St. Bellingham, WA 98225, and the other to the south side at 1590 Harris Ave. Bellingham, WA 98225. These fire stations lie on main arterial roads that provide them with access to the neighborhoods surrounding WWU and the lower south side of Bellingham. Harris Ave has one WTA route that runs along it (14), and Billy Frank Jr. St. has 11 WTA routes that run along it (14, 25x, 70x, 80s, 90b, 105, 107, 108, 190, 196 and 197). Considering that buses leave the station every 15 minutes during peak times of the day, it is likely that a fire engine or paramedic vehicle can encounter a bus on its way to the site of an emergency. With two large vehicles, as well as added automotive traffic, it can negatively impact the efficiency and response times that responders can have. The shuttles that are trailing buses can be an added hazard to fire crews as well.

Wear to roadways is another important consideration when it comes to buses. While buses may remove cars from the roadway, buses are much heavier. There are a number of older roads that surround campus that can be affected by bus use. During periods of inclement weather, buses also often use chains that magnify the impact on the road. The average weight of a car, in America, is around 4,000 lbs. while the average weight of a bus is between 20,000 and 33,000 lbs. unloaded, and between 30,000 to 44,000 when fully loaded (Hakim, 2004; MORR, 2014). Though a fully loaded bus may serve a greater number of people at a lower weight per passenger, the impact on the roadway is larger.

2.7 Environmental Health

2.7.1 Noise

Noise is measured in decibels (db). The average diesel bus (40ft) emits 80-85 db of noise per vehicle, and upwards of 90 db when pulling away from a stop, as seen in Table 1. The threshold of hearing loss is 85 db, and if a sound is louder or equal to 85 db, it can cause permanent damage to hearing (Dangerous Decibels, 2016). For every 3 db over 85 db that a person is exposed to, the permissible exposure limit is cut in half (NIOSH and CDC, 2002); meaning that the louder and longer the db exposure is, over 85 db, more hearing damage will occur. The WTA buses emit, on average, 80-85 db, making their diesel buses a hazard for hearing loss to their riders, and other community members who operate around buses. The average hybrid bus emits a lower amount of decibels than a diesel bus. The average hybrid bus emits 70-80 db, and so does not reach the threshold of hearing loss. It is hard to calculate which bus, diesel or hybrid, will operate as a shuttle, since it changes on a day-to-day basis. Noise pollution will impact riders and community members, depending on which type of bus is being used as a shuttle. Long exposure to diesel bus shuttles will have a more negative impact on hearing loss, compared to the little to no impact that hybrid buses have on hearing loss.

Table 1. Chart of decibel emissions of vehicles (Edmonton Trolley Coalition, 2016).

Type of Vehicle	Noise in decibels
Gasoline passenger car	62-67
Electric trolley bus	60-70
LRT car	72-75
Medium-sized truck	73-78
Urban diesel bus	80-85
Heavy Truck	80-85
(Adapted from: Transport Action, Transport Canada 2000, October 2001; additional data from BC Transit, 1999 and Calgary Transit)	

2.7.2 Public Health

Exhaust from diesel buses contain significant levels of particulate matter. These fine particles pose a significant health risk to human health; they can penetrate into the human body and cause a range of health problems. Diesel exhaust can contain substances such as arsenic, benzene, carcinogens, formaldehyde, and nickel, which have been known to have the potential for the mutation in cells that cause cancer (OEHHA, 2001). Exposure to diesel exhaust can also have immediate health effects. Exhaust from diesel buses can irritate the eyes, lungs, nose, and throat. Breathing, and being around diesel exhaust, can irritate allergies and asthma, and cause coughs, fatigue, headaches, inflammation in the lungs, lung function changes, lightheadedness, nausea, and respiratory changes (Sydbom et al., 2001). The nitrogen oxides produced by diesel buses can also damage lung tissue, lower resistance to respiratory infection, and worsen chronic lung diseases (OEHHA, 2001).

3. Proposed Alternative 1: Electric Buses

3.0.1 Introduction

The first proposed alternative is the transition from diesel and hybrid-diesel to electric buses. We recommend WTA's entire fleet be replaced with electric. Currently electric buses are significantly more expensive than diesel and hybrid buses, but for the purpose of this assessment, economic factors were not considered. If upgrading the entire fleet is economically unfeasible, a pilot project could potentially be implemented to test the costs and benefits of electric buses. In this scenario, we recommend at least four buses be purchased.

3.1 Air

Electric buses produce no point-source pollution, and replacing four diesel buses with electric would significantly reduce WTA's total emissions. An estimated 8,641 tons of CO_2 is emitted from WTA's fleet, and if WTA replaced all 58 of their buses with electric, this number would drop to zero.

According to the United States Department of Transportation (USDOT), every zero emission electric bus (when compared to diesel) eliminates approximately 1,690 tons of CO_2 over its 12 year lifespan. In addition, electric buses also eliminate up to 10 tons of NO_x and 350 pounds of diesel particulate matter in their lifespan (USDOT, 2016). This would greatly improve the air quality around campus, where the buses frequently run. In this EIS, a life cycle analysis was not conducted and emissions that could have been emitted during the production and disposal of electric buses, was not considered.

A number of cities have begun to switch to electric buses. Chicago Transit Authority (CTA) was the first major U.S. transit agency to use all-electric buses as part of their daily service. CTA has seen many benefits, including both environmental and economical. Some positive impacts each bus has had on the environment include:

- a 121-ton reduction in CO_2 per year, per bus
- 0.0428 ton reduction in hydrocarbons per year,
- 0.5938 ton reduction of NO_x per year and
- 0.0274 ton reduction in particulate matter per year. (CTA, n.d.)

Globally, cities who have historically had issues with smog are leading the way in the transition to electric transportation.

3.2 Water Runoff

Electric buses produce no emissions, so there will be a decrease in fallout pollution and fluid drips caused by buses. But, since electric buses are significantly heavier than diesel and hybrid buses, they cause more damage to the roadway, and may result in more maintenance and infrastructure needs. Electric buses, on average, weigh about 30,000-40,000 lbs. when empty (CTA, n.d.). This significant difference in weight will also have negative impacts on the tire wear of the buses. Because electric buses are heavier, tires will need to be replaced more often, resulting in increased water pollution from the runoff of rubber and other pollutants being dispersed into the environment from tire wear.

3.3 Energy and Natural Resources

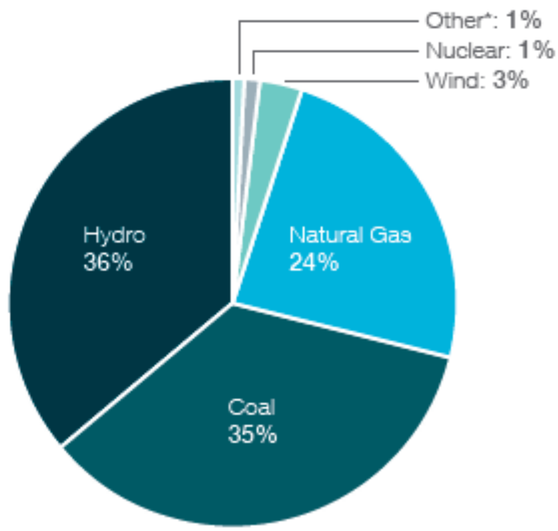
There are many positive benefits to electric buses. As an example, the Proterra Catalyst E2 series 40-foot bus is used in the analysis. This electric bus uses 1.82 kilowatt hours (Kwh) per mile (Proterra, 2016). This is the amount of energy equivalent to that produced by 0.04 gallons of diesel, meaning an electric bus can use the same amount of energy that a 0.04 mpg diesel bus would. This is a reduction in energy use of over 99%. It is important to note that the previous and following calculations are based off of predicted assumptions and estimates.

The exact values of the amount of resources required to generate the electricity required to charge an electric buses cannot be obtained. However, the derived source of power to charge the electric buses can be seen in Puget Sound Energy's (PSE) 2014 electricity fuel mix, as seen in Figure 2. If WTA would have had electric buses making up the total fixed route miles of 2015, 3.7 Mwh would have been used. This estimate does not consider efficiency losses in the generation or transmission of the electricity, but is not significant enough to include in this analysis. PSE would power WTA's electric fleet. The resources allocated to meet the increased demand from the WTA would depend on PSE's chosen method of electricity generation. PSE's top two electricity sources are hydropower and coal.

2014 Electricity Fuel Mix

The PSE fuel mix for electricity delivered to customers in 2014 is detailed in the graph below, as published by the state of Washington.

Fuel	Percentage
Coal	35%
Hydroelectric	36%
Natural Gas	24%
Nuclear	1%
Other*	1%
Wind	3%
Total	100%



** Biomass, landfill gas, petroleum, and waste.*
Source of data: Published by the Washington Department of Commerce, December 2015, with data reported by PSE in April 2015.

Figure 2. Electricity fuel mix of 2014 (Puget Sound Energy, 2014).

3.4 Transportation

Switching WTA’s fleet from diesel to electric would cause a slight change in transportation services, as electric buses would need to be charged periodically. There are two main options for charging electric buses: an overnight charge which runs at the time of peak cost for energy, and a quick supplemental charge, which would be ran throughout the day. The quick charge option requires buses to be charged for 15 minutes out of every hour (Bozzo, 2016).

While it would be cheaper for WTA to run quick charges when the cost of energy is lower, this would require installing infrastructure at the downtown bus station, or on WWU’s campus to accommodate the charging of the electric buses. This may also change shuttle schedules, because each bus will need to take a break periodically to charge.

The alternative to quick charge is for WTA to install overnight charging stations at their fleet facilities, where the buses return every night. This comes at an additional cost to WTA though, as peak energy costs are typically in the evening and charging multiple electric buses for the next day requires a large amount of energy. The benefit to this alternative is that WTA will not have to install infrastructure in town, and can continue to run their buses throughout the day, without having to worry about periodic charging.

3.5 Public Services and Utilities

WTA has multiple sizes of buses that they use to service different routes and needs. Their larger buses typically service WWU's campus, as well as other high volume routes, to maximize the most passengers on each trip. It is assumed that the electric bus model WTA would pick will be relatively the same size as the buses currently being used. Capacity for passengers will therefore be close to the same, and it can be assumed that public access to services would not change. The number of buses on the road, and the routes they take will stay the same as current conditions.

Electric buses require large batteries that carry their energy supply for the day. Because of this added material, electric buses tend to weigh significantly more than diesel buses. This added weight can mean additional stress to the parts of an electric bus, such as brakes, joints and especially tires. Tires need to be replaced more frequently on electric buses, and can be an additional cost to the organization operating them. The extra weight can also contribute to increased road wear. In this proposed alternative, the routes of the buses will stay the same, but it is possible that the increased weight can cause more wear to roads, and require more frequent upkeep (Bozzo, 2016).

4.6 Environmental Health

4.6.1 Noise

Noise pollution will decrease, because electric buses only emit 60-70 db, compared to the 80-85 decibels that diesel buses emit. Hearing loss will not be affected by this alternative, as the db of electric buses do not come near the threshold for hearing loss (85 db).

4.6.2 Public Health

There will be less negative health effects if electric buses are integrated into WTA's fleet. Electric buses produce no emissions, so negative health effects caused by diesel exhaust emissions will decrease.

3.7 Summary

Element	Impact
Air	+
Water Runoff	+
Energy and Natural Resources	+
Transportation	=
Public Services and Utilities	=
Environmental Health	+

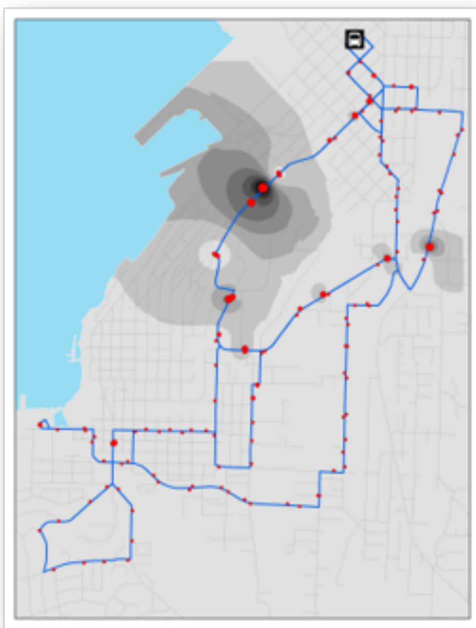
- \+ **Positive impact**
- \- **Negative impact**
- = **Equal impact**

Figure 3. A summary of the overall impacts proposed alternative one has on each environmental element (WWU Shuttle Bus Analysis Group 2016).

4. Proposed Alternative 2: Fixed Loop Route

4.0 Introduction

This alternative was formed using information from WTA's ridership database. Data was analyzed by individual stop to identify the locations where riders are most frequently boarding buses around campus. Figure 4 highlights the areas where the most passengers are boarding. The major areas of passengers getting on are along Billy Frank Jr. Street, Highland Street, and the Bill McDonald Parkway. The purpose of the fixed loop route is to remove the four shuttle buses being used on established routes, and condense them to one bus that would run continuously throughout the day as shown in Figure 5. This will ideally result in less overall mileage, while addressing the demand placed on the system by WWU students.



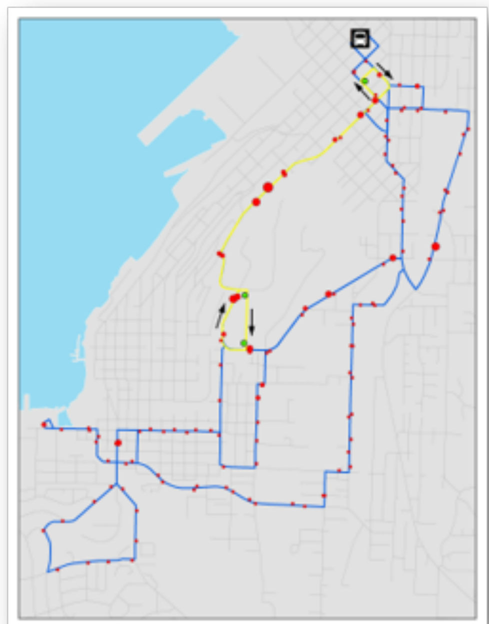


Figure 4. (Left) Density of ridership map (blue = routes, red = stops) (Robinson, 2016)
Figure 5. (Right) Proposed fixed route, shown in yellow (Robinson, 2016)

4.1 Air

This proposal is predicted to increase air quality based off the assumed decrease in total daily miles driven by WTA's fleet. The new route will limit miles and only service high-demand stops on campus, as determined by a ridership density map (Figure 6). The total emissions from the added shuttles were not calculated due to a lack of data, and the variability in service from year to year. We therefore were unable to compare the shuttle emissions to the hypothetical emissions from the proposed route. However, we concluded it would reduce overall emissions because the proposed route is less total distance, and would be replacing four shuttle routes.

4.2 Water Runoff

The fixed route is predicted to neither increase nor decrease water runoff pollution. This alternative would replace the added shuttles to high-ridership routes, and create a new route that would service high-ridership stops. In doing this, water runoff pollution would not change, because no buses would be added or taken away. It is likely that water pollution may decrease slightly, on the assumption that the fixed route contains less mileage than the shuttle routes.

4.3 Energy and Natural Resources

The fixed route, still accommodating for the high demand periods, is intended to replace the existing shuttles while travelling less miles. The change in diesel usage would be the difference between the proposed fixed-route miles driven, and the existing shuttle miles. Along with diesel, the use of other materials and substances produced from natural resources such as oil, antifreeze, metals, rubber, etc., would be reduced.

4.4 Transportation

The main intention of this alternative is to provide increased, more efficient access to students getting to and from campus. High demand stops on the main corridor leading to WWU will be serviced more frequently throughout the day, and this route will be able to loop continuously bringing students to and from campus on the north and south side. Since this bus does not return to the station, it will be able to run quicker than other routes, and can be switched out with another bus periodically when needing to refuel.

The goal of this route is to put into place a bus that can service the area surrounding WWU continuously. Shuttles currently run as accessories to predetermined routes. They start near the beginning of a route, continue with the lead bus until their riders empty off, and then go ‘out of service’ while returning back to the start of the route they began on. This means that 50% of the time these buses are running, they are not servicing passengers. This alternative will be serving passengers 100% of the time.

4.5 Public Services and Utilities

This route would provide increased accessibility to students living on the main corridor through WWU, going up Billy Frank Jr. Street, down Highland, and along the Bill

McDonald Parkway; though it may take away the added shuttle service from other routes that surround WWU's campus. It is hoped that this route that continuously services campus would alleviate congestion on the highest demand stops, but it is possible that the other routes now lacking shuttle service will become increasingly congested.

With any option that involves removal or change of routes, it can be hard to quantify how students or the general public might react. It is possible that while this route helps the student population, it could lead to increased back up for the general public that lives around campus, who are not using these routes to get to campus, but instead to get across town.

Because this route would remove shuttles from other routes, it would reduce impact to those selected roadways. Though the fixed route would run repetitively on the same roads more often, it would condense the impact to a smaller area more frequently. The impact of this is hard to measure, as the shuttles are a dynamic service and change as needed. Therefore, calculating an exact number for mileage was not possible.

4.6 Environmental Health

4.6.1 Noise

Noise is not likely to increase with this alternative, but decrease. Though, based on where the fixed route is placed, it could affect certain neighborhoods that are not typically used to bus traffic. Noise pollution may be transferred from one place to another, but not eliminated. It is assumed that noise pollution will decrease, as long as the fixed route is less mileage than what the shuttles travel.

4.6.2 Public Health

Public health will likely increase. The alternative route would not be emitting as many pollutants as the shuttles, because there would be fewer buses and they would be running a shorter distance.

4.7 Summary

Alternative	Impact
Air	+
Water Runoff	=
Energy and Natural Resources	+
Transportation	+
Public Services and Utilities	=
Environmental Health	+

+ **Positive Impact**
- **Negative Impact**
= **Equal Impact**

Figure 6. A summary of the overall impacts proposed alternative two has on each environmental element (WWU Shuttle Bus Analysis Group 2016).

5. Proposed Alternative 3: Opt-In Bus Pass

5.0 Introduction

In the opt-in bus pass alternative, students would have access to a bus pass, however, the alternative transportation fee would be optional. The fee would likely increase from $26.50, because WWU may be purchasing a smaller number of WTA bus passes.

5.1 Air

We made the assumption that a percentage of students who live within walking/biking distance of campus, will choose to opt-out of the $26.50 fee, if given the opportunity to save money each quarter. This would lead to reduced ridership and the removal of the shuttle buses. With fewer buses on the road, we concluded there would be an increase in air quality from reduced tailpipe emissions.

There is also the potential for an increase in student drivers, which will negatively impact air quality. Students who previously used the bus service for commuting may choose to drive instead. Single occupancy vehicles emit significantly less CO_2 per passenger mile (see Figure 7). Passenger mile is a measurement used to evaluate the energy efficiency of a vehicle or transportation mode. It is obtained by multiplying the miles per fuel gallon (mpg) by the average capacity or the passenger capacity; the greater the ridership, the smaller the passenger miles. After the Alternative Transportation Fee was implemented, there was a five percent decrease in student drivers (Figure 1). We hypothesized this decrease was a result of more students taking the bus. If the fee was optional, there is the potential for a number of student drivers to increase again. It is hard to predict the unforeseen consequences of this alternative. However, we assume that students who are not within walking/biking distance will still find paying the fee more convenient than driving, and therefore concluded that this alternative would result in positive impacts on air quality.

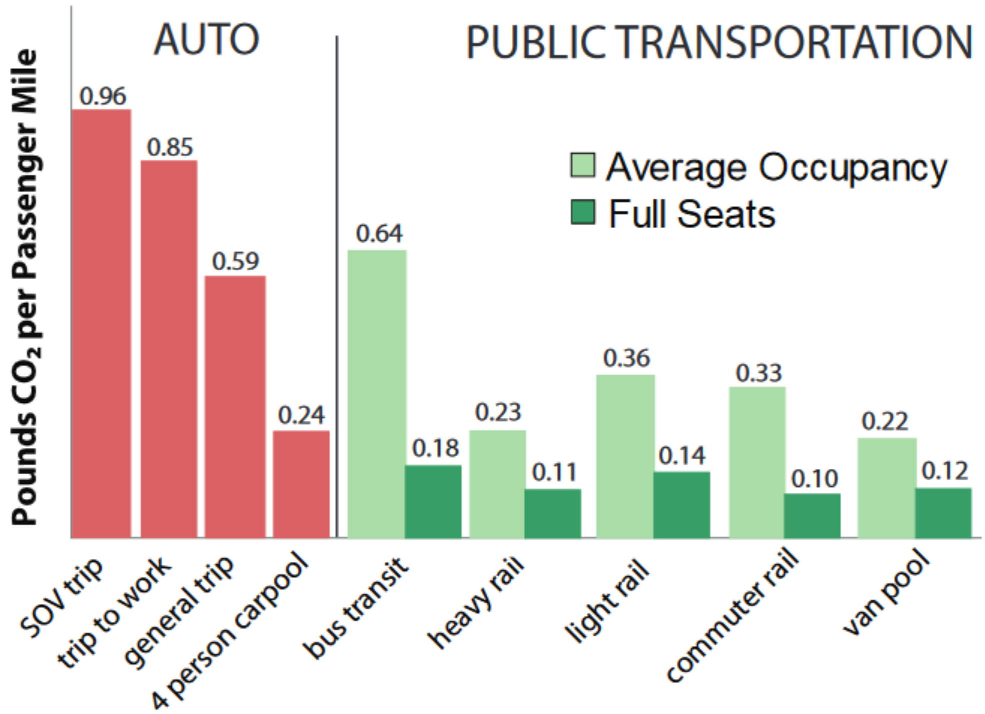


Figure 7. A comparison of average pounds of CO2 per passenger mile at average occupancy (28%) and full occupancy for various types of public transportation versus automobile trips (Hodges, 2010).

5.2 Water Runoff

Although difficult to calculate, it can be assumed that there will be less pollution from water runoff as long as the use of shuttles are reduced and/or eliminated. There would be less of a need for road maintenance and infrastructure, so long as ridership of shuttles is decreased and the use of them is reduced and/or eliminated. There is also potential for increased water runoff pollution. If this alternative causes students to drive individual cars, this would then increase water runoff pollution, road maintenance and infrastructure.

5.3 Energy and Natural Resources

Eliminating the need for the shuttle buses will positively affect energy and natural resources. Like in Alternative 2, a reduction in diesel usage, and other materials and substances, would reduce the overall consumption of energy and natural resources. But this would be a greater amount, because the fixed-route will not be needed.

5.4 Transportation

With this alternative, it is assumed that ridership would drop drastically. It is hoped that a behavioral change will revert students back to modes of transportation that they typically used before the universal bus pass was available, such as walking or biking. It is possible that with this drastic change, students may instead search for less sustainable alternatives, such as driving alone or carpooling to campus.

As mentioned in the fixed route, it is hard to quantify what will happen when changes take place to existing infrastructure. With the removal of shuttles to existing routes and decreasing accessibility, it is important to educate students on the benefits of walking or biking to campus instead, as a cheaper and healthier alternative to the bus. This will be an important mitigation measure to making sure that this proposed change goes smoothly when implemented.

5.5 Public Services and Utilities

If this alternative is introduced, the overall access to student population will go down. While it hopefully will not cost students any additional amount to receive a bus pass, it is possible that it will change the behavior associated with getting one. One foreseen consequence that can happen with this action, is that students who are used to taking the bus may continue doing so, instead of changing their behavior to an alternate mode of transportation. This can potentially overcrowd the stops around campus more than they are currently.

With potential for the student ridership to stay the same, it is also possible that this option can have a negative impact on the general public. It is not only students who benefit from the shuttle service around campus, but members of the general public as well, who also use these routes. If routes continue to back up further, it can force them to seek alternate modes of transport to their destination.

One benefit of this alternative is that with fewer buses on the road, less impact to infrastructure would take place. Specifically the impact on roadways will decrease from less bus traffic on a daily basis.

5.6 Environmental Health

5.6.1 Noise

Noise is likely to be decreased with this alternative, because the opt-out option will hopefully reduce ridership, and thus reduce and/or eliminate the added shuttles needed for high-ridership areas. But, there is a potential increase for student driving, which would then increase noise pollution, rather than decreasing it.

5.6.2 Public Health

Public health will likely increase because of this alternative. This alternative will expectedly reduce and/or eliminate the added shuttles, resulting in a decrease in emissions, and thus producing less harmful health effects. But, there is potential for increased student driving for this alternative, which would result in more cars on the road. If this results, then there would be an increase in emissions, and a decrease in public health.

5.7 Summary

Alternative	Impact
Air	+
Water Runoff	+
Energy and Natural Resources	+
Transportation	-
Public Services and Utilities	-
Environmental Health	+

+ **Positive Impact**
- **Negative Impact**
= **Equal Impact**

Figure 8. A summary of the overall impacts proposed alternative three has on each environmental element (WWU Shuttle Bus Analysis Group 2016).

6. Impact Matrix

Natural Environment	Air	Water Runoff	Energy & Natural Resources	Environmental Health	Noise	Transportation	Public Services	Utilities	TOTALS
Existing Conditions	-2	-1	-2	-2	-1	-1	-1	-1	-11
Electric Buses	2	1	-1	2	2	-1	-1	-1	3
New Route	1	1	-1	1	-1	1	0	-1	1
Opt-in Bus Pass	1	1	-1	1	0	-1	1	-1	1

Figure 9. A breakdown of the positive and negative impacts of the current conditions and the proposed alternatives (WWU Shuttle Bus Analysis Group, 2016).

Legend:
2 = significant positive impact
1 = minor positive impact
0 = no impact
-1 = minor negative impact
-2 = significant negative impact

6.1 Recommended Action

Our recommended action is Alternative 1, electric buses. We believe that converting the WTA's fleet to electric buses will be economically beneficial to them in the long-run while also having the greatest positive impact on the environment. While we realize that converting the whole fleet to electric buses may be economically infeasible in the short-run, they will save WTA the most money over time, as seen in Figure 12. Implementing a pilot program of four electric buses into WTA's fleet may exemplify their positive effects and provide information for decision making.

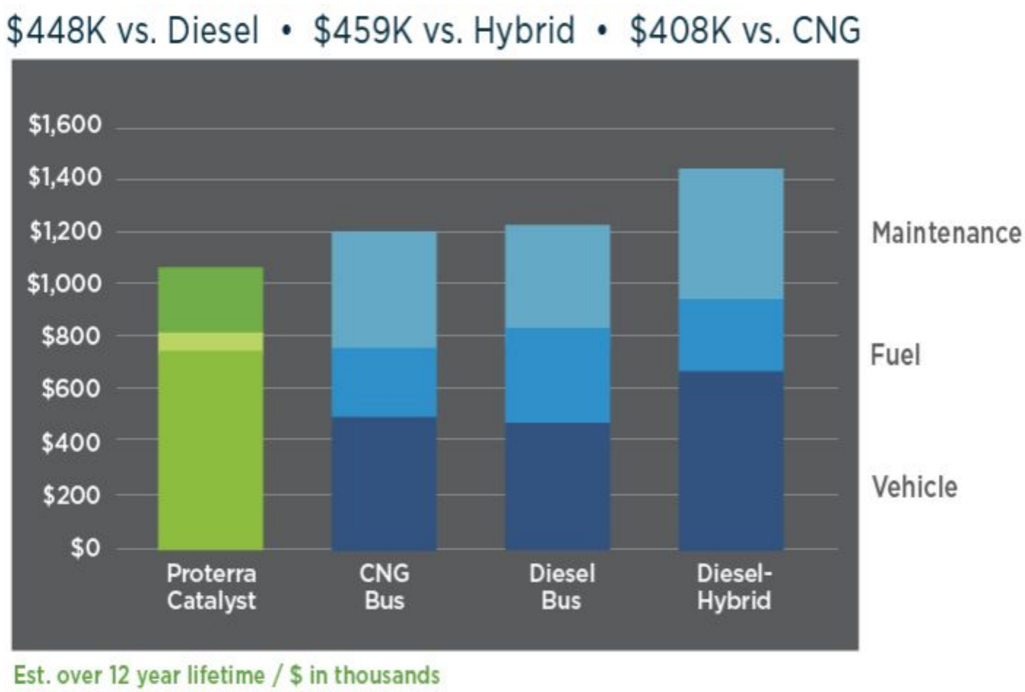


Figure 10. Comparison of cost savings between electric, CNG, diesel, and hybrid buses (Proterra, 2016).

7. Mitigation

All of the alternatives proposed should include an educational campaign. This campaign would promote alternative forms of sustainable transportation, such as biking and walking, in order to inform students of the positive health effects of non-vehicular transportation, and encourage lifestyle changes surrounding sustainable transportation. This educational campaign may be funded through the Sustainable Action Fund at

WWU, and work together with WTA, to educate students on the benefits of biking and walking.

The implementation of this campaign can help solve the shuttle bus problem. The root cause of the problem is students living in a one to two mile of radius of campus choosing to ride the bus out of convenience. As a result, ridership increased, and shuttles were added to accommodate. By implementing this campaign, it could educate students on the benefits of biking and walking, and hopefully reduce and/or eliminate the number of shuttles needed.

Appendices

For more information on the application of electric buses in public transit, the following sources are provided:

- http://www.transitchicago.com/
- https://www.ridetarc.org/

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