PORTA POSSIBILITIES: SMARTCART

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H.S.U. ENGR 215 IN COLLABORATION WITH ZANE MIDDLE SCHOOL

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1 Problem Formulation

1.1 Introduction

In Section 1 of the design process, Porta Possibilities provides an objective statement to summarize the final goal of the project. A Black Box Diagram shown in Figure 1.3.1 is used to demonstrate the initial problem and the desired output after completion.

1.2 Objective Statement

The objective of this design project is to develop a reliable cart to clean Zane Middle School's daily waste in preparation for recycling.

1.3 Black Box Model

The black box model, as shown below in Figure 1.3.1, is a visual representation of Zane Middle School's recycling cleaning process before and after the new recycling cleaning cart is completed.

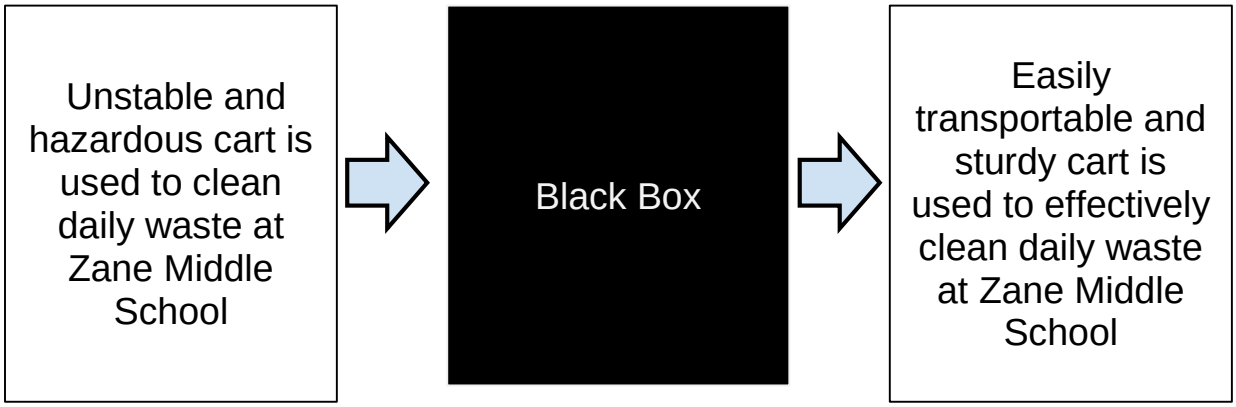

Figure 1.3.1: A Black Box Diagram displays a simplified view of the initial state of Zane Middle School's recycling cleaning system and the end goal of the design project.

2 Problem Analysis and Literature Review

2.1 Introduction to Problem Analysis

This Problem Analysis Section covers the goals and requirements that must be met to accomplish the objective discussed in the Section 1. Section 2 includes specifications and considerations that pertain to the provided weighted criteria. Usage and production volume of the recycling cleaning cart design are also discussed within the Problem Analysis.

2.2 Specifications and Considerations

Specifications and considerations are the requirements and characteristics of the cleaning cart based upon the client's needs, wants, and unique environment. Specifications and considerations for the Recycling Cleaning Station are described below.

2.2.1 Specifications

The specifications for the Recycling Cleaning Cart that must be met are:

- Can be used by 6-8th graders with adult supervision
- Cart can be moved by one individual
- Cart has controlled drainage system
- Cleaning station can be covered between uses
- Cannot fall over onto children or adults
- Does not spill water while moving
- Fits through gates and doorways
- Can be locked from rolling

2.2.2 Considerations

The considerations for the Recycling Cleaning Cart that must be met are:

- Keeps water warmer than room temperature for at least 5 hours
- Maximum cart width of 2.5 feet to ensure clearance through doorways
- Height of cart must be between 39-41 inches

2.3 Criteria

Criteria is provided below with specific constraints based on the client's vision and feedback. Each criteria is weighted on a scale from one to ten, ten being of highest importance. The criteria for the Recycling Cleaning Cart can be seen in Table 2.3.1 below.

Table 2.3.1: Criteria and Constraints for the Recycling Cleaning Station.

Criteria	Constraints	Weight
Portability	Cart can be transferred through narrow doorways and over a variety of uneven terrains	10
Durability	Cart can withstand daily use without degrading quality	9
Stability	Cart remains stationary when in use	9
Safety	Cart can be used by Middle School children with adult supervision	9
Ease of Cleaning	Cart needs little maintenance and is easily washed after use	8
Upcycled	Cart is made of as many upcycled materials as possible	6
Aesthetics	Cart is visually appealing	5

2.4 Usage

The client uses the current cart daily. The cart is filled with hot water behind the cafeteria at 7:30am before the Zane Middle School's breakfast ends. The cart is then brought into the cafeteria, after traveling approximately one-hundred feet. The cart takes narrow turns through a 2 ¾ foot wide gate and a 3 foot wide cafeteria door. A bird's eye view from Google Earth of the route traveled can be seen in Figure 2.4.1. The Cart is used to clean the recyclables from breakfast and is then left to sit until it is used again at the end of lunch at 1:00pm. Once all of the recyclables are cleaned inside the cafeteria, the cart is returned to behind the cafeteria to be emptied and cleaned.

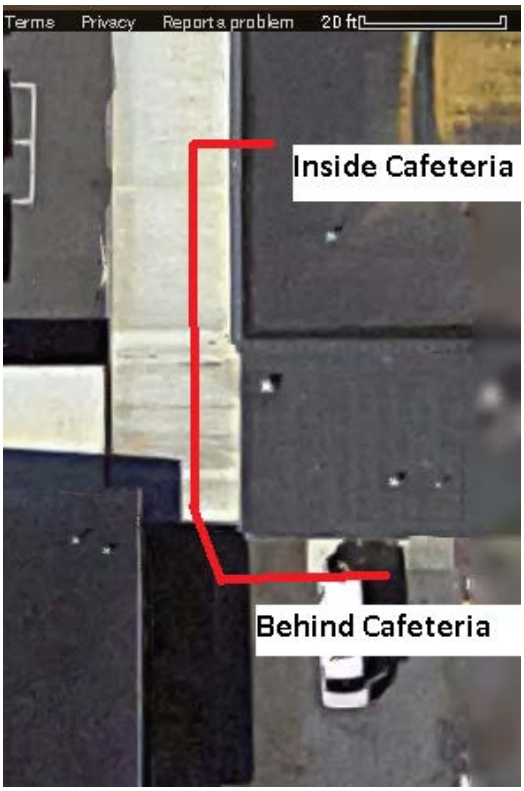

Figure 2.4.1: A bird's eye view captured from Google Earth of the path traveled by the cart at Zane Middle School. (https://www.google.com/maps/place/Zane+Middle+School/@40.7887889,-124.1461093,187a,20y,270h/data=!3m1!1e3!4m2!3m1!1s0x54d3ffc68973a4c1:0x57fe6cf77764b986)

2.5 Production Volume

Team Porta Possibilities will provide Zane Middle School with one cart that can withstand the daily use previously described in the Usage Section.

2.6 Introduction to the Literature Review

The purpose of this Literature Review is to provide relevant information and background for the Recycling Cleaning Cart design project. This Literature Review will cover the following topics: Client Criteria, Zane Middle School Daily Waste, Local Recycling, Upcycling, Recycling Cart Materials carts and School Regulations.

2.6.1 Client Criteria

Zane Middle School in Eureka, California is the client. The client has requested for an improved recycling cleaning cart so that Zane Middle School's daily recyclable waste can be cleaned with a reliable cart. Currently the cleaning process uses five gallon buckets on an unstable reused computer cart. The waste materials that are washed in the process are produced from Zane Middle School's daily breakfast and lunch served in the school's cafeteria.

2.6.1.1 Zane Middle School Daily Waste

Zane Middle School's daily waste consists of different types of materials. The majority of their waste consists of:

- 150 Plastic Cereal Containers
- 450 Milk cartons
- 500 Paperboard Lunch trays
- 300 Plastic Utensils
- 6 - 7 Large garbage bags of paper
- 7 Gallons of Milk

2.6.2 Milk Cartons

Milk cartons are made of 80% paperboard and 20% polyethylene. The polyethylene is applied to the cartons in the form of low-density polyethylene (#4 Plastic) wax (earth911, n.d). Examples of a standard milk carton structure are shown in Figure 2.6.1.

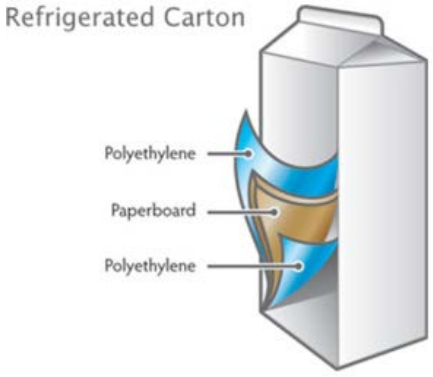

Figure 2.6.1: Milk Carton Packaging.
(http://www.earth911.com/news/recycling-mystery-milk-and-juice-cartons/)

2.7 Paperboard

Paperboard is a 100% recyclable material that can be re-recycled many times. The paperboard is soaked in water and then put through a "pulp"-machine and ground to a fine pulp. The new material is dried and formed into its new shape. Paperboard, including cardboard, is 100% environmentally friendly product. Although paperboard is essentially made without toxic materials, these products are very customizable and can be manufactured to order by the company that uses them. The production and recycling of the material processes are setup to remove heavy metals and other toxins (rpa100, n.d).

2.8 Local Recycling

The Humboldt Waste Management Authority is located in Eureka, California and includes a recycling center that accepts #1-7 plastic, glass, bi-metal, paper and aluminum. They also have facilities that take electronic waste, batteries and used oil. Plastic containers and bottles must be empty to be recycled. Milk cartons are not recyclable everywhere due to the polyethylene lining. To recycling milk cartons recycling facilities must use a process called hydro-pulping. Hydro-pulping is process where they can remove the polyethylene lining through placing the materials in a hot water bath in the tank that will separate the polyethylene and also Aluminum from the paper. From there the paper can be shredded and recycled (Schlesinger, 2007).

2.9 Upcycling

Upcycling can be defined as the process in which waste, or otherwise useless materials are transformed into products of better quality or are more environmentally friendly. Upcycling isn't constrained to any particular form of waste, and in fact, there has been numerous products made from all kinds of waste materials (Here, 2015). Both plastic and cardboard have potential to be upcycled. Either by reformation, combination, or repurposing the current state.

2.9.1 Repurposing

Upcycled plastic has been used for anything from plant pots to improving indoor lighting to creating pure carbon microspheres (Upcycling, 2015). Figure 2.9.1 shows how a plastic liter bottle can be converted into a plant pot (Recycled, 2015).

Figure 2.9.1: Two liter soda bottles are converted into planters with drainage. (http://www.brooklynseedcompany.com/wp-content/uploads/2013/02/DSCN2048.jpg)

Figure 2.9.2: A skylight made of a plastic bottle is used inside a Philippine home. (http://phys.org/news/2011-09-bottle-brighten-millions-poor-homes.html)

2.9.2 Reformation

For the most part, the examples above have all used upcycled plastic in their original form. This is, however, not a limitation to upcycling plastic. Projects have been done in which the plastic is shredded then melted and formed into a shape using a mold as displayed in Figure 2.9.3 (Atomicshrimp, 2015). This technique of upcycling allows for creativity because molds can be made into anything. Although these are only a few examples of plastic upcycling, countless projects have been done.

Figure 2.9.3: A plastic bowl is made from shredded plastic caps. (http://atomicshrimp.com/post/2011/06/16/More-Plastic-Recycling-Experimental-Stuff)

2.9.3 Combination

Upcycling projects can also be done using reused cardboard. Upcycled cardboard can be used for art projects and indoor furniture. Sculptures and artwork can also be made from reused cardboard as seen in Figure 2.9.4 (Web Ecosit, 2015).

Figure 2.9.4: Cardboard artwork created by Ohio artist Mark Langan.
(http://webecoist.momtastic.com/2010/02/03/corrugated-art-incredible-upcycled-cardboard-sculptures/)

Figure 2.9.5: Layered cardboard is made into a seat.
(http://www.treehugger.com/travel/summing-yok-casa-cultura-upcycled-cardboard-furniture-voc-free-paint-and-sustainable-tourism.html)

2.10 Cleaning Cart Materials

This section of the Literature Review is going to provide specific information about the potential materials for the Recycling Cleaning Cart.

2.10.1 Plastics

Plastics, or synthetic polymers, are artificially manufactured materials that make up most man-made materials. The majority of plastics are derived from carbon containing vessels, such as petroleum oil and natural gas. Today, some are now being made out of organic waste. Each single molecule in plastic is called a monomer. During a chemical reaction called polymerization, monomers connect to form polymers, the basic building blocks of plastics. They are then heated and molded to form the things that make up humans daily lives (NoblePrize, n.d).

There are many types of plastics. Properties of each plastic are reliant on what the polymer chains look like. In order to identify different plastics, one must look somewhere on their product to find a small resin number that will inform on the type. This section is going to describe the 7 most common commercial plastics used, their properties and purposes. This section will also give a brief outlook to how recyclable each type of plastic is. These seven main plastics can all be recycled, but it depends on whether or not the local recycling company will accept certain types based on the plastics properties.

2.10.1.1 #1 Polyethylene Terephthalate

Polyethylene Terephthalate is also referred to as PET. Polyethylene Terephthalate is classified as a thermoplastic polyester resin. Polyethylene Terephthalate resins are commercially produced from ethylene glycol and either dimethyl terephthalate or terephthalic acid (EPA, 1995). The equilibrium melting point was determined to be 564+/-2 Kelvin (X.F. Lu, J.N. Hay, 2001). When Polyethylene Terephthalate is recycled it has a 19.5 percent of total recovery (EPA, n.d). Polyethylene Terephthalate is considered to be the easiest plastic to recycle and will be turned back into plastic items such as plastics bottles and carpets. (Wastecare Corporation, n.d.). Yet Polyethylene Terephthalate is easily contaminated by the adhesives used for the labels and base cap. Even after commercial washing some adhesive residues are trapped in the Polyethylene Terephthalate causing the recycled Polyethylene Terephthalate to be discolored (Baum, Burnett et al. 1992). Some examples of products made out of Polyethylene Terephthalate are soft drink bottles, water bottles and vegetable oil containers.

2.10.1.2 #2 High Density Polyethylene

High Density Polyethylene is commonly abbreviated into HDPE. High Density Polyethylene is a thermoplastic material made up of carbon, hydrogen atoms and ethylene. These elements form together to make a high molecular weighted product. High Density Polyethylene has a greater proportion of crystals which results in High Density Polyethylene have a greater density and strength (Lester H, n.d). The melting point of High Density Polyethylene is 130 degrees Celsius (eng.buffalo.edu, n.d). After recycling the total amount of High Density Polyethylene recovered is 10.7 percent (EPA, n.d). Examples of High Density Polyethylene are as milk containers and laundry soap container.

2.10.1.3 #3 Vinyl

Vinyl plastic is also known as Polyvinyl Chloride (PVC). Since Vinyl plastic contains chloride in the form of vinyl chloride it poses as a health hazard. Short periods of time exposed to high concentrations of vinyl chloride has caused dizziness, drowsiness and headaches (EPA, 2001). There are also other harmful chemicals found in Vinyl plastic like lead and Ethylene Chloride (Sea Studios Foundation, n.d). Vinyl plastic recycling is not encouraged since just one Vinyl plastic bottle in 100,000 Polyethylene Terephthalate (#1 Plastic) bottles will contaminate the entire load. This factor is a threat to cost-efficient recycling and is not favored since the

plastics look so alike (Anderson, n.d). Examples of Vinyl plastic are liquid clearer containers and shampoo bottles.

2.10.1.4 #4 Low Density Polyethylene

Low Density Polyethylene is also commonly referred to as LDPE. Low Density Polyethylene is usually a transparent opaque color that is very flexible. Low Density Polyethylene is also made up of high pressured ethylene. Low Density Polyethylene has a melting point of 120 degrees Celsius (Dynalab Corp, n.d). Low Density Polyethylene is not usually recycled (Smart Plastic Guide, n.d). Examples of products made up of Low Density Polyethylene are plastic bags and squeezable bottles.

2.10.1.5 #5 Polypropylene

Polypropylene plastic often referred to as PP, is commonly used for packaging, automotive parts and different types of containers (CalRecycle, n.d). Polypropylenes have a low density and great strength and stiffness which makes it very versatile. It have a high melting point that ranges from 160 to 170 degrees Celsius and also a very strong chemical resistance, but polypropylene products become unstable when they experience conditions of oxidation and UV radiation (Dominick, 1993). Polypropylene is not easily recycled (eng.buffalo.edu, n.d).

2.10.1.6 #6 Polystyrene

Polystyrene can come in a solid or foamed form. The solid form is usually clear, brittle and hard. The foamed or expanded form, commonly referred to as Styrofoam is softer and generally used for the insulation of hot beverages. The majority of polystyrene products are not recycled and therefore build up in the ocean where they disturb aquatic life and it takes several decades to hundreds of years to deteriorate (reuseit, n.d). Polystyrene products are also likely to leach styrene, an endocrine disruptor and human carcinogen. It should be avoided, especially when in contact with food or drink (Chin, 2011).

2.10.1.7 #7 Miscellaneous

Number 7 plastics usually fall into the category of other, meaning they are not composed of plastics #1 through #6. Sometimes they are a mixture of safe plastics, but it is best to do research on specific #7 plastic in terms of health hazards. The most common number #7 plastic is Polycarbonate which has been proven to leach bisphenal-A, a hormone disruptor when exposed to heat or acidic solutions (reuseit, n.d).

2.10.1.8 Melting Plastic

In commercial recycling companies, workers use injection molding machines to melt and repurpose plastic. The machines use different methods to chop up the plastic into small pieces. Then the small pieces are melted down into molten material and place it in a mold where it is pressed until it cools and the new product is formed. The safest and best plastics to melt are #2, #4, and #5. These release the least chemicals, but precautions must be taken whether in ventilation or containment of the hazardous fumes. Melting and repurposing plastic can be a much better act for the environment if you do not overheat the plastic and cause more fumes than intended. That is why it is important to be aware of the types of plastics being used and their melting points. The mold for the plastics must have either a clay, liquid, metal, glass or powdered plastic inner layer for the plastic to cool on, but a releasing agent must typically be used to remove the final product (Aric, 2013).

2.10.2 Sinks

There are many types of materials sink can be made from. Common materials for sinks to be made out of are different types of metals, ceramic and rock mixtures. This section will be describe two different types of sinks, stainless steel and ceramic.

2.10.2.1 Stainless Steel

Stainless Steel sinks are commonly used in restaurants due to the easy to clean stainless properties. Stainless steel contains chromium, which creates a chromium oxide film that protects the material from being stained or oxidized, hence the name stainless (BLÜCHER, 2015). This film protects the steel from oxygen in surrounding air and water (BLÜCHER, 2015). If a section of the steel is exposed to oxygen, the chromium oxide film automatically regenerates covering the exposed steel and provides the sink with a shine which can be seen in Figure 2.10.1 (BLÜCHER, 2015).

Thermal Conductivity is the amount of heat a substance can hold for a unit of time. Stainless Steel has a thermal conductivity of 16 W/mK (engineeringtoolbox, n.d). The units W/mK represents how many Watts are lost per one meter thickness of the material in Kelvin (Koolance, n.d).

Figure 2.10.1: Demonstrates a basic stainless steel sink with two sinks.
(http://www.made-in-china.com/showroom/jkysinks/product-detailMbJntVuHhBkN/China-Stainless-Steel-Kitchen-Sink-3218-.html)

2.10.2.2 Ceramic

Ceramic also known as porcelain, is commonly used for kitchen and bathroom sinks. Porcelain sinks are easy to clean, but may discolor and become stained over time as seen below in Figure 2.10.2 (Pearson, n.d). Porcelain has a very low thermal conductivity of 1.5 W/mK which means it loses heat at a very slow rate (engineeringtoolbox, n.d).

Figure 2.10.2: Reveals hard to remove stains on a basic porcelain sink.
(https://www.pinterest.com/pin/191684527862921887/)

2.10.3 Wheels

Wheels can vary in material, size, hardness and tread. Wheels can be made out of metal, phenolic resin, plastic, rubber and pneumatic rubber depending on where they will be used (MHI, n.d). Considerations for wheel design includes: the weight the wheels will be hauling, the terrain that they will be wheeled over, the appropriate amount of operating noise, the environment the wheels will thrive in and how often the wheels will be used. For example, daily use over cement and asphalt require high shock absorbing and durable tires (Bickle, n.d). This section will describe pneumatic tires and elastic solid rubber wheels.

2.10.3.1 Pneumatic Tires

Pneumatic tires are made out of soft rubber and contain compressed air inside their usually large diameter. This along with a grooved outer tread, makes pneumatic tires very good at absorbing shock and provides a low rolling resistance when going over uneven surfaces. Pneumatic tires last longest in environments with temperatures between -30 to 50 degrees Celsius and are also resistant to many aggressive substances besides oils. They are typically used as bike wheels or for garden wagons because they can haul a large mass over unpredictable surfaces with little vibration (Bickle, n.d).

2.10.3.2 Elastic Solid Rubber Wheels

Elastic Solid Rubber wheels have a smooth rolling quality that can carry a huge load with little vibration. They can thrive in a wide variety of temperatures from -30 to 80 degrees Celsius. Similar to Pneumatic tires, elastic solid rubber wheels are also resistant to many aggressive substances, not including oil. Overall, they are easily pushed over different surfaces giving them a high operational comfort (Bickle, n.d).

2.10.4 Drainage

There are mainly two different types of pipes and fittings used in drainage, waste, and vent systems. This section will cover Polyvinyl Chloride and Acrylonitrile Butadiene Styrene drain materials.

2.10.4.1 Polyvinyl Chloride

Polyvinyl Chloride is widely known as “PVC”. Polyvinyl Chloride has certain qualities that make it an exceptional pipe for drainage waste and vent systems. In Figure 2.10.3 a common Polyvinyl Chloride pipe can be seen.

Figure 2.10.3: A common Polyvinyl Chloride pipe. (http://www.plumbinghelp.ca/pipes.php)

Polyvinyl Chloride has a maximum service temperature of 140 degrees Fahrenheit (Temperature, 2015). This allows for hot water to move through the pipes with no damage to the system. Polyvinyl Chloride is also flexible and can be installed underground in seismic zones (PVC, n.d). Although these are good qualities for a drainage system, there is however bad qualities that Polyvinyl Chloride also possesses. Polyvinyl Chloride itself is a carcinogen. Dioxins and other carcinogens are the byproduct of Polyvinyl Chloride production. Polyvinyl Chloride is also not able to be recycled, and is not biodegradable (Plastic, 2015).

2.10.4.2 Acrylonitrile Butadiene Styrene

Acrylonitrile Butadiene Styrene is better known as "ABS". It is a thermoplastic polymer that has many uses. One of these uses is for drain-waste-vent pipe systems. A common Acrylonitrile Butadiene Styrene drainage pipe can be seen below in Figure 2.10.4.

Figure 2.10.4: A common Acrylonitrile Butadiene Styrene pipe used for drainage systems. (http://www.rona.ca/en/abs-pipe-00685481--1)

A benefit of using an Acrylonitrile Butadiene Styrene drainage system is the material's wide operational temperature range. For a system that is said to have no-pressure, or a static head that does not exceed 15 pounds per square inch at any point in the system, Acrylonitrile Butadiene Styrene piping can be used from 0 to 180 degrees Fahrenheit (ABS Guide, n.d). Because of the smooth inside lining of Acrylonitrile Butadiene Styrene drainage system, there is no buildup of limescale. Limescale is a chalky deposit that commonly builds up in hot-water drainage systems.

The installation of an Acrylonitrile Butadiene Styrene drainage system is fairly simple and requires few steps for joining pieces. Unlike comparable Polyvinyl Chloride systems, there is no primer needed. Connections between pipes are made by solvent cemented joints with low volatile organic compounds. The connections are made with no heat or additional operations (ABS, 2015). Appendix B demonstrates the simple step by step process to assemble Acrylonitrile Butadiene Styrene piping.

2.10.5 Steering

Depending on what you are guiding, the maneuverability of an object is highly dependent on what type of steering system is implemented. This section will discuss Particular and Wagon style steering.

2.10.5.1 Particular

Particular style steering is simply a handle to push. The Particular type of steering is often paired with an object that can easily change directions, or has pivoting wheels. There are numerous objects that use this style of steering. Figure 2.10.5 below is one example of this Particular style of steering. Particular steering can be effective when the cart is equipped with pivoting wheels, allowing the cart to be turned and controlled easily.

Figure 2.10.5: The cart above has a handle for Particular steering. (http://www.blackjackgroutpumps.com/package_d-eh.htm)

2.10.5.2 Wagon

Another style of steering is Wagon style steering. Wagon style steering consists of pulling a handle to maneuver an object. In the case of carts, the handle is typically attached to two wheels. The two wheels are guided by the direction of the shaft that is attached to the handle. If the handle is moved side to side, as are the two wheels. With this Wagon style, the wheels are constricted to the direction of the handle. This is quite different when compared to the “free” direction wheels of the Particular style. This wagon-style of steering system is commonly seen in wagon carts. In Figure 2.10.6 an example of a Wagon style steering system can be seen.

Figure 2.10.6: Example of wagon style steering in which the direction of the cart is dependent on the direction of the handle’s shaft. (http://www.amazon.com/outdoor-garden-carts-bins/b?ie=UTF8&node=917870)

2.11 School Regulations

As there should be, multiple clauses in the California Education Code were created to ensure the safety of faculty and students. The California Education Code Title 1.Division 4. Part 27. Chapter 8. Article 4.49341 Clause B. states that it is desired of the state to have a trained staff member that is a designated lab consultant responsible for laboratory safety (CALIFORNIA, 2015).

Clause C declares that the current effort to provide programs to train staff is inadequate and should be fixed. Clause B points at the state to assume leadership and provide guidance and implementation through the State Department of Education to provide training programs (CALIFORNIA, 2015).

The previous two clauses are clearly for the safety of the students and faculty. The last clause in the article gives concern for not only the humans involved, but, in addition, the ecosystem in which they live. Article 4 is concluded with Clause D that requests that the State Department of Education consider making the training program a part of the energy and environmental education program. With these codes in effect, the well-being of the students, faculty, and environment are insured (CALIFORNIA, 2015).

3 Alternative Solutions

3.1 Introduction

The Alternative Solutions Section demonstrates different designs that originated from the brainstorming process. Each design meets the needs of the client through the criteria and specifications for a portable station to clean recyclables. A total of nine different Alternative Solutions were developed from individual brainstorming and one group brainstorming session.

3.2 Brainstorming

Each member of Porta Possibilities brainstormed individually in preparation for the group brainstorming session that took place on February 26, 2015. We begin by broadly sharing and illustrating all of our ideas. Then, as a group we collectively narrowed down which design aspects to continue with and disposed of impractical designs. We have found that a large blank surface and some markers is effective for the success of our brainstorming, which we found in Science D, Room 23. Notes from the brainstorming process can be seen in Appendix A.

3.3 Alternative Solutions

A description of each design and its functions is discussed before the illustration of the design. Each member of Porta Possibilities created three designs. Below is a list of the names of the Alternative Solutions determined to be the most suitable recycling cart options to be evaluated for the final design.

- Easy Rider
- The Janitors Friend
- The Carton-Wheel
- The Box of Doom
- Bucket-About It
- The Let It Slide
- Up The Ante Cart
- Two Can Play That Game
- The Captain of Crush

3.3.1 Easy Rider

Easy Rider has several features that allow for easy transportation. It features two bike wheels on one side of it, and two pegs on the other side. On the side of the pegs it has a handle that is used to lift the rear end during transportation. Most of the components of the cart, including the storage tank and the drain, are on the wheel side of the cart. They are on this side to take weight off of the other side, allowing it to be easily lifted. The two bike wheels increase the range of the carts mobility, and make for a smoother ride because of the inflated tires. The frame is from an upcycled cart. There is a stainless steel sink in the middle of the frame. Dimensions and labels are as shown in Figure 3.3.1.

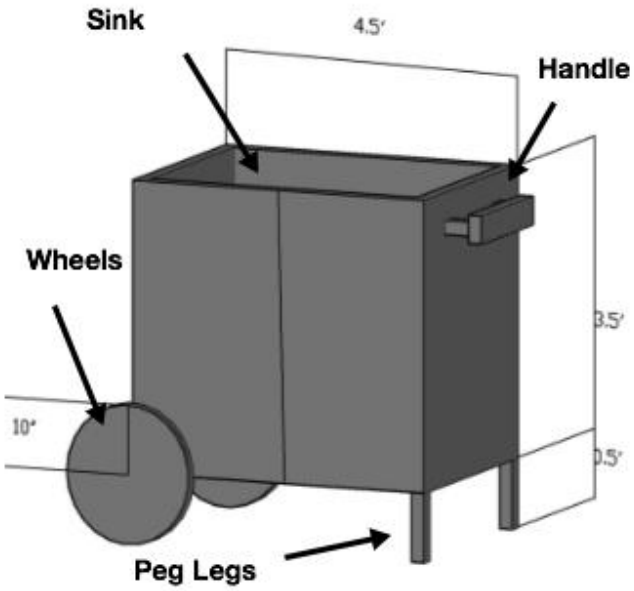

Figure 3.3.1: Easy Riders placement of Components make lifting during transportation easy. (Design by Brent Davis)

3.3.2 The Janitors Friend

The Janitors Friend is a modified janitor's cart. A used janitors cart is chosen to reuse a cart that no longer serves a janitor's' needs, but can be used and modified to meet the client's needs. A janitor's cart is a reliable and sturdy frame to ensure durability and the safety of children. Most janitor's carts are made of hard plastic with two basic cut out handles for easy Particular steering and equipped with elastic solid rubber wheels. The Janitors Cart, which is illustrated in Figure 3.3.2 and Figure 3.3.3 comes with a garbage bag holder area that has a shelf underneath. The Two separate sinks provide the client to use one sink with soapy water, and the second sink to have clean rinsing water. The sinks are made out of reused plastic bins in order to have upcycled aspects. The area under the sinks is utilized with drawers for storage. Behind these drawers are the sinks separate drainage system demonstrated in Figure 3.3.3. The drainage system is an easy, one valve system for each sink, with an activation handle. This drainage system provides the client with an easy to drain process.

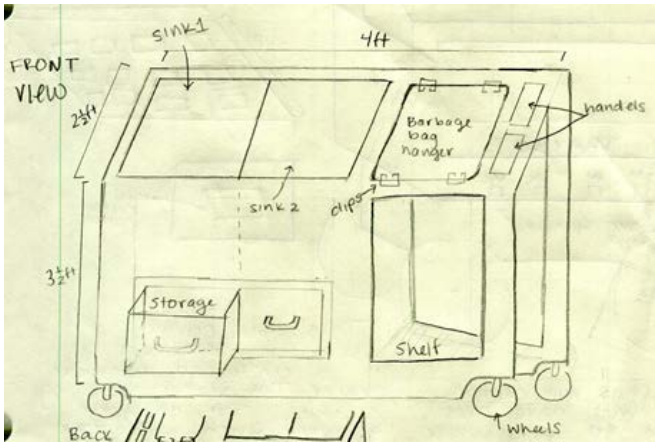

Figure 3.3.2: Shows the front view of The Janitors Friend that comes with a garbage bag hanging area, four wheels, two drawers, two sinks, and two handles.
(Design by Merissa Coello)

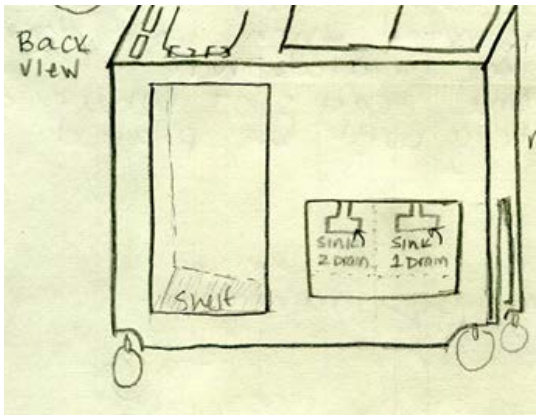

Figure 3.3.3: Show the back view of the Janitors Friend showing the two separate drains for each sink (Design by Merissa Coello).

3.3.3 The Carton-Wheel

The Carton-Wheel has two rectangular sinks, parts E and F made out of stainless steel on its base. One of the sinks, E uses soap while the other, F only uses clean water. This is why they have separate draining containers underneath each sink. Each sink also has a drain that can be plugged by a rubber piece. The water from sink F that does not use soap, can possibly be reused to water the garden, whereas the other soapy water will be directly drained and sent to a water treatment plant. Each sink has a faucet that has a retractable head so it can be used in other places besides the sink. The base where the sink is placed is made out of upcycled plastic.

Piece A is used to clean the milk cartons. It is in the form of a wheel, so open and empty milk cartons are placed all around the wheel. The bottom of the piece A is a large suction cup that is stuck on area 1 of the sink. The wheel is then spun by the two vertical sticks on its side so water from the sink can quickly clean out many open milk cartons. The milk from the milk cartons is disposed in piece B, a basic bucket after being strained through piece C. Piece D of the cleaning cart is an extra space where the bucket (Part B) can be placed. Part D can also fold upward over sink E and latch itself between the two sinks so that it can insulate and contain warm water for longer periods of time. Part D also folds down by the wheels to conserve space if needed. The two wheels are made out of rubber so that they do not bounce around on asphalt or spill water easily. The cart

is held stable by to wooden pegs on the other side of the cart. The cart has a wooden hold on the end with the wooden pegs where it is pushed and easily fit through narrow doorways.

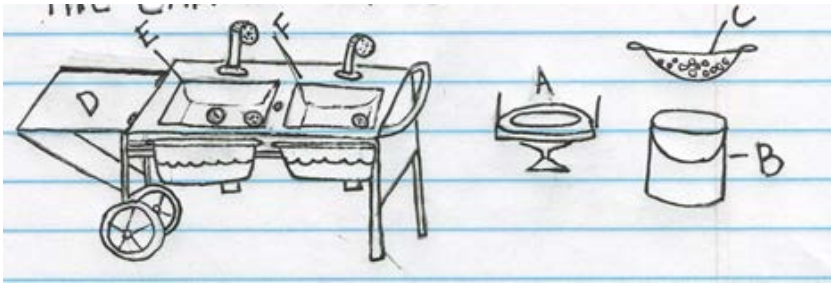

Figure 3.3.4: The Carton-Wheel contains: A) milk carton cleaning rack, B) milk bucket, C) milk bucket strainer, D) shelf, E) sink using soap, F) sink using water.
(Design by Erin McDannold)

3.3.4 The Box of Doom

The Box of Doom is a portable Recycling Cleaning Station. The Box of Doom can be seen in Figures 3.3.5-7. The Box of Doom is a contained automatic cleaner that can only be activated when the door are closed which can be see Figure 3.3.5. For the milk cartons to be cleaned the water sprayers will be activated from a switch once the doors are closed. The doors and entire box are made up of reused stainless steel, while new stainless steel slabs cost from $1000-3000 for 500 kilograms. The Box of Doom cart has four recycled bike tires used as wheels. There is one tray slot where the one tray can be placed. The tray can be seen in Figure 3.3.6. This single tray is made up of recycled stainless steel pieces. The tray can hold 12 milk cartons at a time. The trays milk carton holders have holes in them for the water to be squirted through which can also be seen in Figure 3.3.6. The water used to clean the milk cartons is contained in a tank that can be drained manually. There is also a water-in adaptor that can connect to an average hose. Both the drain and the hose adaptor can be seen in Figure 3.3.7. Figure 3.3.7 also demonstrates the attachable milk discard bucket with a built in strainer top providing the client with the ability to easily remove leftover food from the milk container. The bucket attaches to the Box of Doom cart, which can also be seen in Figure 3.3.7.

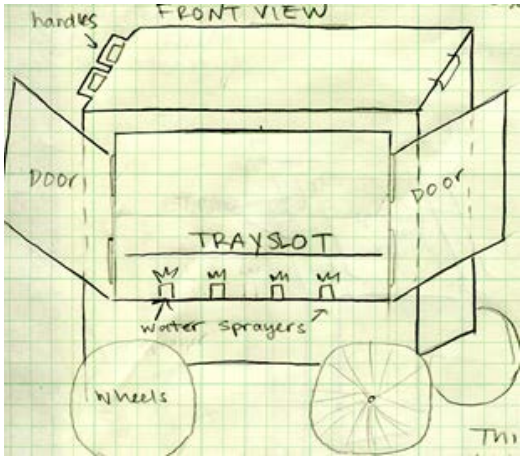

Figure 3.3.5: Demonstrates the front view of the Box of Doom cart, this cart includes four wheels, two doors, one tray slot, multiple water sprayers, and handles.
(Design by Merissa Coello)

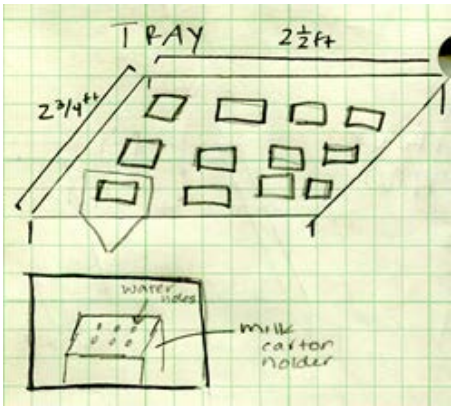

Figure 3.3.6: Shows the tray used in the Box of Doom that holds 12 milk cartons. (Design by Merissa Coello)

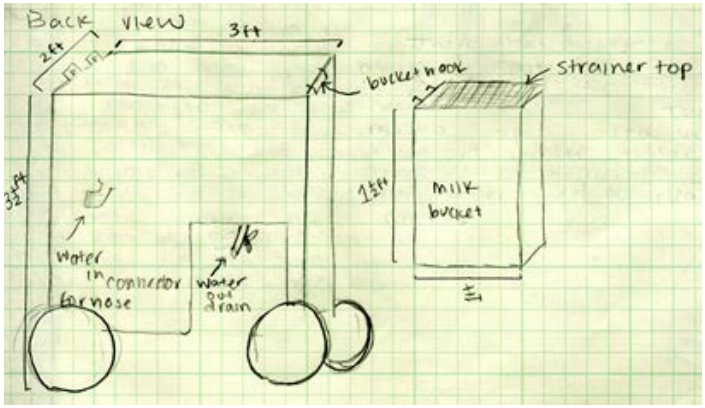

Figure 3.3.7: Shows the back view of the Box of Doom with the hose adaptation, drain and the attachable milk bucket. (Design by Merissa Coello)

3.3.5 Bucket-About it

The Bucket-About it cart has three rectangular bucket sinks made out of upcycled plastic on its top frame. Bucket A is where the milk from the cafeteria milk cartons is disposed after being strained through part E. Bucket sinks B and C are used to clean the cafeteria silverware and cartons. All of the buckets can be pulled off of the cart by their handles and covered with part D, a basic plastic bucket cap to insulate and store warm water more easily. There is one retractable faucet between bucket sinks B and C that hooks up to a hose. Eight open and empty milk cartons can be cleaned at a time by placing each carton in a snug box hold in piece G. Piece H attaches to the retractable faucet and is used to power wash the eight cartons placed in part G. After being washed, part G is then flipped and held by a handle on its opposite side in order to drain the eight cartons into sinks B and C. The second level of the cart contains the separate drainage tanks. Sink B drains water that contains soap so it can go to a water treatment plant and sink C only uses water which may be reused. The water from sink B and C are stored in a storage tank F. The second level also leaves extra room for storage. The cart has four wheels which are all made out of elastic solid rubber so they did no wobble over asphalt. Wheels one and four have stoppers on them to hold the cart in place when in use. The cart is mainly made out of different upcycled plastics including the handle on the right side used to push the cart through narrow doorways.

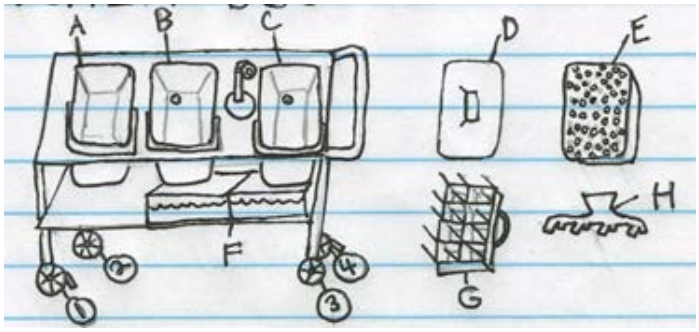

Figure 3.3.8: Bucket-About it contains: A) milk bucket, B/C) normal sink, D) lids, E) milk bucket strainer, F) sink storage container G) milk carton holder H) power washer.
(Design by Erin McDannold)

3.3.6 The Let It Slide

The Let it Slide is an adjustable cleaning cart. The frame of the cart, as well as cabinets are made of upcycled stainless steel. The top of the cart is made of 1/8 inch sheet metal attached to a stainless steel reused sink by caulking. The cart features a convertible layer of sheet metal. The purpose of this particular layer is to both, lay atop of the sink to insulate heat within the sink and to also provide extra counter space when the sink is being used. The cart has four elastic solid rubber wheels on the bottom to allow for easy transport. A small storage tank as well as a drainage system is built into the cart. Dimensions are as shown on Figure 3.3.9.

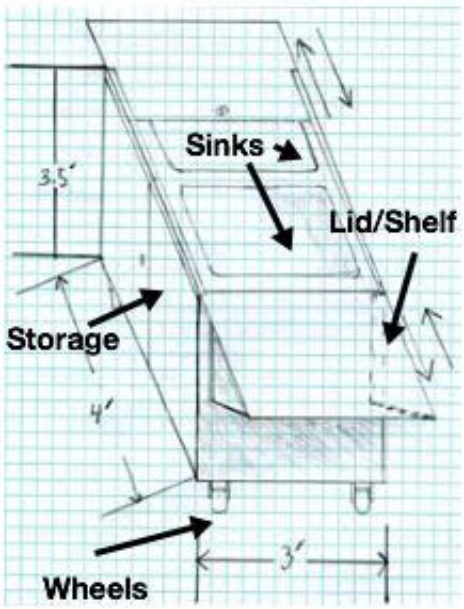

Figure 3.3.9: Adjustable counter space serves multiple purposes in the Let It Slide.
(Design by Brent Davis)

3.3.7 Up the Ante Cart

The base of the Up the Ante Cart design is made out of different upcycled plastics. The two rectangular sinks, parts A and B are made out of stainless steel and contain a drain in the bottom inner corner. The drains go into separate drainage containers in the middle of the second level of the cart. Sink A uses soap and water that can be disposed in a sewage drain to go to a water treatment plant and sink B only uses water that can possibly be reused. The second level of the cart also contains extra space for storage. Part E, a basic bucket, is placed in hole D where the milk from the milk cartons can be disposed after being strained through part F that goes on top of part E. Each sink has a hole in the bottom middle that a hose can attach to. Twelve empty and open milk cartons are then placed in the snug boxes of part C and then flipped upside down used to cover the sink. The hose placed at the bottom of the sink then pressure washes the inverted carts. The cart has two large pneumatic rubber wheels on its front side that keep it from wobbling on asphalt and two wooden stilts on its backside to keep it stable while in use. It is pushed by a wooden handle on its backside and can easily pass through narrow doorways.

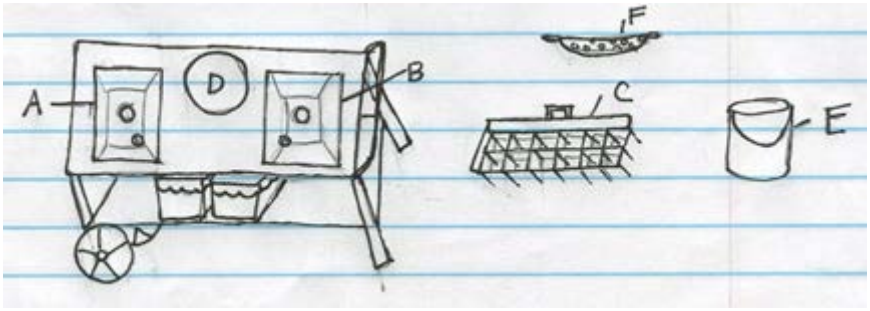

Figure 3.3.10: Up The Ante Cart contains: A/B) sinks, C) milk carton holder D) milk bucket space E) milk bucket F) milk bucket strainer. (Design by Erin McDannold)

3.3.8 Two Can Play That Game

Two Can Play That Game is a mobile Recycling Cleaning Station that can be seen in Figure 3.3.11. The cart provides two separate sinks and is designed to be wide enough to fit two milk carton trays in a sink at a time. The trays are made out of a wire frame with wire milk carton holders, each tray has 9 wire milk carton holders. The frame of the Two Can Play That Game cart is made out of discarded lumber. The Two Can Play That Game cart has two sinks in it that are made of recycled stainless steel sinks in order to use recycled materials. Sink 1 is for the primary rinse with soapy water to rinse out the leftover milk, while the second sink provides an area for the secondary rinse with normal water for the final rinse. Each sink has a separate manual drainage system activated with one faucet style valve. The faucet style valves are reused part from backyard watering systems. Each sink has one lid that can fold over the side for full access to the sink from both sides; this is where the name Two Can Play That Game was originated. The lids are made out of recycled flexible plastic that are easily cleaned after use. This cart has 4 recycled pneumatic wheels to absorb the shock of the uneven pavement. The Two Can Play That Game cart has an area where a garbage bag can be hung for easy placement of the cleaned milk cartons. This cart also has two handles for easy Particular steering.

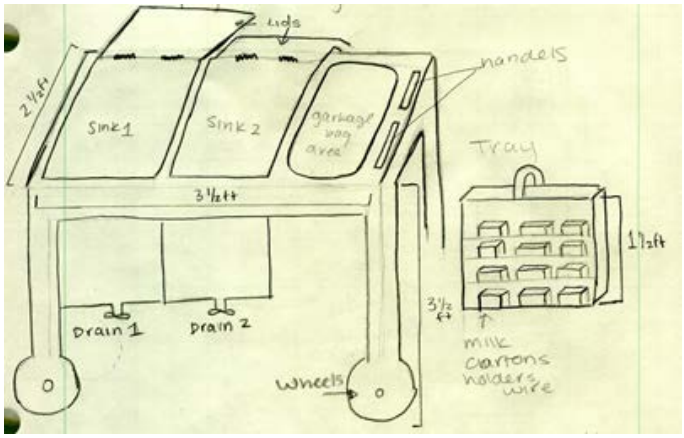

Figure 3.3.11: Shows the Two Can Play That Game Design which includes two trays, two sink with personal drains, garbage bag holder, four wheels, two lids, two handles and one cart frame.
(Design by Merissa Coello)

3.3.9 The Captain of Crush

The Captain of Crush has an incorporated crusher that can be used to crush milk cartons. This crusher will make the process of cleaning cartons more efficient. The crusher is a metal plate that rests just inside the cart walls next to the handle. Moving the handle in the vertical direction, either up or down, results in movement of the plate as well. When the handle is moved all the way down, the plate pushes against the bottom layer of the cart. Milk cartons can be placed in this designated area to be successfully crushed. The handle for the crusher serves both as a lever for the carton crusher and also as a handle to pull the cart as displayed in Figure 3.3.12. This wagon style steering makes maneuverability and transportation easy. The Captain of Crush also has elastic solid rubber wheels, and a cabinet for storage next to the sink basin and drainage system. It features a stainless steel sink, and a repurposed metal cart as the frame.

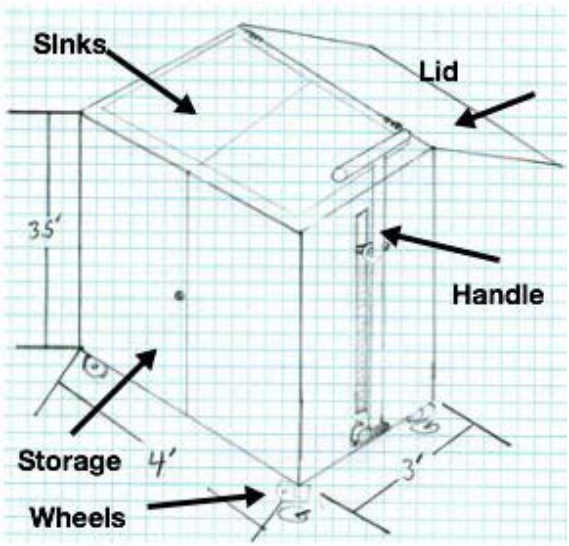

Figure 3.3.12: The Captain of Crush cart has an operable handle for both transportation and crushing purposes.
(Design by Brent Davis)

4 Decision Process

4.1 Introduction

Section 4, the Decision Process, evaluates the Alternatives Solutions discussed in Section 3 to determine an ultimate solution. Section 4 uses a combination of a Delphi Matrix Method and a Pro/Con Chart to identify the final solution. By using the client criteria discussed in Section 2, the Delphi matrix method helps to narrow down the best solution based on the criteria, and the pro/con list helps to reveal which aspects of each Alternative Solution should be included in the final design.

4.2 Criteria Definition

A list of criteria specified by the client is given below to help identify project goals. Each criterion is described in detail to determine which alternative solution will best fit the client's needs.

Portability: The final products ability to be transported throughout the school grounds and on different terrains for different phases of the recycling/washing process

Durability: The ability of the final product to withstand extensive use and any weathering the product may experience in its regular usage

Stability: The cart remains stationary when in use

Safety: The ability for middle school students to operate the final product under adult supervision with little to no risk of injury to themselves or others involved in the cleaning process

Ease of Cleaning: The ability of the operator to effectively disinfect and keep the cart sanitary and ready for use

Upcycled: The products overall percentage of recycled/upcycled materials for a more sustainable and cost effective product

Aesthetics: The cart is visually appealing and promotes school spirit

4.3 Alternative Solutions

The following is a list of Alternative Solutions that are evaluated to determine a final solution. A description and illustration for the each design is provided in Section 3 of the document.

- Easy Rider
- The Janitors Friend
- The Carton-Wheel
- The Box of Doom
- Bucket-About It
- The Let It Slide
- Up The Ante Cart
- Two Can Play That Game
- The Captain of Crush

4.4 Decision Process

A Delphi Matrix Method and a Pro/Con Chart are used to decide on a final design. The Delphi Matrix Method is used by determining a weight for each criterion on a scale of one to ten and then determining a weight on a scale from one to fifty based on how well the alternative solutions fit each criterion. The criteria weights that can be seen in Table 4.4.1, are multiplied by the Alternative Solution weights for each specific criteria category and then added together to display a final score for each design. The higher the score, the more suited the design is to the client's criteria. This Delphi Matrix can be seen in Table 4.4.2. After creating the Delphi matrix, the four designs with the highest scores: The Easy Rider, Two Can Play That Game, Bucket-About it and the Box of Doom were put into a Pro/Con Chart. The Pro/Con Chart evaluates which parts of each design were beneficial and which aspects may create complications for the client. The chart was used to create a list of which elements to include in the final design. The Pro/Con Chart and the final design elements chart can be viewed in Appendix B. A final design was then drawn by combining all the elements stated in the chart to create the best possible recycling cleaning cart for the client.

Table 4.4.1: Weight Criteria

Criteria	Weight
Portability	10
Durability	10
Stability	9
Safety	9
Ease of Cleaning	8
Upcycled	6
Aesthetics	5

Table 4.4.2: Delphi Matrix Method

Criteria		Solutions								
List	Weight	Easy Rider	The Janitors Friend	The Carton-Wheel	The Box of Doom	Bucket-About It	The Let It Slide	Up the Antee Cart	Two Can Play That Game	The Captian of Crush
Portability	10	49 / 490	35 / 345	36 / 363	39 / 390	37 / 365	41 / 405	33 / 325	37 / 368	41 / 405
Durability	10	35 / 350	30 / 300	33 / 325	30 / 300	40 / 403	41 / 405	37 / 373	41 / 410	38 / 378
Stability	9	33 / 297	37 / 335	39 / 347	39 / 349	36 / 320	35 / 315	38 / 342	39 / 349	35 / 315
Safety	9	27 / 243	27 / 243	39 / 351	29 / 261	37 / 333	29 / 261	49 / 441	35 / 315	35 / 315
Ease of Cleaning	8	36 / 288	38 / 300	35 / 278	37 / 298	41 / 330	36 / 286	36 / 284	40 / 322	38 / 304
Upcycled	6	35 / 207	39 / 234	42 / 254	37 / 222	39 / 231	35 / 210	38 / 227	38 / 228	33 / 198
Aesthetics	5	45 / 225	33 / 163	36 / 178	40 / 199	38 / 190	35 / 174	38 / 191	38 / 191	36 / 178
	Totals	1857	1677	1743	1758	1838	1795	1741	1868	1777

4.5 Final Decision

The final design, the SmartCart, is a collaboration of the top three Alternative Solutions: Easy Rider, Bucket-About-it and Two Can Play That Game. These three solutions were derived from the Delphi Matrix Method and the Pro/Con Chart. However, the client decided to remove multiple aspects of the Alternative Solution designs such as the milk carton holders and the milk carton crushers to make the cart more simplistic. The SmartCart will be equipped with three sinks for cleaning recyclables, heavy duty pneumatic wheels, basic steering, a milk bucket holder, a simple drainage system, and one insulating lid. The SmartCart will vary in design and cart structure depending on the recycled and upcycled pieces collected.

5 Specifications of Final Design

5.1 Introduction

Section 5 provides specifications of the SmartCart including in depth descriptions and images of the final design's components. The following includes an analysis of the hours spent on each section of the document and the cost of materials used to build the SmartCart. Instructions on how to use, maintain the cart and results on the implementation of the SmartCart at Zane Middle School are also provided.

5.2 Solution Description

SmartCart was designed and built by Porta Possibilities as a recycling cleaning cart for staff at Zane Middle School. The cart has three stainless steel sinks where the client will clean the cafeterias used milk cartons, cereal boxes and silverware so they can be properly recycled. SmartCart is a sturdy design that makes transporting and storing water an easier process. The cart's base is a mesh garden wagon with pneumatic rubber wheels. The stainless steel sinks are held up with four steel legs built off of the wagons base. The SmartCart is also equipped with a bucket holder, tension clip to hold the wagon handle, a wooden block to keep the cart stationary while in use, a simple drainage system, and one customized insulating lid. The finished SmartCart can be seen in Figure 5.2.1. Solution components that will be discussed in Section 5 are listed below.

- Sinks
- Bucket Holder
- Cart Frame
- Wheels
- Cart Legs
- Insulating Lid
- Tension Clip
- Drainage System
- Safety Measures

Figure 5.2.1: The SmartCart at Zane Middle School.

5.2.1 Sinks

The sink is an upcycled piece from Arcata Scrap and Salvage. This piece is equipped with three identical stainless steel sinks centered in the middle of a five foot workspace. Each sink has a drain that can be plugged with a rubber stopper. The sinks are 9.5” X 14” and 10” deep and can each hold 4.6 gallons of water. The underside of the sinks are coated with plastidip to further insulate and keep the water used in the process hot from 7:30am until 1pm lunchtime. The sinks also have about 1.5 feet of extra counter space on each side that can be used as a drying rack. These sinks serve as the main function of the cart to hold the hot water and to wash recyclables. The SmartCart sinks can be seen in Figure 5.2.2.

5.2.2 Bucket Holder

The right counter side of the sinks has three upright metal rods that can hold and transport a five gallon bucket. This allows the client to easily transport the excess milk waste to the sewer drain. The bucket holder was placed on the same side as the cart handle so that it can be accessed during transport. The bucket holder can be viewed in Figure 5.2.1.

Figure 5.2.2: The SmartCart’s sinks getting filled with hot water to be used.

5.2.3 Cart Frame

The bottom of the cart is made from a ten gauge steel mesh wagon. The mesh wagon’s base is 4 ⅓ feet long, 2 feet wide and can carry up to 1000 pounds. The mesh wagon can be used as an area for the washed recyclables to dry. The semi- wide frame makes the cart stable, but still capable of fitting through narrow doorways. The mesh wagon also has five steel reinforcement brackets on the bottom for extra support. The wagon’s handle has a cushioned grip and is connected to an axle holding the two closest wheels; this makes turning and steering the cart very easy. The SmartCart’s frame can be viewed in Figure 5.2.3.

Figure 5.2.3: Cart being transported with wagon style steering.

5.2.4 Wheels

The wheels used on the SmartCart are turf-tread pneumatic wheels. The turf-tread is the grooved surface of the wheel that gives it more traction against surfaces that the cart will be transported over. The cart has four wheels that are placed underneath the wagon's mesh frame. The front two wheels are attached to the handle, giving the cart a wide turning radius. The two by four wooden block is used as brake when placed in front of the back two wheels to keep the SmartCart stationary when in use. The 10 inch diameter and pneumatic quality of each wheel allows the cart to be smoothly transported over the concrete, asphalt and tile at Zane Middle School. A close up of one the cart's pneumatic wheels can be seen in Figure 5.2.4.

Figure 5.2.4: Close up of Turf Tread Pneumatic Wheel.

5.2.5 Cart Legs

The sink is attached to the cart by 16 inch long steel corner pieces. The steel rods are also upcycled. The steel rod pieces are attached to the mesh wagon with two screws on the base of each corner piece. The cart legs are made up of three separate pieces; two vertical legs and one horizontal piece lying across the top of the legs where the sink rests on. The horizontal pieces are welded to the top ends of each leg. An image of one steel leg apparatus can be viewed in Figure 5.2.5. The corner steel leg pieces are then connected to the sink with two screws on each top of the vertical legs. Each screw is followed and secured with a flat washer, lock-washer and nut.

Figure 5.2.5: Shows the three steel pieces used to support the sink.

5.2.6 Insulating Lid

The cart has one large lid that covers and insulates all three stainless steel sinks. Upcycled marine plywood is used as the lid. The lid has two handles so it can be easily lifted off of the sinks. Zane Middle School's logo is hand painted on the lid with Outdoor Latex Paint displayed in Figure 5.2.6 to promote school pride. The bottom of the lid has a fitted seal lining for each sink that keeps the lid attached to the sink when it is not being used and traps the heat radiating from the hot water. The lid seals can be seen in Figure 5.2.7.

Figure 5.2.6: Reveals the hand painted Zane Middle School logo and one of the two handles on the custom lid.

Figure 5.2.7: Shows the three separate fitted seals for each sink.

5.2.7 Tension Clip

The cart is equipped with a tension clip to hold the cart handle in place while the cart is stationary. The tension clip is a metal piece with a rounded opening that slightly flexes open for the handle to be inserted and quickly closes to hold it in place. The tension clip is placed on the right side of the cart (front view) and holds the handle upright as seen in Figure 5.2.8.

Figure 5.2.8: An image of the tension clip in use holding up the steering handle.

5.2.8 Drainage System

Acrylonitrile Butadiene Styrene or ABS is used for the SmartCart drainage system. All purpose cement glue is used to connect the piping. A diagram demonstrating installation of sink piping can be viewed in Appendix B. The sink drain tubing connects to one single valve that is placed through a hole in the center of the mesh wagon. The placement of the valve allows the used water to be drained directly over the sewer drain. To completely drain the cart after usage, each of the sink plugs must be removed and the blue valve handle must be twisted vertically to release the water. The valve is closed when the blue valve handle is twisted horizontally. An image of the SmartCart's drainage system in use can be viewed in Figure 5.2.9.

Figure 5.2.9: Shows the Acrylonitrile Butadiene Styrene drainage system releasing used water into the sewer drain.

5.2.9 Safety Measures

The upcycled sink has multiple sharp edges that are too difficult to file down. Porta Possibilities cut themselves several times during building and addressed the problem to make the SmartCart safe for children and adults. Plastic tubing split down the middle is used to cover the sharp edges as shown in Figure 5.2.10. The tubing is glued with all purpose cement glue that is also used for the Acrylonitrile Butadiene Styrene drainage system.

Figure 5.2.10: Plastic tubing is used to cover the sharp edges of the sink.

5.3 Cost Analysis

5.3.1 Cost in Hours

The amount of hours spent by Porta Possibilities for the SmartCart is shown in a pie chart demonstrated in Figure 5.3.1. The pie chart is split up into the six sections of the document. Building hours are included in the Section 6. About 60 hours of the 85 hours in Section 6 are building hours. A total of 169 hours was spent on the SmartCart.

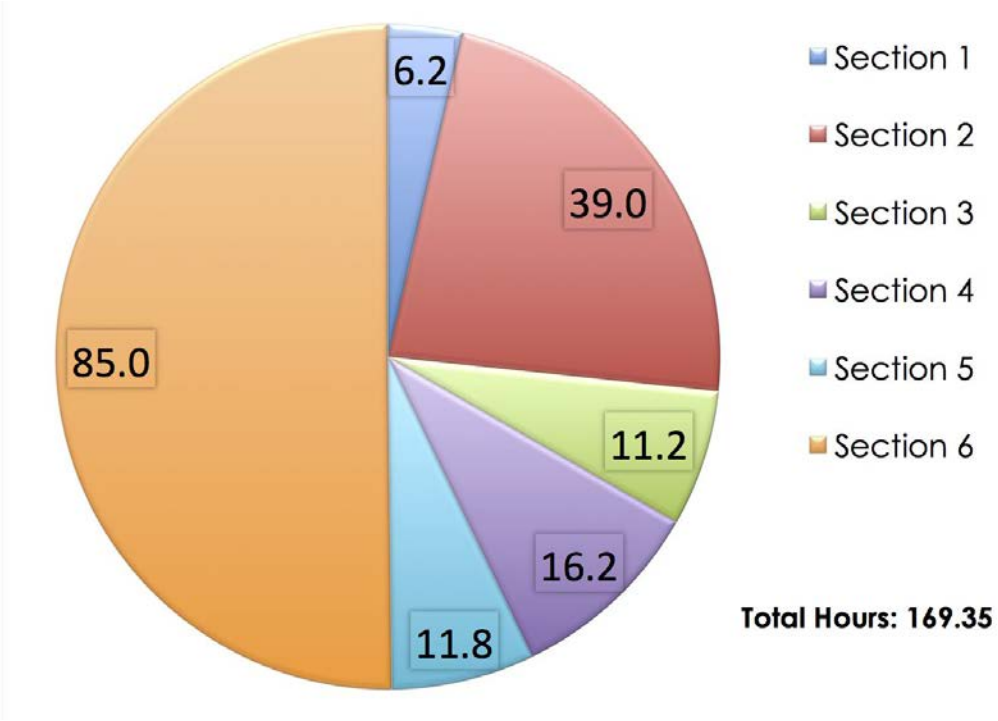

Figure 5.3.1: Design Cost in Hours.

5.3.2 Material Cost

All the materials used in building the SmartCart are recorded in Table 5.3.1. Each item is accompanied by the amount used in the SmartCart, the retail cost, and the team cost. Multiple items were donated as reused materials and reduced the team cost by around $200. A total of $240.16 was spent by Porta Possibilities on the SmartCart, using $459.86 worth of materials.

Table 5.3.1: Material Cost

Items	Amount	Retail Cost ($)	Team Cost ($)
Sinks	1	84.00	Donated
Garden Wagon	1	81.55	81.55
Clip Tension	1	3.99	3.99
Paint	2	48.59	48.59
Lid	1	40.00	Donated
Lid Seal	1	10.00	10.00
Lid Handle	2	9.98	9.98
Sink Insulation	2	13.98	13.98
Drainage System	1	70.55	70.55
Edge Tubing (ft.)	8	1.52	1.52
Steel Legs	6	86.70	Donated
	Total	**450.86**	**240.16**

5.4 Maintenance

After each use, the entire cart must be rinsed down to prevent build up. The drainage system must be cleaned once a month by filling the system with bleach while the valve is closed, letting it sit for 30 minutes, and then draining the system to prevent back up in the drains. The air in the tires must be checked monthly and refilled as needed. The plastic tubing covering sharp edges must be checked once a month to ensure no edges have been exposed.

5.5 Instructions of Use

The cart is designed to have a durable, portable and stable area to wash wastes produced by Zane Middle School's cafeteria. After the items are emptied of the food waste they will be washed by hand in the cart. The cart is filled with hot water behind the cafeteria at 7:30am before the Zane's breakfast ends. The cart is then safely brought into the cafeteria, after traveling approximately 100 feet. The cart clears narrow turns through a 2 ¾ foot gate and a 3 foot wide cafeteria door. The Cart is used to clean the recyclables from breakfast and is then left to sit until it is used again at the end of lunch. Once all of the recyclables are cleaned inside the cafeteria, the cart is returned to behind the cafeteria to be emptied and cleaned. The cart is then brought directly over a sewer drain and drained.

5.6 Results

The SmartCart allows the client to easily transport 13.8 gallons of water and a 5 gallon bucket of excess milk waste through the narrow doorways and over uneven asphalt, tile and cement without spilling. Recyclables are easily cleaned and the sinks are drained directly down the sewer drain with the simple turn of one valve. After testing the cart's insulation, it was discovered that the hot water only dropped 23 degrees Celsius after remaining stationary for over five hours. The new recycling cleaning cart also allows kids to safely join in the process. In conclusion, the overall cleaning experience was enhanced and the carts colors and logo further promote Zane Middle School pride.

Figure 5.6.1: This picture was taken the first day presenting the SmartCart to the client at Zane Middle School. Students Savannah, Nick and Jasper were a few of the thrilled students to see their new recycling cleaning cart.

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7 Appendices

7.1 Group Members Hours

Merissa Coello's Hours spent on the SmartCart, including Client Meetings.

Merissa Coellos' Project Hours Time Sheet
Engr 215, Spring 2015

Date	Task Descritption	Project Time	Total Project Time
2/12/2015	Team Contract	0.3	0.3
2/14/2015	Project Overview	1.7	2.0
2/20/2015	Lit review research/note taking	1.0	3.0
2/21/2015	Start Contructing Lit review	2.5	5.5
2/22/2015	Lit review/group work	5.5	11.0
2/23/2015	Lit review rap up/edit	3.0	14.0
2/24/2015	Final lit review review	1.0	15.0
2/27/2015	Client Meeting	1.2	16.2
2/27/2015	Gannt Chart	1.5	17.7
3/1/2015	phase 2	1.7	19.4
3/3/2015	group meeting:fixing lit review	0.5	19.9
3/5/2015	Meeting With Lonny	0.2	20.1
3/6/2015	Meeting with Client	0.5	20.6
3/7/2015	Altemtive Solutions	1.2	21.8
3/10/2015	Altemtive Solutions	3.0	24.8
3/12/3015	Group meeting decision process	1.5	26.3
3/13/2015	Group meeting decision process	0.3	26.6
3/15/2015	Section 3	0.2	26.8
3/16/2015	Section 3	0.2	27.0
3/18/2015	Section 3	0.2	27.2
3/20/2015	Section 3	0.2	27.4
3/22/2015	Section 3	1.2	28.6
3/27/2015	Client Meeting	0.7	29.3
3/27/2015	ACAD 4	1.0	30.3
3/29/2015	Section 5	0.5	30.8
3/30/1015	building/Group Meeting	2.0	32.8
4/2/2015	section 5/ACAD4/Group Meeting	1.0	33.8
4/3/2015	Building!!!	3.5	37.3
4/7/2015	Section 5/Group Meeting/Poster	7.0	44.3
4/9/2015	Group Meeting/ Building	2.5	46.8
4/10/2015	Client Meeting	1.0	47.8
4/12/2015	Presentation	2.5	50.3
4/13/2015	Presentation	0.5	50.8
4/14/2015	Building/Presentation	4.5	55.3
4/16/2015	Building/Presentation	2.5	57.8
4/17/2015	Building	2.0	59.8
4/18/2015	Building	6.0	65.8
4/19/2015	Building/Presentation/Appro	5.0	70.8
4/20/2015	Presentation	1.0	71.8
4/21/2015	Building/Presentation	4.0	75.8
4/22/2015	Presentation	1.0	76.8
4/24/2015	Doc Stuff	2.0	78.8
4/26/2015	Doc Stuff	3.0	81.8
4/27/2015	Doc Stuff	2.0	83.8
4/28/2015	Doc Stuff	2.0	85.8
5/1/2015	Doc Stuff/Appro	3.0	88.8
		Total Hours	**88.8**

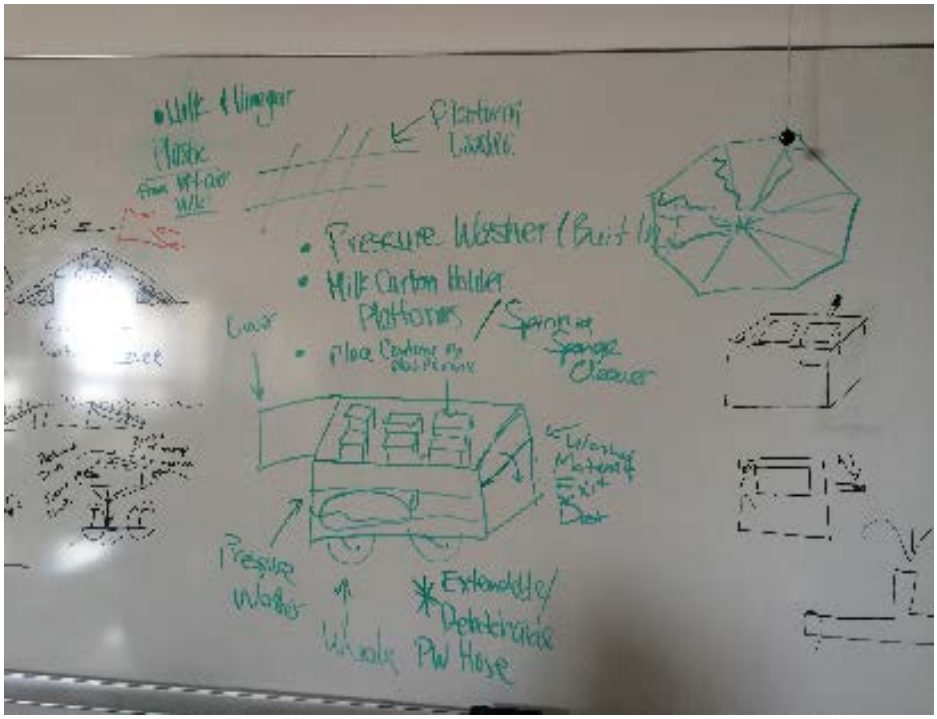
Erin McDannold's Hours spent on the SmartCart, including Client Meetings.

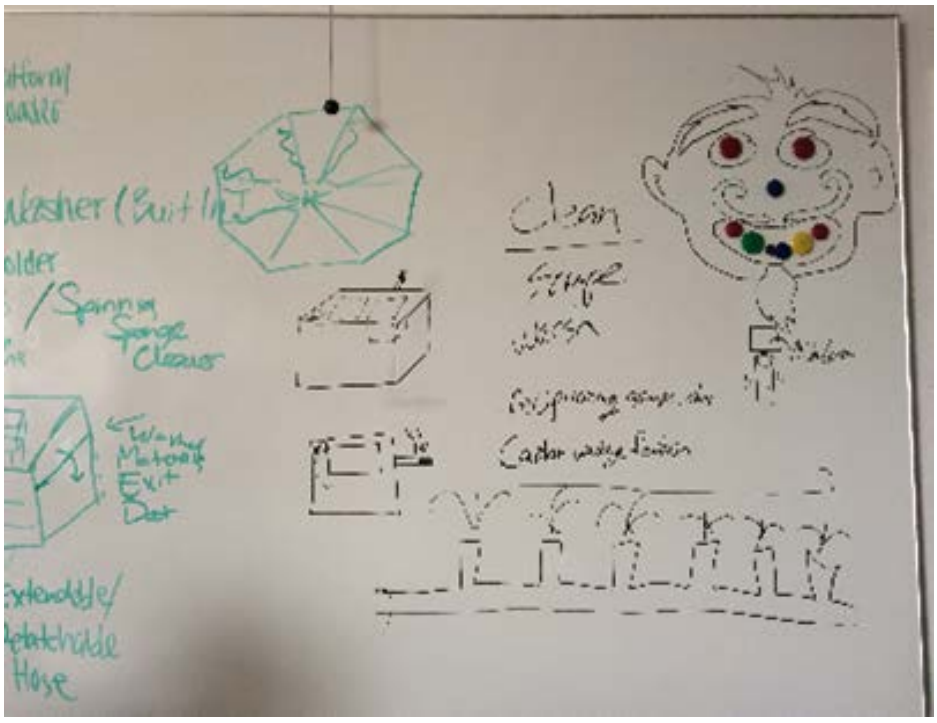
Erin McDannold's Project Hours Time Sheet

Engr 215, Spring 2015

Date	Task Description	Project Task (hrs)	Total Project Time (hrs)
2/13/2015	Meet Project Client	1.0	1.0
2/14/2015	Team Brainstorm	1.5	2.5
2/15/2015	Section One Project	1.0	3.5
2/17/2015	Team Brainstorm	1.5	5.0
2/22/2015	Literary Review	3.5	8.5
2/24/2015	Literary Review	3.5	12.0
2/28/2015	Met with Client	1.0	13.0
2/28/2015	Gantt Chart	1.5	14.5
3/1/2015	Section Two	0.5	15.0
3/2/2015	Team Brainstorm	1.0	16.0
3/8/2015	Alternative Solutions	2.0	18.0
3/10/2015	Catme/Group Eval	1.0	19.0
3/11/2015	Group Member Evals	1.0	20.0
3/13/2015	Brainstorming final soln	1.0	21.0
3/15/2015	Ranking Solutions	0.5	21.5
3/17/2015	Creating Final Soln	1.0	22.5
3/22/2015	Section 5	1.0	23.5
3/31/2015	Gathering Materials	4.0	27.5
4/3/2015	Putting Cart together	0.5	28.0
4/7/2015	Poster	7.0	35.0
4/9/2015	Group Meeting	2.0	37.0
4/12/2015	Section 5/Presentation	5.0	42.0
4/13/2015	Presentation	0.5	42.5
4/14/2015	Building/Presentation	4.5	47.0
4/16/2015	Building/Presentation	2.5	49.5
4/18/2015	Building	6.0	55.5
4/19/2015	Building/Presentation	5.0	60.5
4/20/2015	Presentation	3.0	63.5
4/21/2015	Building/Presentation	4.0	67.5
4/22/2015	Presentation	1.0	68.5
4/24/2015	Poster	2.5	71.0
4/26/2015	Document Work	3.0	74.0
4/27/2015	Document Work	2.0	76.0
4/28/2015	Document Work	2.0	78.0
5/1/2015	Document Work	3.0	81.0
		Total Hours	**81.0**

7.2 Appendix A: Group Brainstorm Session Notes, February 26, 2015



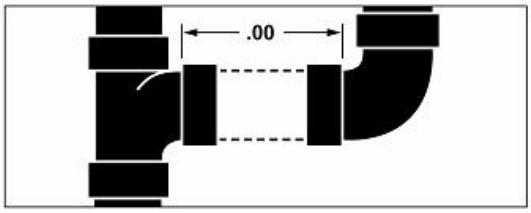


7.3 Appendix B: Acrylonitrile Butadiene Styrene Installation Instructions

10 Quick Installation Steps

1

Measure pipe from bottom or shoulder of each socket into which pipe is to fit.



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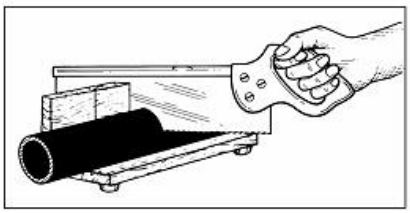
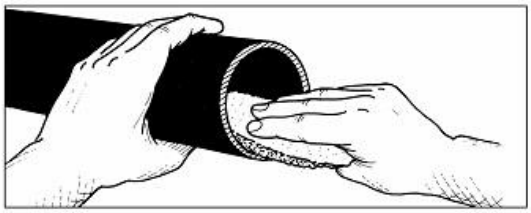


Cut pipe to required length, making sure cut is square. (See page 10 for a listing of proper tools.)

3

Ream inside and chamfer outside of pipe to eliminate all burrs. Sand lightly.



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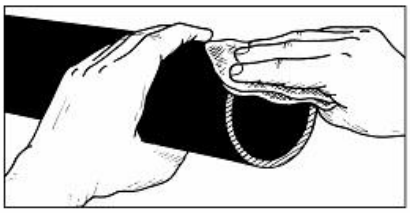
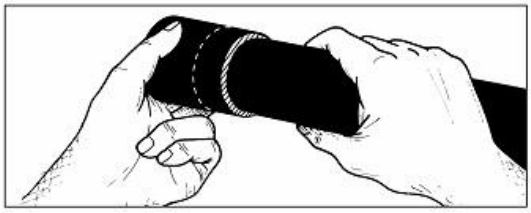


Clean all dirt, moisture, and grease from pipe and fitting socket, using a clean, dry cloth.

5

Check dry fit of pipe in fitting socket. Pipe should enter fitting socket to between 1/3 and 3/4 of the socket depth. Be sure to use only approved types of fittings and adapters.



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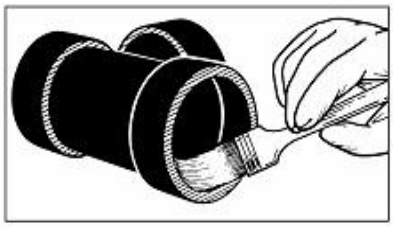
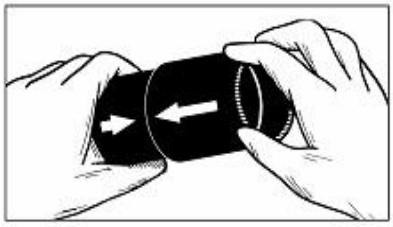


Using a brush or dauber-type device, apply a light coat of ASTM D2235 ABS solvent cement to the inside of the fitting socket, using straight, outward strokes. Apply solvent cement to the outside of the pipe in a similar manner. Time is important at this stage: apply cement quickly and do not allow it to set before the joint is put together. Be especially quick when the temperature is over 100°F (38°C) or humidity is over 60 percent. Always follow safe-handling practices when using solvent cements: use in a well-ventilated area, avoid skin contact (wear gloves) and do not use near heat, sparks or open flame.

7

Immediately insert pipe into fitting socket, giving the pipe a one-quarter turn and making sure it goes all the way to the socket bottom.

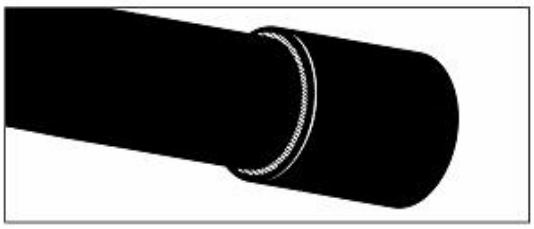
8



Hold the joint together until a tight set is attained.

9

Check cement bead around joint. A proper joint will normally show a bead around its entire perimeter. Any gaps may indicate insufficient cement or the use of light-bodied cement on larger diameters where heavy-bodied cement was required. After setting, wipe excess cement from the pipe.



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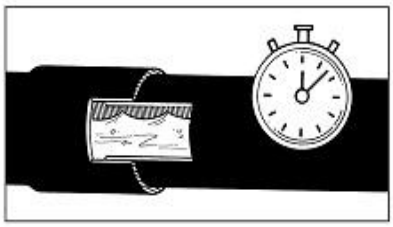

Don't move the system until the joints have cured (set) at least as long as recommended by the solvent manufacturer. MEK-based solvent cement conforming to ASTM D2235 usually sets up in two minutes at about 70°F (21°C), with faster setting at higher temperatures and slower at lower temperatures. An ABS pipe stack can usually be tested within one hour after the last joint is completed. At this point, a water test can be done to test the integrity of each joint. Do not air test, as it is not recommended for ABS pipe systems. Check local code requirements for clarification.

7.4 Appendix C: Alternative Solution Pro/Con Cart

Solution	Pros	Cons
Easy Rider	Bike Wheels Simple Design	2 Wheels Heavy
Two Can Play That Game	Handles Folding Lids Trash Bag Area	No Shelf
Bucket About It	Milk Bucket Holder Removable Buckets 4 Wheels 2 Wheel Stoppers	Hard to Create Possibly Messy
Final Solution	4 Wheels Wheel Stoppers Shelf/Storage Milk Bucket Holder	