

# Basic Utility Vehicle (BUV) Irrigation System

A Baccalaureate thesis submitted to the  
Department of Mechanical and Materials Engineering  
College of Engineering and Applied Science  
University of Cincinnati

in partial fulfillment of the  
requirements for the degree of

Bachelor of Science  
in Mechanical Engineering Technology

by

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April 2018

Thesis Advisor: Professor Moise Cummings

## **ACKNOWLEDGEMENTS**

The 2018 MET Senior Design BUV Team would like to thank the following individuals for their contributions, donations, and support.

With your support, we succeeded in designing and fabricating a BUV.

To Mr Dave Conrad, for your contributions of time, and advice on our project.

To Mr Lorenzo Cooks, for your generous donation to the project.

To my team members: Marty Kowall, Brad Sackett, Chris Saranita, and Cole Rardon, for working hard to accomplish the goal

Last but not least, to Professor Moise Cummings, for your advice and support to lead us to the final goal.

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## **ABSTRACT**

University of Cincinnati has the brilliant idea of building a Basic Utility Vehicle for the annual BUUV Competition. This year, we were responsible to build the vehicle by using advice from the previous team from UC students. In 2013, UC finished 3<sup>rd</sup> place in the competition and their recommendation for future groups is that secure barrels before working on irrigation system and design the front suspension. Another recommendation is continue using the frame, chassis, truss design, and angle iron. Some good specifications they had: cargo bed area less than 18ft<sup>2</sup>, and a 2000lb payload at a 20-degree slope. Plywood and angle iron reduce the cost and weight of the BUUV. It is highly recommended.

## INTRODUCTION

### *PROBLEM STATEMENT*

The project is to design a Basic Utility Vehicle. A basic utility vehicle is vehicle designed to help bring aid to people and communities in third world countries without access to basic necessities such as water. The design of this vehicle needs to be as simplistic as possible while abiding by the specifications laid out by the Institution of Affordable Transportation. Some of these specifications are low cost, agile performance, 1750 lb payload and a 20 MPH max speed.

Each member has a main section of the vehicle they are responsible to lead as listed below. Throughout the year we will collaborate and assist each member of our group in each other's' designated responsibilities to complete this project by April 2018.

### *TEAM MEMBER RESPONSIBILITIES*

*Cole Rardon*

*\*Drivetrain*

*Chris Saranita*

*\*Suspension and Steering*

*Brad Sackett*

*\*Brake system*

*Marty Kowall*

*\*Chassis*

## **BACKGROUND AND RESEARCH**

### *B a c k g r o u n d*

Will Austin founded the Institute of Affordable Transportation in the year 2000 after he realized the quality of life was dependent on cheap transportation. A year later the first annual BUV design competition was held. Every year people try to improve upon the winning design. The idea is to design the cheapest, lightweight and durable vehicle for transporting water and aid for impoverished countries. The IAT sets out specific specifications that are to be abided by. These specifications include speed, weight payload and more.

### *R e s e a r c h*

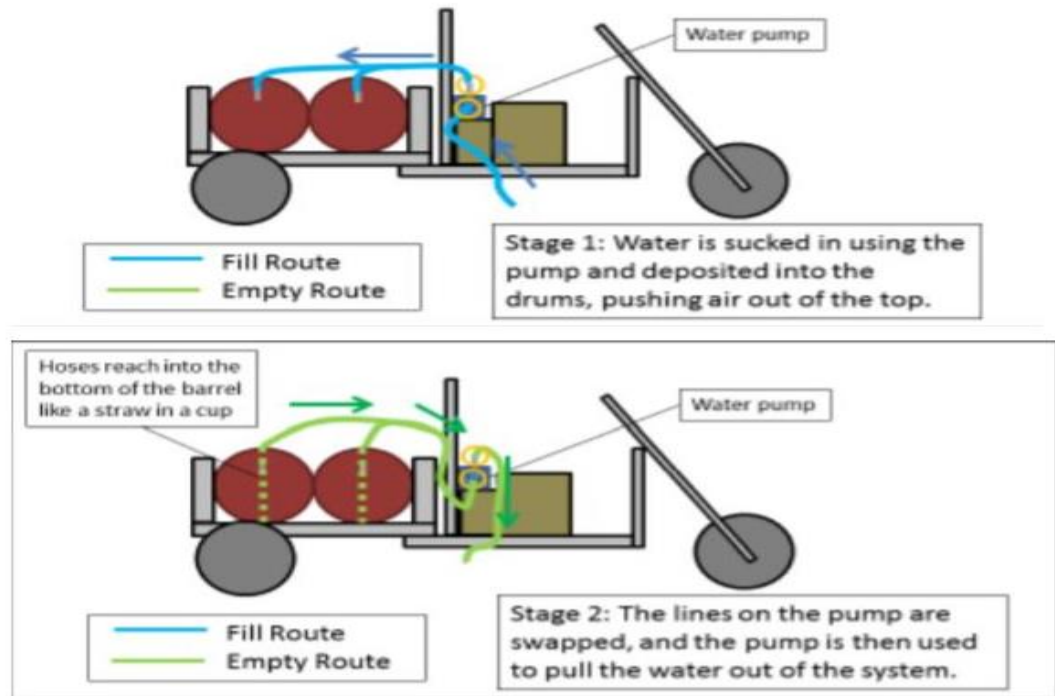


Figure 1 UC BUV 2014

In 2014, University of Cincinnati BUV designed two barrels of 55 gallons. They used gasoline-powered water pump. The benefits of this setup is less discharge time and less material usage. The disadvantage is that this setup carry less water compared to the three barrels ( figure 1 ).

## 2013 University of Cincinnati BUUV Design



Figure 2 UC BUUV 2013

This setup is more beneficial because it carries more water. It is also ease of use because it is not connected to the engine. The problem on this setup is that it cannot resist bump or shocks. The PVC piping attached to the barrels cracked because they used single pipe to connect barrels.

## CUSTOMER NEED AND REQUIREMENTS

### *Project objectives*

- Coming in under budget (\$6500)
- Finding most lightweight durable parts (Carbon fiber, aluminum, etc.)
- Speed tests with different loads
- Making sure vehicle is not bigger than allowed
- Ability to fill 55-gallon drums and all pumping must be carried on vehicle
- Good gas mileage
- Ease of maintenance

### *customer features and specification*

- Affordable
- Durable: \$6500 or less
- Utility: power water pump, mill, compressor
- Ease of use: quick release hosing
- Clear Visibility
- Fuel Economy
- Ease of maintenance
- All terrain and weather

## PROJECT MANAGEMENT

The bill of material of the irrigation only is listed below. Water pump and barrels were donated.

# Bill of materials

- 3 - ¾ PVC close nipples
  - 3 - ¾ pvc ball valves
  - 3 - 2in adapter with tread ( for the barrels)
  - 2 - TEES 2in PVC pipe
  - 1 - ELL 2in PVC pipe
  - 2 - 2in hose barb
  - 1 - Glue ( Gorilla PVC )
  - 2 – 6in cap
  - 1 - Rubber Coupler 6" x 6"
  - 1 - PVC pipe 6" x 2"
  - 2 - 2in Hose Clamps
  - 1 - 2in M camlock – 2in hose
  - 1 - 2in F camlock tread
  - 1 - 1 ½ MPT – 1 ½ Slip
  - 1 - 1 ½ FM slip – 2in M
  - 1 - 2in Valve Treaded both side
  - 2 - 2 ¾ exhaust clamp
  - 1 - 2in x 10 ft
  - Tape
- Estimated Cost  
\$ 250

## Table 1 - Budget

## S c h e d u l e

<b>Task</b>	<b>Start date</b>
<b>Design concept</b>	October 2 <sup>nd</sup> 2017
<b>Detailed outlook of each role</b>	November 2 <sup>nd</sup> 2017
<b>Bill of materials</b>	November 11 <sup>th</sup> 2017
<b>Detailed design</b>	November 16 <sup>th</sup> 2017
<b>Completed design in CAD</b>	December 30 <sup>th</sup> 2017
<b>Layout scheduling for manufacturing</b>	January 1 <sup>st</sup> 2018
<b>Presentation Proposal</b>	January 26 <sup>nd</sup> 2018
<b>Design modifications/manufacturing</b>	January 31 <sup>th</sup> 2018
<b>Order parts</b>	February 1 <sup>st</sup> 26 <sup>th</sup> 2018
<b>Start Testing</b>	March 1 <sup>st</sup> 2018
<b>Spring break</b>	March 12 <sup>th</sup> -18 <sup>th</sup> 2018
<b>Testing modifications</b>	April 1 <sup>st</sup> 2018
<b>Final test / expo</b>	April 15 <sup>th</sup> 2018
<b>Competition / Final Presentation</b>	April 22 <sup>nd</sup> 2018

T a b l e 2 – S c h e d u l e

## DESIGN

### *DESIGN ALTERNATIVES AND SELECTION*

There are three main methods for powering the irrigation system. Water pump with integrated engine, water pump driven by drivetrain engine, and water pump driven by electrical power. Only two methods were considered while designing the irrigation system: Water pump with integrated engine and water pump driven by electrical power.



Figure 3 Pacific Hydrostar

Driven by an engine that is integrated into the system and no other drive components are required. The disadvantage is standard pull start cord and high price.



Figure 4 Electric pump

The advantage on the water pump is the low cost, small size and simple working principle. The disadvantage is low pumping rate.

The electric pump was finally picked and donated. It made our design really simple since it is small, we mounted a small bracket behind the vehicle to hold it in place.

## FABRICATION

Fabrication and assembly of the irrigation system was performed in the machine lab, Victory Parkway North Lab building.

Our challenge for this system is to avoid leaking and learn from the previous year mistake or failure to have a better system.



Figure 5 Wood and strap

The first step for the system is to start by making the wood block. The block is putted between the barrels ( 2 on each side) to maintain the barrels while the vehicle is moving. The strap is used to hold the system together.



Figure 6 Connection of PVC to barrels

Tape is applied on close nipple and connect  $\frac{3}{4}$  valve and barrels (top of barrels). On the bottom, tape is applied on 2in adapter treated also inside the adapter and the TEES, Ell we have a piece of 2 in pipe glued to connect the adapter and T, L. There is also two 2in rubber connected to the pipe to avoid any crack.

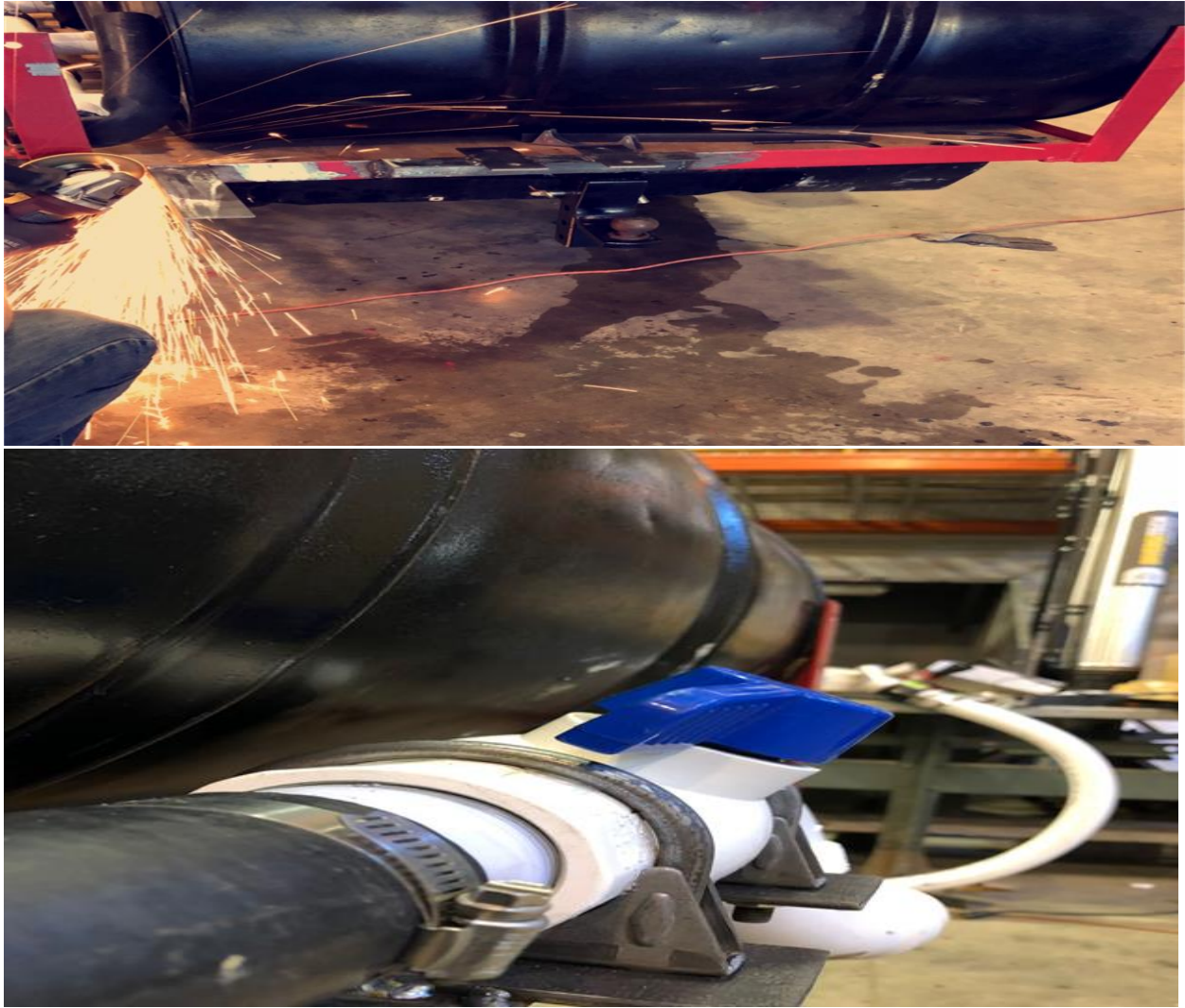


Figure 7 Water pump and valve location

Valve and water pump were mounted in the back of the vehicle. Flexible hose is used to connect T and the valve, and exhaust clamps are used to make the valve stable when opening and closing.



Figure 8 electric outlet

The electric is used to plug water pump adapter cord.



Figure 9 Pump and adapter cord

Adapter cord to reach to the electric outlet.

## TESTING

Testing was calculated

Time to Fill	Time to Empty
4.46 minutes	3:25 minutes

Table 3 – Fill / Empty time

## CONCLUSION / RECOMMENDATION

Due to drivetrain, our team was unable to participate to the competition. IAT competition took place Saturday, April 21<sup>st</sup> and the failure occurred on 20<sup>th</sup>. Also, the irrigation system was not able to put on the field for any demonstration.

My recommendations for the next BUV senior design team is first go with the design picked and all selection made in the design. Spend a lot of time on the design and also think about other components. Start the project early, make sure the chassis frame is in a good condition. Then, I prefer the electric pump it is simple and make the system easy to connect and disconnect.

## WORKS CITED

- 1- **Deamann Strefas**. Basic utility vehicle (BUV) irrigation system. [online]. April 2017  
<https://scholar.uc.edu/downloads/bc388289q?locale=en>
- 2- **WELLS, Sara**. Basic utility vehicle (BUV). [online]. April 2013.  
<https://drc.libraries.uc.edu/handle/2374.UC/701569>
- 3- **BURKET, Chris**. Basic utility vehicle (BUV) irrigation system. [online]. April 2014.  
<https://drc.libraries.uc.edu/handle/2374.UC/731805>
- 4- BUV Bearcats (Basic Utility Vehicle) - Home. BUV Bearcats (Basic Utility Vehicle)  
<https://uc.collegiatelink.net/organization/buv>
- 5- Harbor Freight. Pacific Hydrostar 1". Harbor Freight  
<http://www.harborfreight.com/15-79cc-1-in-gas-engine-clear-waterpump-37-gpm-69747.html>

## APPENDIX A – COMPETITION SPECIFICATIONS

### BUV FARM TANKER & TRANSPORTER 2017 Design Specifications

Engine Use up to 11 horsepower unmodified engine. An auxiliary fuel tank may be added.

Exhaust Stock muffler, which may be relocated, with additional heat shields as needed.

Gauges An engine temperature indicator located in view of the driver.

Fuel Retail pump fuel and oil with provisions to prevent spilling fuel on a hot engine.

Transmission It is builder's choice, to meet event conditions, but should have reverse\*\* and should have at least two forward speeds\*\* not counting any variable drive features.

Power Takeoff The ability to power auxiliary equipment\*\* at approximately 1000 rpm. A V-belt drive is anticipated for auxiliary equipment.

Electrical A 12-volt 35 amp or larger automotive alternator and an automotive battery are required\*\*.

Cargo Bed The bed must hold two, but may hold three 55-gallon standard steel drums. The drums must be located on their sides with the small hole at the top. The drums must be located as low as possible in the bed. The drums must not be stacked in any manner. The front of the cargo bed must have a 16-inch minimum high bulkhead between the driver and the cargo. The other sides of the bed must be a minimum of 8 inches high. Drums should be easily removable for cargo\*\*.

Roll Bar A minimum height of 36 inches above the surface the driver is seated upon. The roll bar must be completely padded above the seat height. It must have a cross member that covers the ends of the vertical structures, and adequate bracing to prevent the vehicle from rolling over.

Driver Safety A helmet is required for each person aboard the vehicle. Seat belts are at the option of the team and the team advisor.

Safety Items To participate in the event, you must have the following safety items:

1. An engine shutoff device marked with a nine-inch red streamer located within reach of the driver.

2. A dead man throttle with the spring located directly on the engine throttle linkage and not on the throttle control devices of vehicle.

3. Guarding from all moving parts and Padding of all sharp or dangerous areas.

4. Automotive horn, a fire extinguisher, and a high visibility safety flag above the vehicle.

**Brake System** A redundant brake system\*\* that will prevent total brake failure if a brake line is severed anywhere on the vehicle. The brakes must be located at the wheels and not on the driveline. A front wheel brake is not required on three wheeled vehicles. The parking brake is not considered the redundancy that is required. Hydraulic drives may use reverse for brakes.

**Parking Brake** A parking brake capable of overcoming the engine power. It may be on the drive-line.

**Tires** Agricultural tread, or aggressive tire chains are required. Chains must be carried by the vehicle if removed from the tires.

**Towing** Each vehicle must have a 20-foot looped-end tow strap. There must be an attachment point at the front of the vehicle for towing. The trailer ball will be the rear attachment point for towing.

**Trailer Hitch** A 1-7/8 inch trailer ball must be mounted 15 inches above the ground when the vehicle is unloaded.

**Weatherproof** The vehicle should have protection from the weather elements to provide better reliability and greater durability.

**Speed** Maximum of 20 MPH.

**Load** Maximum of 165 gallons of water, weighting roughly 1376 pounds.

**Water Pump Ability** to fill 55-gallon drums from within 15 feet of a pond. All pumping equipment and hoses must be carried on the vehicle during the event. Pump driven form PTO device only.

**Name Plate** The school name and team number displayed in 4-inch font on all sides of the vehicle.

## APPENDIX B – COMPETITION GUIDELINES

### Features

- Affordable: \$6500 US(\$)
- Durable: automotive parts
- Utility: power water pump, mill, compressor, etc.

### Specifications

- 10 hp engine - diesel
- 1250 lb vehicle weight and low ground pressure
- 12' length x 63" width
- 2-wheel drive with differential
- automotive hydraulic brake

### Automotive Grade Components

- axle / tires / wheels / hubs
- brakes / suspension / frame
- expected life: 20+ years for auto parts

### Service / Maintenance

- common "off-the-shelf" parts
- easy access to engine and drivetrain
- 95% less parts than a typical car

### Performance

- 1750 lb payload
- 40% gradeability - high torque
- 30+ mpg diesel
- Turns sharp like a scooter
- 20 mph max speed

### Safety

- Low center of gravity
- Excellent driver visibility
- Controlled speed - 20 mph max
- Hydraulic brakes



# BUV SENIOR DESIGN GROUP 2018

PAUL KOWALL, BRAD SACKETT, CHRIS SARANITA, COLE RARDON, EL  
HASSANE KAMAGATE

## BACKGROUND

- Will Austin founded the Institute of Affordable Transportation in the year 2000 after he realized the quality of life was dependent on cheap transportation. A year later the first annual BUV design competition was held. Every year people try to improve upon the winning design. The idea is to design the cheapest, lightweight and durable vehicle for transporting water and aid for impoverished countries. The IAT sets out specific specifications that are to be abided by. These specifications include speed, weight payload and more.
- The success of a BUV depends on the weight of the vehicle, and the vehicles ability to hold and transport large sums of water. Because of this, the strongest, most light-weight material will be used to build the chassis and frame of this vehicle.

## PROBLEM STATEMENT

- The project is to design a Basic Utility Vehicle. A basic utility vehicle is vehicle designed to help bring aid to people and communities in third world countries without access to basic necessities such as water. The design of this vehicle needs to be as simplistic as possible while abiding by the specifications laid out by the Institution of Affordable Transportation. Some of these specifications are low cost, agile performance, 1750 lb pay load and a 20 MPH max speed.
- Each member has a main section of the vehicle they are responsible to lead as listed above. Throughout the year we will collaborate and assist each member of our group in each other's' designated responsibilities to complete this project by April 2018.

## END USER PROFILE

- When constructing this basic utility vehicle, the end user kept in mind are people from third world countries. The end user will likely require a vehicle that can maneuver around tough environments, is easy to use and simplistic in repairs, can transport water efficiently. Making sure that the vehicle is very simplistic and overall durable are big keys to this vehicle. Making the vehicles too complex can really make it harder for the end user to operate and maximize the use out of the vehicle. Also, keeping it simplistic makes it easier to repair if it does brake down since people in third world countries to do not have the kind of resources and mechanical knowledge to fix complex systems.
- Allowing the vehicle to carry as much water as it can so that it can so that it can take less trips and to maximize the potentially water carried from the vehicle each time without too much stress on the vehicle and its frame.

# PROJECT OBJECTIVES

Coming in under budget (\$6500)

Finding most lightweight durable parts (Carbon fiber, aluminum, etc.)

Speed tests with different loads

Making sure vehicle is not bigger than allowed

## Features

- Affordable: \$6500 US(\$)
- Durable: automotive parts
- Utility: power water pump, mill, compressor, etc.

## Specifications

- 10 hp engine - diesel
- 1250 lb vehicle weight and low ground pressure
- 12' length x 63" width
- 2-wheel drive with differential
- automotive hydraulic brake

## Automotive Grade Components

- axle / tires / wheels / hubs
- brakes / suspension / frame
- expected life: 20+ years for auto parts

## Service / Maintenance

- common "off-the-shelf" parts
- easy access to engine and drivetrain
- 95% less parts than a typical car

## Performance

- 1750 lb payload
- 40% gradeability - high torque
- 30+ mpg diesel
- Turns sharp like a scooter
- 20 mph max speed

## Safety

- Low center of gravity
- Excellent driver visibility
- Controlled speed - 20 mph max
- Hydraulic brakes

LIST OF  
CUSTOMER  
FEATURES AND  
SPECIFICATIONS  
FROM THE IAT

# IRRIGATION SYSTEM

BY EL HASSANE KAMAGATE

## STATE OF THE ART-IRRIGATION

- Background:
- Ability to gather water
- Place on the vehicle (side or full back)
- Better to use water pump to move the water in the barrels
- Irrigation system: hosing connected to a water pump, which is also connected to the barrels
- Barrels (depends of weigh of our vehicle. We can use two 55 gallons or three 40 gallons)
- Water Pumping (different type)
- Gasoline water pump
- Electric water pump

## ELECTRIC PUMP



Volts	12
Max. Total Head (ft.)	40
Suction Port (in.)	3/4
Self-Priming	Yes
Dimensions L x W x H (in.)	8 x 8 x 7
Weight	7.0 lbs
Port Size (in.)	3/4
Flow (GPH)	340
Amps	15

## PROOF OF FABRICATION



- Mounted plate to hold pump support



## IRRIGATION CALCULATIONS

- Time to fill

- $55\text{gal} * 3 * \frac{1}{37} = 4.46$  minutes

Hazen Williams equations

$$V = kCR^{0.63}S^{0.54}$$

V is velocity

k is a conversion factor for the limit

C is a roughness coefficient (150 for PVC)

R is the hydraulic radius

S is the Slope

$$\begin{aligned} Q &= \left( \frac{(hfC^{1.85}d^{4.87})}{10.67L} \right)^{0.45} \\ &= \left( \frac{(2 * 150^{1.85} 1^{4.87})}{10.67 * 20} \right)^{0.45} \\ &= 719.16 \frac{\text{gal}}{\text{hr}} \end{aligned}$$

Pump is 2220 gal/hr.

## PROOF OF FABRICATION



TAPE IS APPLIED ON CLOSE NIPPLE AND CONNECT ¾ VALVE AND BARRELS

BOTTOM, TAPE IS APPLIED ON 2IN ADAPTER TREATED ALSO INSIDE THE ADAPTER AND THE TEES, ELL WE HAVE A PIECE ON 2 IN PIPE GLUED TO CONNECT THE ADAPTER AND T,L



## RECOMMENDATION



- Use the design that has been picked
- Spend time on design part
- Start project early
- Make sure there is available chassis or make sure to get one as soon as possible
- Check schedule to make sure process is respecting the time

# QUESTIONS?