Washington University in St. Louis
Washington University Open Scholarship

Washington University / UMSL Mechanical Engineering Design Project JME 4110

Mechanical Engineering & Materials Science

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Alternative Approach to Sand Bags for Flood Prevention Through the use of 3D Printed Flood Panels

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Joint Engineering Program

University of Missouri–St. Louis ▪ Washington University in St. Louis

ELEVATE YOUR FUTURE.
ELEVATE ST. LOUIS.

This project serves as an alternative approach to traditional sandbags for floodwater prevention and mitigation. Seeking for a less time consuming and inexpensive way for municipalities and homeowners to lower risk of flood waters damaging property and hindering commerce.

JME 4110
Mechanical Engineering
Design Project

Modular Flood Barrier

Tom Beaver
Matt Gilliam
Will McBryan

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1 INTRODUCTION

1.1 VALUE PROPOSITION / PROJECT SUGGESTION

We anted to come up with a better solution to traditional sandbags which are used to prevent flood waters from reaching critical parts of homes or small towns which are usually falling victim to high crests on major rivers and flooding these areas which are built nearby or in flood plains.

1.2 LIST OF TEAM MEMBERS

Tom Beaver

Matthew Gilliam

Will McBryan

2 BACKGROUND INFORMATION STUDY

2.1 DESGIN BRIEF

When flooding occurs people either resort to sandbags or abandon their homes till flood waters recede. The problem with sandbags is they are time consuming to fill, they are heavy, and they can be ripped or dropped and the bag could break spilling out sand everywhere. There needs to be a better solution to a problem that has plagued those living in a floodplain.

Our project, as defined by our team, is to develop a flood prevention apparatus that will satisfy several pre-defined parameters, those being: low impact on the existing environment, a design that can be constructed relatively quickly in the flood zone as well as quickly deconstructed after the flood event, the design should not leave behind any mess as a consequence of the design itself, the design will be modular (i.e. the apparatus will consist of units which can be connected together continuously to create a barrier), the cost of materials for the project may not exceed four-hundred dollars, and the culmination of our teams effort will produce a scaled-down model of a working prototype by the end of the term. Our project will involve a hypothetical customer, Dr. Jakiela, who owns a house in a flood-prone area for which we will be providing protection. Our design will either be a novel idea of our own or a revision of an existing design. This begins by researching existing solutions for flood prevention and documenting the pros and cons of each respective design. As the semester moves forward, so will our concepts and ideas, until our team reaches a practical solution to the problem, all culminating into the fruition of our efforts: a working prototype.

2.2 BACKGROUND SUMMARY

There are a plethora of flood barriers out there currently. They range from inflatable barriers, mechanical flood walls that rise into place through mechanical actuation or through buoyancy with the water and simple modular barriers that can redirect water.

Our project, as defined by our team, is to develop a flood prevention apparatus that will satisfy several pre-defined parameters, those being: low impact on the existing environment, a design that can be constructed relatively quickly in the flood zone as well as quickly deconstructed after the flood event, the design should not leave behind any mess as a consequence of the design itself, the design will be modular (i.e. the apparatus will consist of units which can be connected together continuously to create a barrier), the cost of materials for the project may not exceed four-hundred dollars, and the culmination of our teams effort will produce a scaled-down model of a working prototype by the end of the term. Our design will also be a reflection of the codes and standards we have found to be in close support of our problem and solution. Our project will involve a hypothetical customer, Dr. Jakiela, who owns a house in a flood-prone area for which we will be providing protection. Our design will either be a novel idea of our own or a revision of an existing design. This begins by researching existing solutions for flood prevention and documenting the pros and cons of each respective design. As the semester moves forward, so will our concepts and ideas, until our team reaches a practical solution to the problem, all culminating into the fruition of our efforts: a working prototype.

By building a structure to prevent over-spill, we must consider several additional factors: the existing soil permeability, existing zoning and building codes for the area, the durability and longevity of the design, and the maximum height of the crest for which our design may effectively prevent a flood.

We may also consider the current effects of global warming and rising sea levels. On the coast, in places like Nahant, Massachusetts and Miami, Florida, the Atlantic Ocean is rising rapidly. These areas are filled with prime real estate and will need new solutions to deal with the rising waters. In Miami, they are building concrete walls higher and higher. The question remains: what is the best solution to deal with rising flood waters? Continually building walls may only succeed as a temporary solution.

3 CONCEPT DESIGN AND SPECIFICATION

3.1 USER NEEDS AND METRICS

3.1.1 Record of the user needs interview

Project/Product Name: Modular Flood Unit

Customer: Dr. Mark Jakiela

Design Team: Tom Beaver, Matthew Gilliam, William McBryan

Address: Washington University

Users/Uses: Anyone/Modular Design, Easy Set-up Flood Barrier, Effective up to Three Feet

<table>
<tr><th>Question</th><th>Customer Statement</th><th>Interpreted Need</th><th colspan="2">Importance</th></tr>
<tr><td>What amount of time are we allowed for the on-site construction of the flood-barrier?</td><td>Two to three hours.</td><td>The barrier's efficacy depends upon the barrier's installment prior to the flood.</td><td colspan="2">5</td></tr>
<tr><td>What is the maximum height of the flood barrier?</td><td>A maximum of one meter (three feet and four inches).</td><td>This is the maximum crest for which our design will be effective.</td><td colspan="2">5</td></tr>
<tr><td colspan="2">How much storage space will be allotted for our design?</td><td>The size of a vacant car space within a garage.</td><td>We want the apparatus to be storable for the</td><td>5</td></tr>
</table>

		customer, such that no additional costs will be incurred.	
What is the perimeter of the property?	Around fort by forty feet (or roughly twelve by twelve meters).	Knowing the perimeter of the property gives us an idea of how many units (of our design) is necessary to safely surround the house and lawn.	5
What is the general terrain of the property we will be protecting from flooding?	The house and yard sit on an area which is roughly flat.	Our design will generally be effective for flat areas, without large fluctuations in height.	4
(Customer asks): Will I be able to construct the barrier myself?	Our design is optimized so that an average person will be able to construct the barrier themselves.	The design must be light-weight and easy to assemble	5

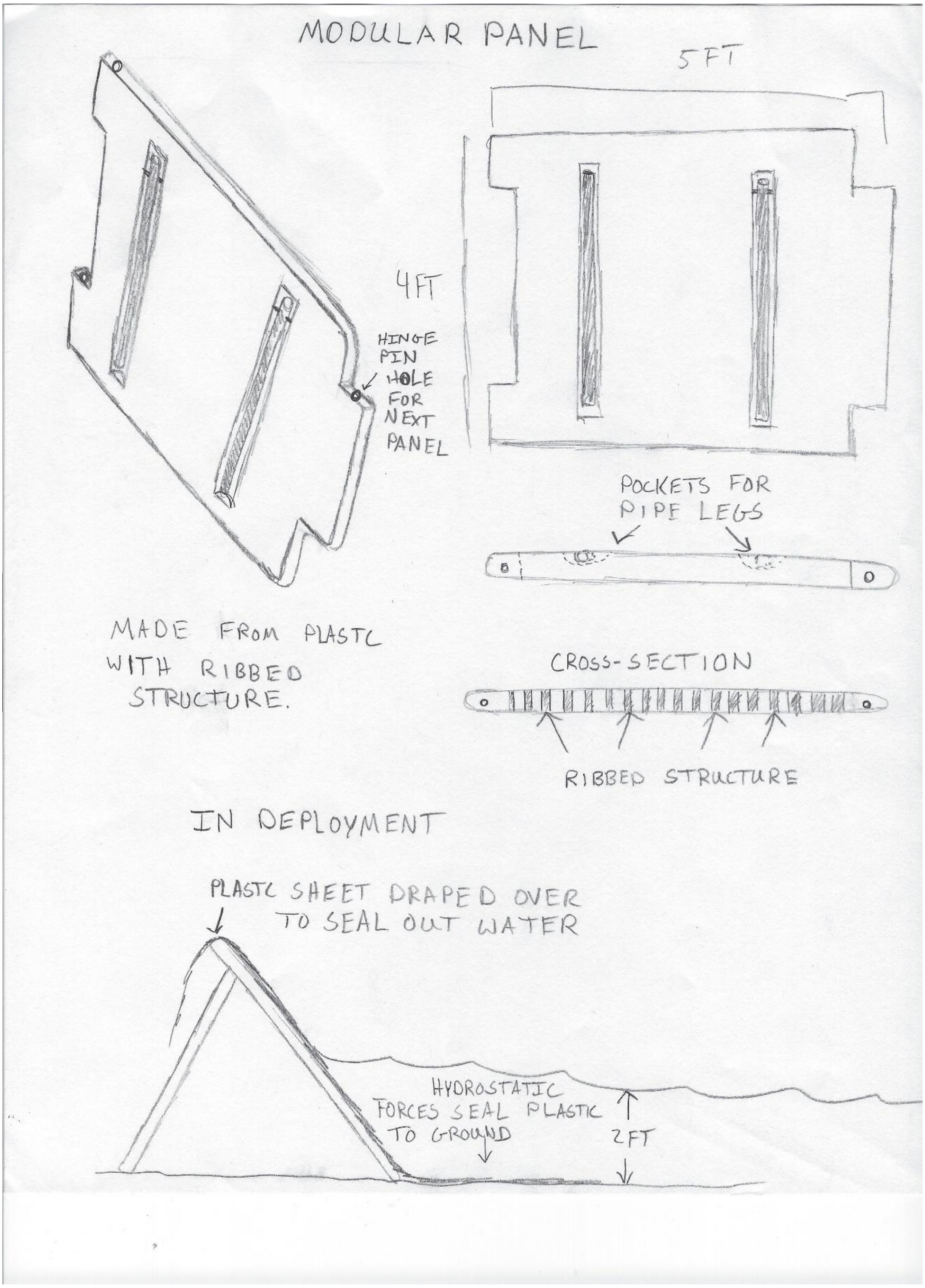
3.1.2 List of identified metrics

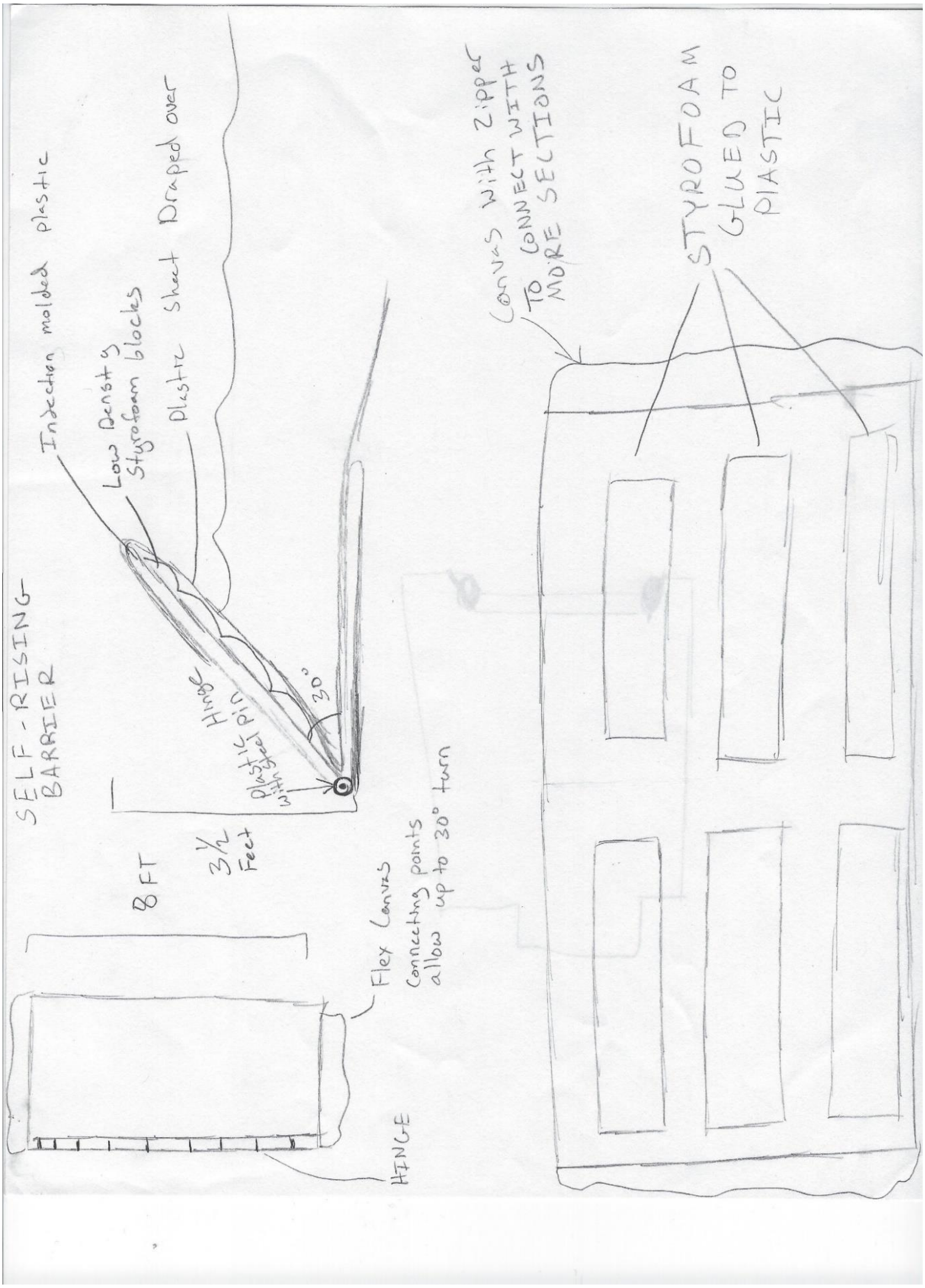
Metric Number	Associated Needs	Metric	Units	Min. Value	Max Value
1	1, 3, 4	Height	ft	3.5	4.5
2	2, 3, 4	Length	ft	2	5
3	3, 1, 2, 4, 5	Weight	lbs	16	45
4	4, 1, 2, 3	Project Total Cost	U.S. Dollars	250	400
5	5, 1, 3, 6, 7	Customer Set-Up Time	minutes	45	180
6	6, 1, 2, 3, 7	Storage Space Requirement	ft^2	160	160
7	7, 2, 5, 6	Property Perimeter	ft	140	220

3.1.3 Table/list of quantified needs equations

Need	Metric	Units	Min. Value	Max Value
Barrier is tall enough	Height	ft	3	5
Barrier is long enough	Length	ft	3	5
Light enough for user to move	Weight	lbs	10	45
Affordable	Purchase price	U.S. Dollars	15	50
Able to be deployed within 2 hrs	Customer Set-Up Time	minutes	45	120
Fits in a parking space in garage	Storage Space Requirement	ft^2	160	160
Can encompass a property	Property Perimeter	ft	140	220

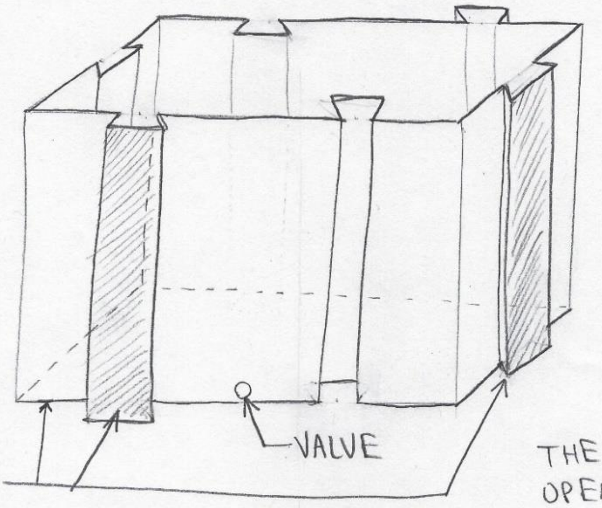
3.2 CONCEPT DRAWINGS




SELF-RISING BARRIER
Indection molded plastic
Low Density Styrofoam blocks
Plastic Sheet Draped over
Hinge
30°
Plastic with steel pin
8 FT
3½ Feet
Flex Canvas
Connecting points allow up to 30° turn
HINGE
Canvas with Zipper TO CONNECT WITH MORE SECTIONS
STYROFOAM GLUED TO PlASTIC

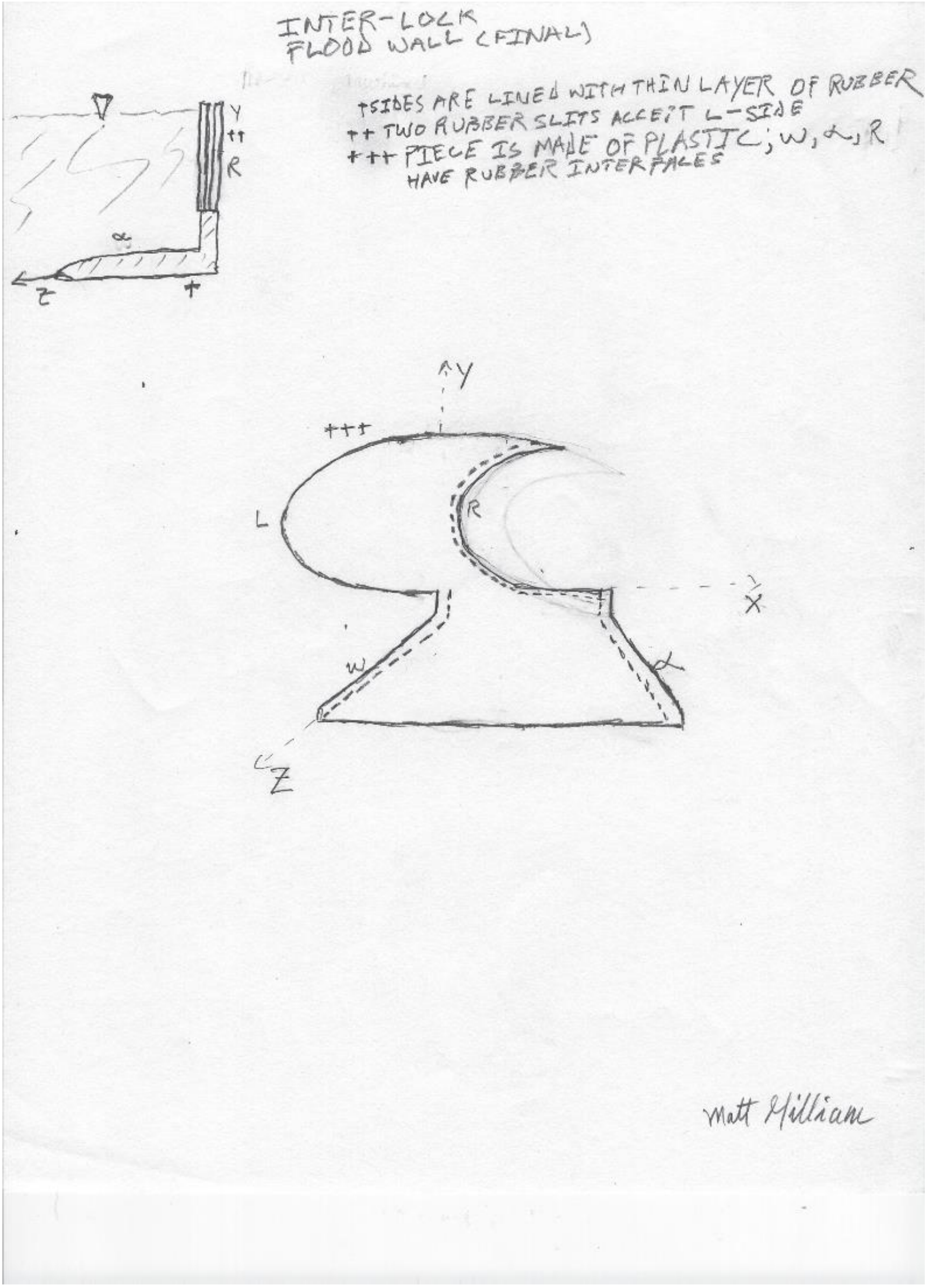
BLOCK WALL CONCEPT

EACH BLOCK IS HOLLOW PLASTIC, AND CAN CONNECT WITH EACH OTHER TO FORM A SOLID, MODULAR WALL.



THIS COATING IS ONLY ON THE OUTWARD SECTIONS AND BOTTOMS OF EACH BLOCK. IT WILL CREATE A WATERPROOF SEAL BETWEEN AND UNDERNEATH BLOCKS.

THE VALVE IS AN OPENING ON THE SIDE OF EACH BLOCK, ALLOWING FOF WATER TO FILL THE CONTAI ER. THIS WILL ADD WEIGHT AND STABILIT TO THE ENTIRE WALL AS THE FLOOD WATERS RISE.


INTER-LOCK
FLOOD WALL (FINAL)
+SIDES ARE LINED WITH THIN LAYER OF RUBBER
++ TWO RUBBER SLITS ACCEPT L-SIDE
+++ PIECE IS MADE OF PLASTIC; W, α, R
HAVE RUBBER INTERFACES
Y
++
R
α
Z
+
Y
+++
L
R
X
W
α
Z
Matt Gilliam

3.3 A CONCEPT SELECTION PROCESS.

3.3.1 Concept scoring (not screening)

Modular Panel		Metric															
		Height	Weight	Length	Perimeter of Area	Set-up Time	Storage Space	Purchase Price	Modularity	Material Strength	Metric 10	Metric 11	Metric 12	Metric 13	Need Happiness	Importance Weight (all entries should add up to	Total Happiness Value
Need#	Need	1	2	3	4	5	6	7	8	9	10	11	12	13			
1	The barrier is able to be connected to itself	0.167	0.167	0.167	0.167	0.167			0.167						0.67635	0.25	0.16909
2	The design is simple and easy to setup	0.5	0.5												0.775	0.25	0.19375
3	The barrier is able to withstand hydrostatic pressures and stay in place	0.5	0.5												0.775	0.1	0.0775
4	The barrier is durable and can withstand abuse		0.25							0.75					0.5625	0.1	0.05625
5	The barrier stores easily and takes up minimal space	0.2	0.2	0.2	0.2		0.2								0.87	0.1	0.087
6	The barrier deflects from the hydrostatic pressures minimally	0.2	0.2	0.2	0.2	0.2									0.81	0.1	0.081
7	The barrier is affordable to the average person							1							0.764	0.1	0.0764
8	Need8														0	0	0
9	Need9														0	0	0
10	Need 10														0	0	0
11	Need 11														0	0	0
12	Need 12														0	0	0
13	Need 13														0	0	0
Units		Ft	Lbs	Ft	ft	min	sq ft	dollars	Unit 8	GPA	Unit 10	Unit 11	Unit 12	Unit 13	Total Happiness		0.74099
Best Value		5	10	5	500	200	100	15		3.1							
Worst Value		0	50	1	200	300	200	100		1							
Actual Value		4	20	5	500	250	120	35		2							
Normalized Metric Happiness		0.8	0.75	1	1	0.5	0.8	0.764		0.5							

3.3.2 Preliminary analysis of each concept's physical feasibility

Looking at all the concepts we came up with, we noticed pros and cons of all four. With the panel, there was concern whether it would be strong enough to hold the water back however it was a fairly simple design. The modular box seemed to be the most durable of the four but would be harder to setup then the panels and take up more room so wasn't ideal for storage. The interlock flood wall seemed to be a great modular solution and easy to stack and store but were unsure of the durability. Lastly, the rising flood barrier seemed to be slightly more complicated then were willing to work on as there was a hinge mechanism as well as the addition of buoyancy to make the panel rise with the water respectively.

3.3.3 Final summary statement

We chose to proceed with the modular panel as it seemed to have the right amount of tradeoffs between pros and cons and seemed it would be fairly easy to assemble and test.

3.4 PROPOSED PERFORMANCE MEASURES FOR THE DESIGN

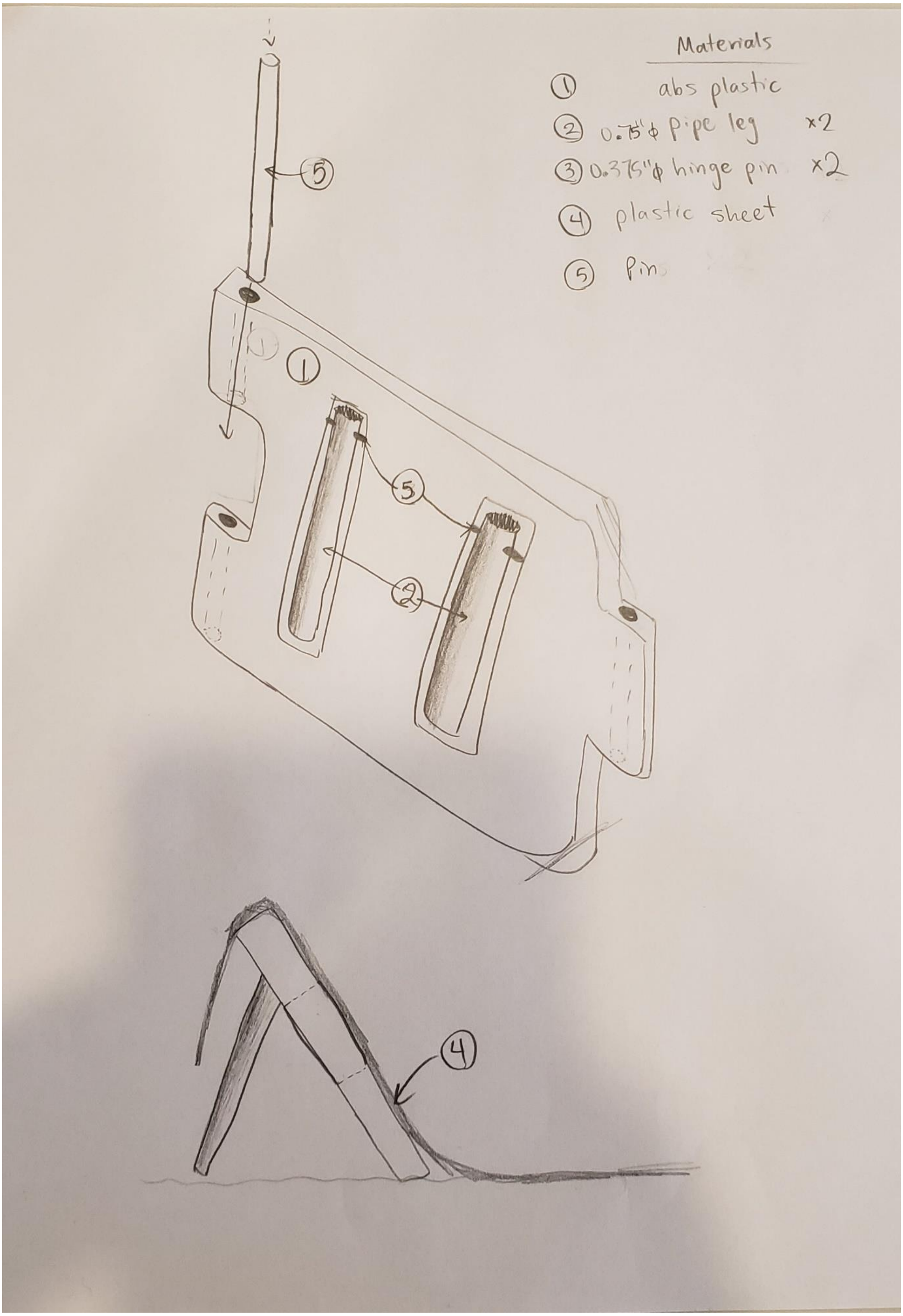
Measure deflection of panels and to see if a ¼ scale version can withstand head water of 10" depth.

3.5 REVISION OF SPECIFICATIONS AFTER CONCEPT SELECTION

Prototype will be ¼ scale to meet costs and ease of testing.

4 EMBODIMENT AND FABRICATION PLAN

4.1 EMBODIMENT/ASSEMBLY DRAWING



4.2 PARTS LIST

Dowel Pin Part
QTY Cost
4037 Alloy Steel, 3/32" Diameter, 1" Long 98381A443 1
(comes in packs of 50) $6.11

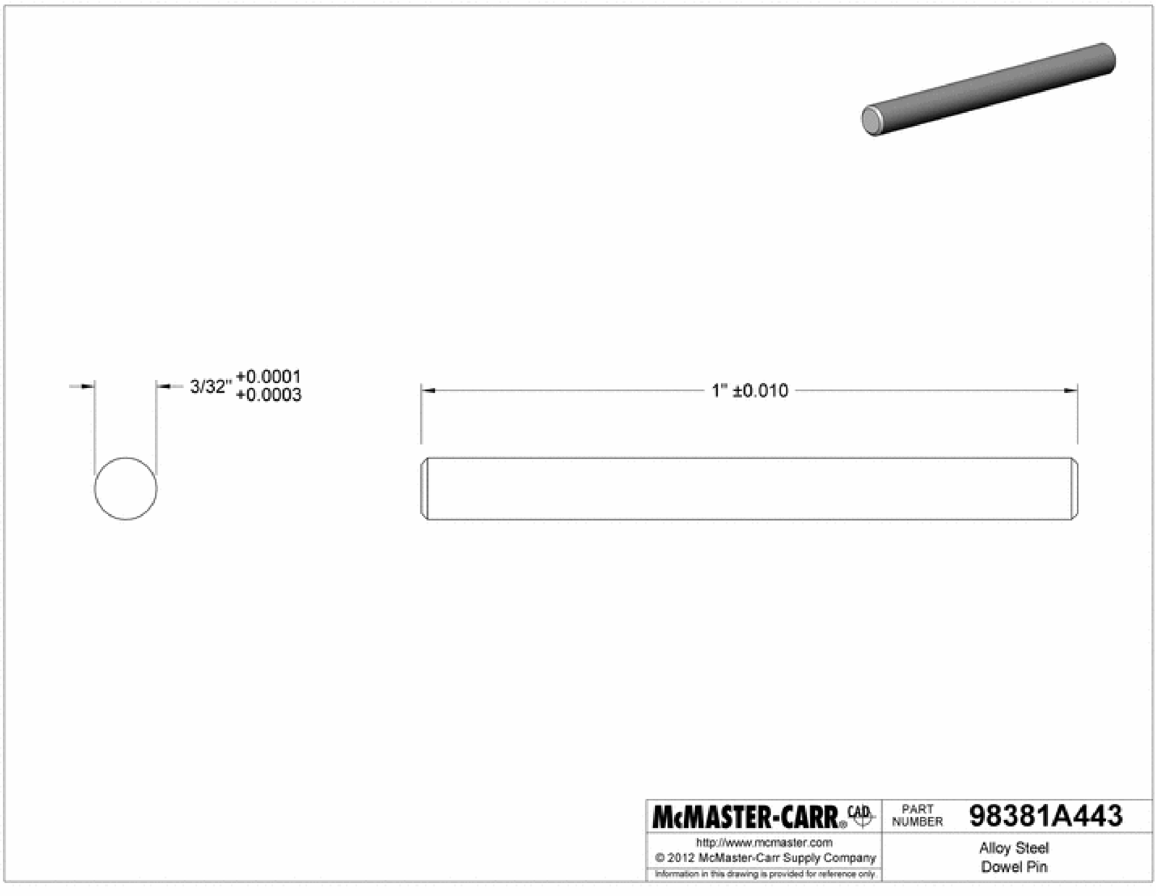
Alloy Steel Dowel Pin Stock
1/8"
Diameter 98912A510 1
$13.29

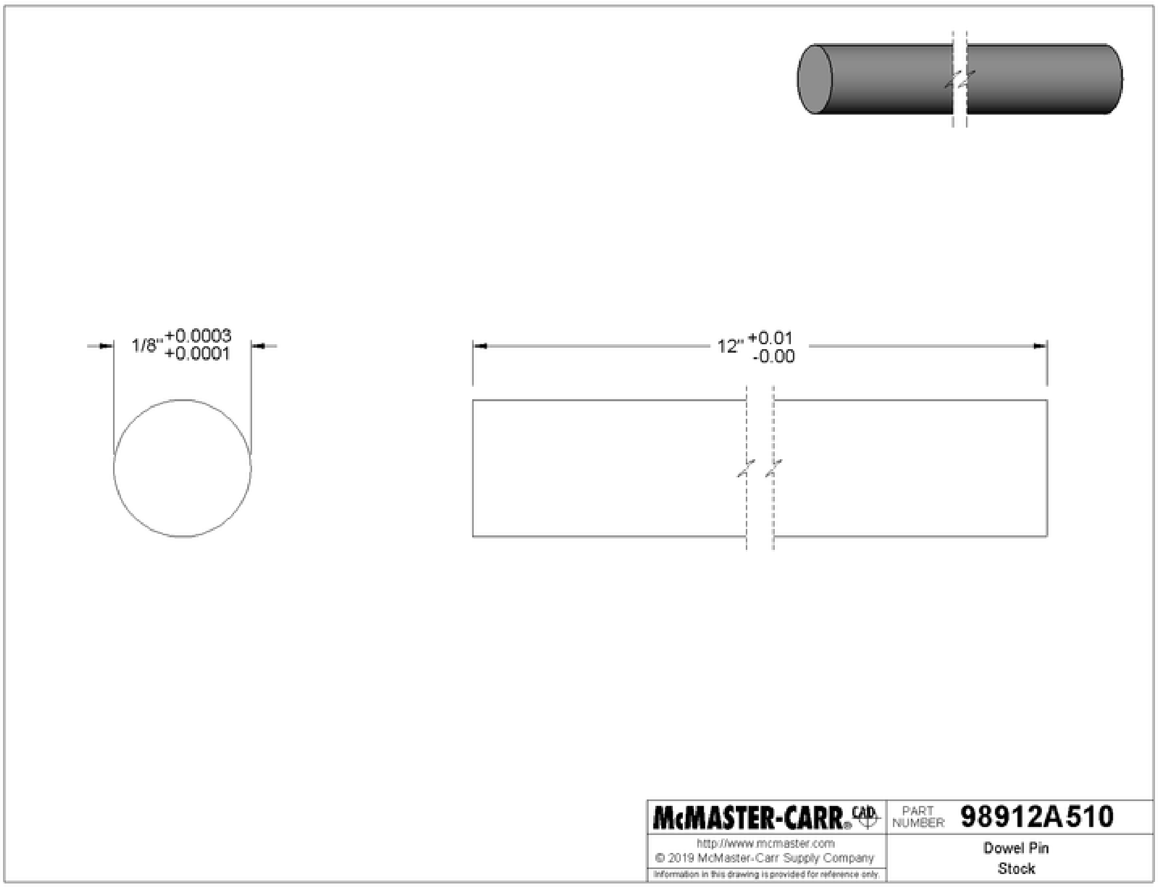
Easy-to-Weld 4130 Alloy Steel Round Tube
0.035" Wall Thickness, 0.188" OD 89955K119 1
(lengths of 1 ft) $6.79

Easy-to-Weld 4130 Alloy Steel Round Tube
0.035" Wall Thickness, 0.188" OD 89955K119 1
(length of 3 ft) $15.76

Structural Adhesive
Waterproof Epoxy, J-B Weld Marineweld, 2 oz.
Tube 7605A15 1 $6.28

4.3 DRAFT DETAIL DRAWINGS FOR EACH MANUFACTURED PART





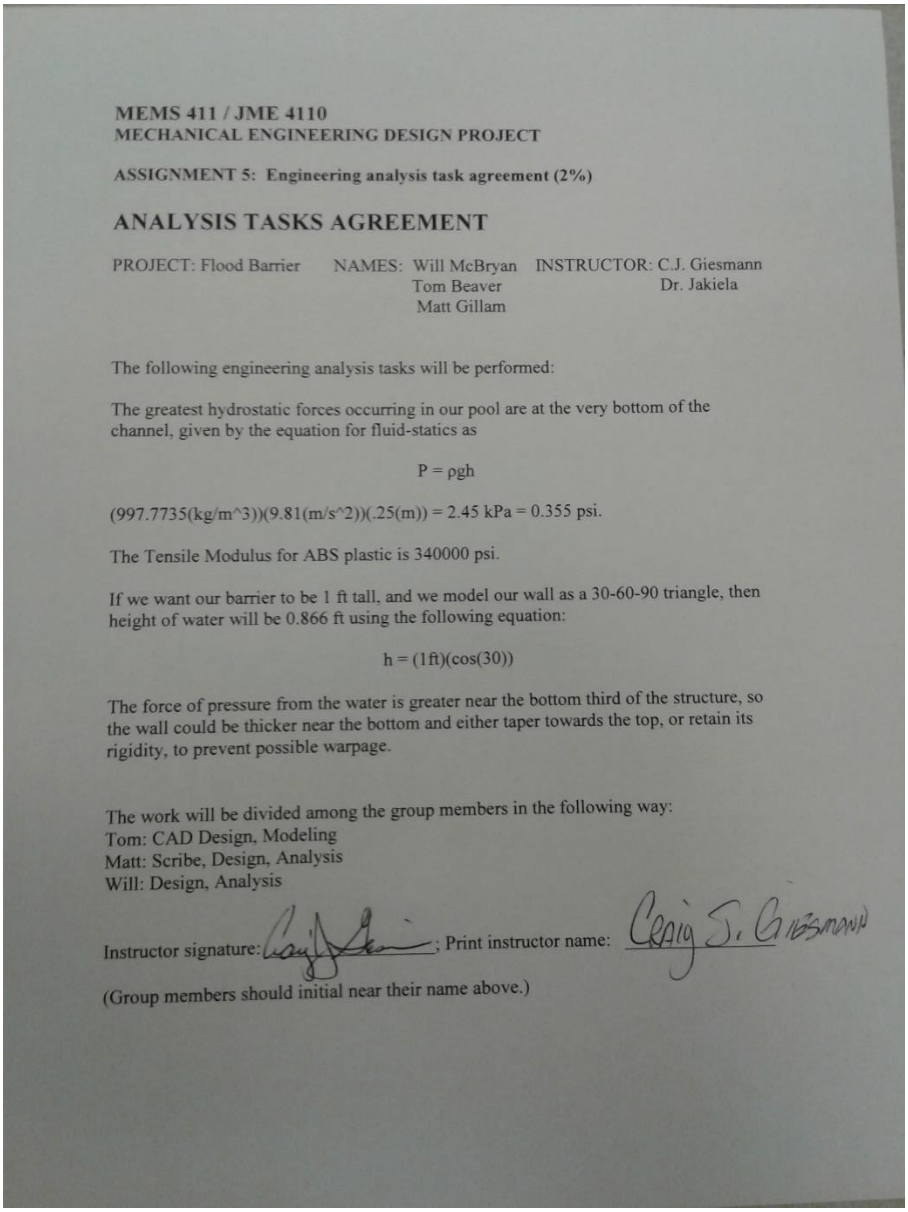
4.4 DESCRIPTION OF THE DESIGN RATIONALE

Each part we used was a ¼ scale of what would be used on the full size version. We also chose parts for cost effectiveness and developed two panels.

5 ENGINEERING ANALYSIS

5.1 ENGINEERING ANALYSIS PROPOSAL

5.1.1 Signed engineering analysis contract



MEMS 411 / JME 4110
MECHANICAL ENGINEERING DESIGN PROJECT

ASSIGNMENT 5: Engineering analysis task agreement (2%)

ANALYSIS TASKS AGREEMENT

PROJECT: Flood Barrier NAMES: Will McBryan, Tom Beaver, Matt Gillam INSTRUCTOR: C.J. Giesmann, Dr. Jakiela

The following engineering analysis tasks will be performed:

The greatest hydrostatic forces occurring in our pool are at the very bottom of the channel, given by the equation for fluid-statics as

$$P = \rho gh$$

(997.7735(kg/m^3))(9.81(m/s^2))(.25(m)) = 2.45 kPa = 0.355 psi.

The Tensile Modulus for ABS plastic is 340000 psi.

If we want our barrier to be 1 ft tall, and we model our wall as a 30-60-90 triangle, then height of water will be 0.866 ft using the following equation:

$$h = (1ft)(\cos(30))$$

The force of pressure from the water is greater near the bottom third of the structure, so the wall could be thicker near the bottom and either taper towards the top, or retain its rigidity, to prevent possible warpage.

The work will be divided among the group members in the following way:
Tom: CAD Design, Modeling
Matt: Scribe, Design, Analysis
Will: Design, Analysis

Instructor signature:______; Print instructor name: Craig S. Giesmann

(Group members should initial near their name above.)

5.2 ENGINEERING ANALYSIS RESULTS

5.2.1 Motivation

We wanted to mathematically prove that for the material we chose to make the panel out of (ABS Plastic) that it would be able to withstand the amount of force that was pushing back on the panel.

5.2.2 Summary statement of analysis done

We conducted some simple calculations based on fluid mechanics of a dam and compared the results to the tensile strength of abs plastic.

5.2.3 Methodology

Mathematically the results of a static load is what we would anticipate the use would be. This would not be ideal for redirecting flowing water or for where the water sways and breaks like it would on a busy lake.

5.2.4 Results

Our calculations showed that we would have a max force of .355 psi and the strength of abs plastic was 340 KPSI, which is more than enough to withstand the water.

5.2.5 Significance

If our analysis was performed wrong, then our prototype would fail catastrophically.

6 RISK ASSESSMENT

6.1 RISK IDENTIFICATION

Risks that could have arisen with this project include but not limited to

Parts not arriving, prototype failing, are estimates being to generous and thus not rating our barrier properly causing the panels to fail prematurely, 3d printer quality not being high and layers separating, not designing the structure to withstand the full hydrostatic force built against the barrier.

6.2 RISK ANALYSIS

We concluded these risks by seeing how short of schedule we had to make our 3d printed panels and ran into problems with the short amount of time we had. Relying on 3d printing through a third party ended up delaying this project till the final week. Our other parts did arrive prior so waiting on the main component of this build was the biggest risk we predicted and experienced.

6.3 RISK PRIORITIZATION

We prioritized the ordering of parts and components to take place as soon as possible. We had 9 business days factored in and it ended up not being enough. Other risks that came after came to engineering analysis, design, and other documentation.

7 CODES AND STANDARDS

7.1 IDENTIFICATION

We sought to utilize the codes and standards that the Army Corps of Engineers published on flood prevention as it provided simple examples of levees, dykes, flood walls and other preventative measures and how they are constructed. These are the most common structures as to which we would try to build a temporary version to compliment these structures.

7.2 JUSTIFICATION

We are using the U.S. Army Corps of Engineers documentation for flood proofing because it outlines types of barriers use and the codes and standards for placing them along with the type of structure they are. This is the most relevant data we could find for our project. They cover many methods of flood proofing and list construction methods for many long lasting barriers such dikes, levees and flood walls.

7.3 DESIGN CONSTRAINTS

Based upon the guidelines of the U.S. Army Corps of Engineers, a flood-prone area can either be protected by a hydraulic loaded floodwall (for which the water is held exclusively behind the wall) or held back by a levee or dike. Given that the property will be flat, will only encompass one house, and will only require a maximum depth of one meter, we are opting for the former: a portable flood wall. The Code further specifies that if the flood wall contains any permeable areas that a sheet should be used to form a seal. Our design will incorporate a polyethylene sheet which can be draped over each section to create a seal near the bottom of the structure and over the area where each section will be held together by pins.

An additional consideration for this project is that the three-dimensional printer will not be able to print an entire unit as our team had planned. We will need to print each unit in four sections, and then use an adhesive to join the sections into one. We must use an epoxy that effectively holds each piece together and that can withstand water, while also being safe for the environment.

7.4 SIGNIFICANCE

As stated prior, the part will need to be broken up into four sections. The original materials and dimensions of each unit shown in the embodiment drawing will not change. For the final documentation drawing the interior structure of each unit will be affected though. The connection of the four section design might have a have a slight impact on the strength of the wall. More testing is required to determine the extent of the impact, as well as if it is either beneficial or detrimental.

The other factor different from the embodiment drawing is the use of an adhesive to bind the four sections. An epoxy could be used, but special consideration will need to be taken in the selection process. The epoxy will need to be waterproof—as we do not want the four sections to separate—and will need to be environmentally friendly—as we do not want to contaminate the soil or groundwater.

8 WORKING PROTOTYPE

8.1 PROTOTYPE PHOTOS





8.2 WORKING PROTOTYPE VIDEO

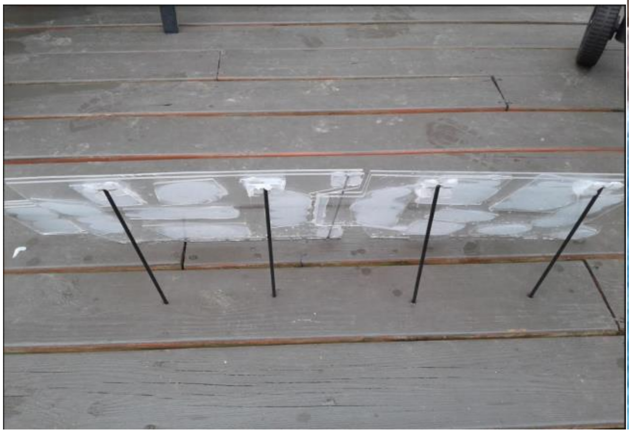
Make-Shift Prototype

https://www.youtube.com/watch?v=267eVk6xUKA

Final Prototype

https://www.youtube.com/watch?v=Cg5jDfbRq9w&feature=youtu.be

8.3 PROTOTYPE COMPONENTS



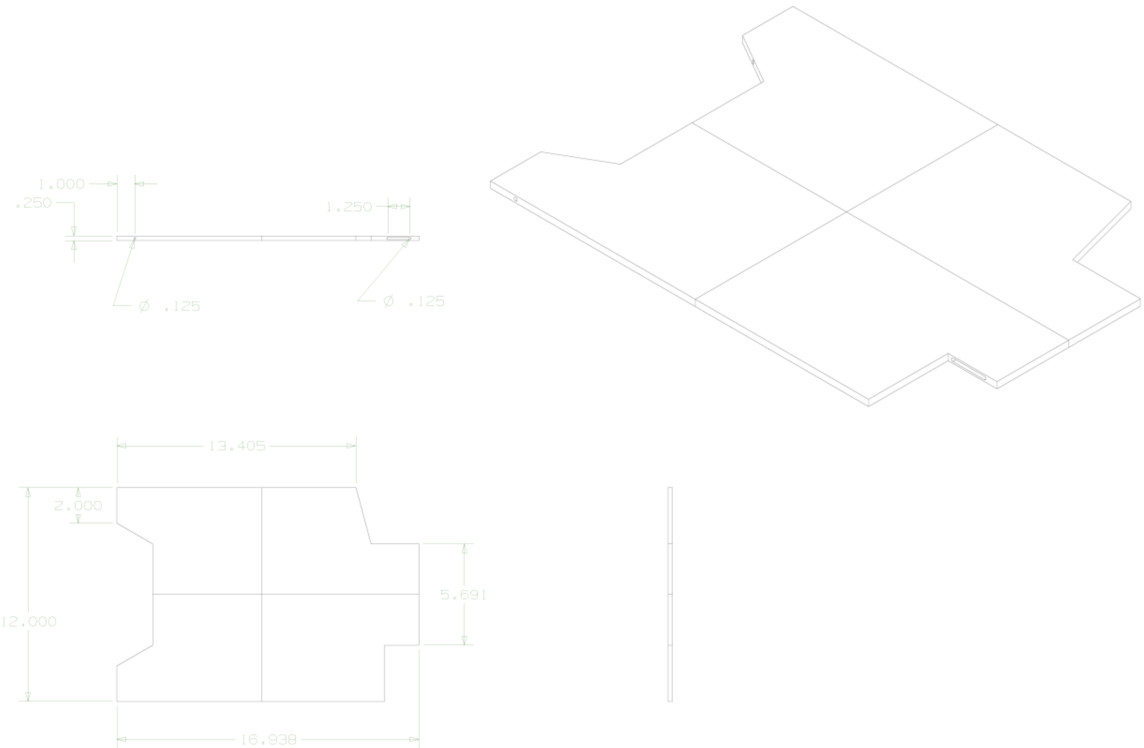
Our original make-shift prototype was done due to time constraints as the 3d printed panels did not arrive until the final day we had class. We made a these panels out of acrylic which was the only alternative we could come up with that would somewhat resemble our final version. However, with not having the same features of mechanically locking in the legs, the panels ended up having enough hydrostatic pressure built up that the legs siliconed in could not stay in place and popped off.

The problem we ran into with our final prototype was that the pressure at the bottom, which is the greatest, forced the panel backwards and had no way to stay in place on the plastic pool. In a later design, I would implement a way for the bottom of the panel to grip whatever surface it was placed on in order to combat this problem.

9 DESIGN DOCUMENTATION

9.1 FINAL DRAWINGS AND DOCUMENTATION

9.1.1 Engineering Drawings



Units are in inches

See Appendix C for the individual CAD models.

9.1.2 Sourcing instructions

9.2 FINAL PRESENTATION

https://www.youtube.com/watch?v=cctkIIJQXYQ

10 TEARDOWN

We ended up not tearing our prototype apart as it had very small miscellaneous hardware and would not be worthwhile to keep on hand. Prototype will on hand to view for anyone interested. Prototype will be in possession of Tom Beaver.

11 APPENDIX A - PARTS LIST

3d Printer Filament – ABS

3/32 dowel pins (leg hinges)

1/8 dowel rod (connect panels together)

3/8 tubing for panel legs

Two part epoxy (marine-weld, jb weld, kwik weld)

12 APPENDIX B - BILL OF MATERIALS

- Acrylic panels

OPTIX 36" x 30" Clear Acrylic Sheet, 0.093" thick

Cut into two 1' x 10" Acted as the flat face of the flood wall. Sandwiched 3 panels together for an overall thickness of 0.279". Small pieces were also used as the joints for the hinge-pins.

https://www.homedepot.com/p/OPTIX-36-in-x-30-in-x-093-in-Acrylic-Sheet-MC-06/202038044

Internet #: 202038044, Model #: MC-06, Store SKU #: 241758

$26.98

- Steel Pins

4140 Alloy Steel Pins, 3/8" diameter, 1' long

1 pin per panel, connected adjacent panels to each other and allowed for pivoting.

https://www.mcmaster.com/catalog/125/3849

Part #: 8927K98

$13.41

- Steel Legs

4140 Alloy Steel Legs, 3/8" diameter, 1' long

2 legs on the back (dry) side of each panel held up the flood wall. A hole was drilled at one end of each leg for a hinge pin to fit into.

https://www.mcmaster.com/catalog/125/3849

Part #: 8927K98

$26.82

- Steel Hinge-Pins

Steel Dowel Pin, 1/32" diameter, 5/8" long

1 pin put into the hole drilled in each leg. 2 pin and leg parts was then attached to each panel, and held in place using adhesive and acrylic.

https://www.mcmaster.com/catalog/125/3460

Part #: 98381A385

$18.12

- Silicone Adhesive

GE 100% Clear Silicone Caulk

Applied between the Acrylic panels to thicken the wall structure, adding strength. Used with small acrylic pieces to attach the hinge-pin and legs to each panel and hold them in place. Used with acrylic strips to create channels for the steel pins to attach to and connect 2 panels together.

Already had access to the silicone adhesive. Initially purchased from Lowe's.

https://www.lowes.com/pd/GE-Silicone-1-10-1-oz-Clear-Silicone-Caulk/3070881

$5.38

- Plastic Sheet

BARRICADE 10' x 25' Clear 3-mil Medium Duty Plastic Sheeting

Draped over top of the flood wall to create a water tight seal with the bottom of the swimming pool.

https://www.lowes.com/pd/BARRICADE-10-ft-x-25-ft-Clear-3-mil-Plastic-Sheeting/1000158123

Item #: 810476, Model #: 110CT6025LOWES3C

$8.38

- Swimming Pool

48” wide x 12” deep Children's Pool

Used to test the final prototype. Flood wall and sheet was placed in one corner of the pool, and water was added to test if the wall kept out the water.

Already had access to a 10' x 30" plastic, children's swimming pool. Similar pools can be found at Walmart at a variety of price ranges.

$12

13 APPENDIX B – PROJECT MANAGEMENT COLLABORATION APPENDIX

1. PRELIMINARY: Team organization

On the first class of Mechanical Engineering Design we were introduced to a vast array of possible projects for which we will implement the design process in order to overcome specific challenges. Proceeding this introduction, we were tasked with formulating a team with which we will work closely throughout the semester. In the case of our team, Matt and Tom started a group based on the fact that they were both enrolled in engineering project management the semester prior, and felt they could utilize the skills they learned in the aforementioned course. Initially both members realized they needed a third group member to further aid in generating ideas and troubleshooting solutions throughout the course. Thus, Will joined and the process of choosing a topic that suited the groups strengths began.

We chose, by process of elimination, three topics for which we could generate ideas on the spot as possible projects: Compaction Solutions, The Hydraulic Car Lift, and The Walk Through Super-Drier. Next, we chose a number and waited to hopefully embark on one of these three projects. As numbers were called, our number was chosen last and we were confronted with a large problem: All of our ideas were chosen by previous groups.

Following this dilemma, we articulated to Professor Jakiela that we were most interested in the Compaction Reduction Project and that all of our projects of interest were already taken; thus, the Professor allowed our group to formulate a project based on existing agricultural problems. We brainstormed about the most problematic effects of global warming and decided as a group on the issue of flooding. The most portable and popular method of preventing flooding is sandbagging. Often the pressure of the water breaks these structures, the water level simply raises too high, or when this method is successful at retaining the crest, a mess is left behind. This method proves to be archaic considering the current level of technology circa 2020.

Our project, as defined by our team, is to develop a flood prevention apparatus that will satisfy several pre-defined parameters, those being: low impact on the existing environment, a design that can be constructed relatively quickly in the flood zone as well as quickly deconstructed after the flood event, the design should not leave behind any mess as a consequence of the design itself, the design will be modular (i.e. the apparatus will consist of units which can be connected together continuously to create a barrier), the cost of materials for the project may not exceed four-hundred dollars, and the culmination of our teams effort will produce a scaled-down model of a working prototype by the end of the term. Our project will involve a hypothetical customer, Dr. Jakiela, who owns a house in a flood-prone area for which we will be providing protection. Our design will either be a novel idea of our own or a revision of an existing design. This begins by researching existing solutions for flood prevention and documenting the pros and cons of each respective design. As the semester moves forward, so will our concepts and ideas, until our team reaches a practical solution to the problem, all culminating into the fruition of our efforts: a working prototype

2. Background information study

A: For our design project, before choosing our final concept, we created a matrix of metrics as criteria to choose the best concept. Additionally, we discussed the feasibility of each model, discussed the pros and cons, possible concerns, and ultimately went with concept for which we agreed would meet our over-all performance measurements; defined as the height and weight of the unit. These two would qualify the product with the greatest amount of storability and portability.

B: We proportioned the work as following: Will worked on 3b, 3c, and helped Matt with the Matrix. Tom produced the final drawings for our prototype and created the Scoring Matrix. Matt created the Customer Question and Answer Matrix and The Table of User Needs.

3. Specification and conceptual design study

A: Initially our team began brainstorming ideas of our own for which we contributed two original ideas per-person. We sketched out concept drawings based on the idea of modularity: or the constraint that each panel would be the same and would harmonize together as a single unit. Additionally, we wanted the structure to be easily stored, assembled, and to be a portable alternative to the most popular flood solution currently in use (i.e. sandbagging).

B: After our concept sketches were finished, we immediately voted down one of each person's concepts, leaving our group with three possibilities. For each drawing, we analyzed the strengths and weaknesses with respect to the aforementioned-criteria. Also, we considered the difficulty of not only constructing a wall with a given model; but discussed the practicality of bringing a certain solution into fruition. We decided 3-D printing would be the cheapest and fastest method of creating our panels and unanimously voted on an idea of Tom's which satisfied the objectives of the project.

C: We decided that Tom would be our principal CAD expert since he works with Solid Works daily. Will and Matt would help write the papers and articulate our status, and concepts to Professor Giesmann and Professor Jakiela throughout the semester. We have each worked as a team to bring our vision to fruition: including writing the papers, attending class weekly, having bi-weekly team meetings, and generally communicating with each other as much as possible so that we all remain on the same page. We will create our second version of our prototype tomorrow (which includes our panels which did not arrive on time) and will each work as a team until we have successfully completed the course.

4. Embodiment and fabrication plan

Tom came up with the design and gave a description of what parts were needed to build the prototype. With these instructions, will was able to draw the embodiment drawing labeling out all parts and how they would be applied to the prototype. With this completed, we proceeded on to conduct our engineering analysis so we could purchase our parts.

If a problem were to arise with parts coming apart, go to working prototype and see part of epoxied panels. If confused on what parts were exactly needed, see parts list. If confused on the manufacture panels, please see working prototype to see printed panels

5. Engineering analysis

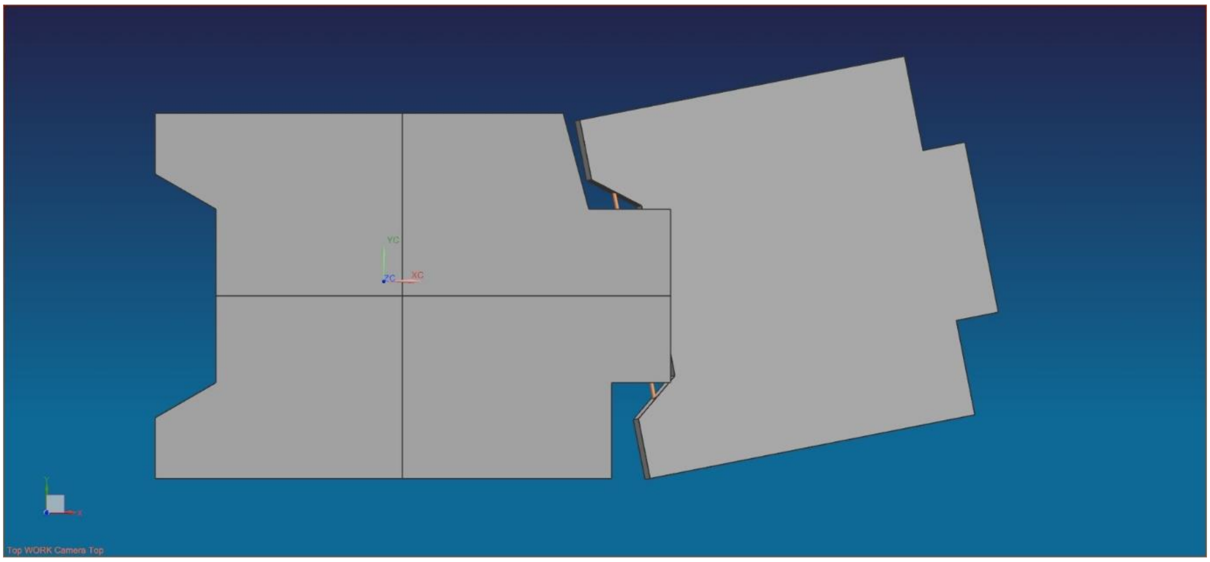
1 steel hinge pins will connect to 1 steel leg. This leg assembly will connect to the 3D printed plastic panel. Each panel will have 2 legs and 1 steel connecting pin. Adjacent panels will be connected to one another by this steel connecting pin. Connecting multiple panels together will create the flood wall.

We are still in the process of building early testable prototypes. Tom had our flood wall modeled using CAD software. We expect our parts to be shipped and have the working prototype 3D printed soon. Tom is currently trying to reserve the printer on campus. Will and Matt continued to work on the paper.

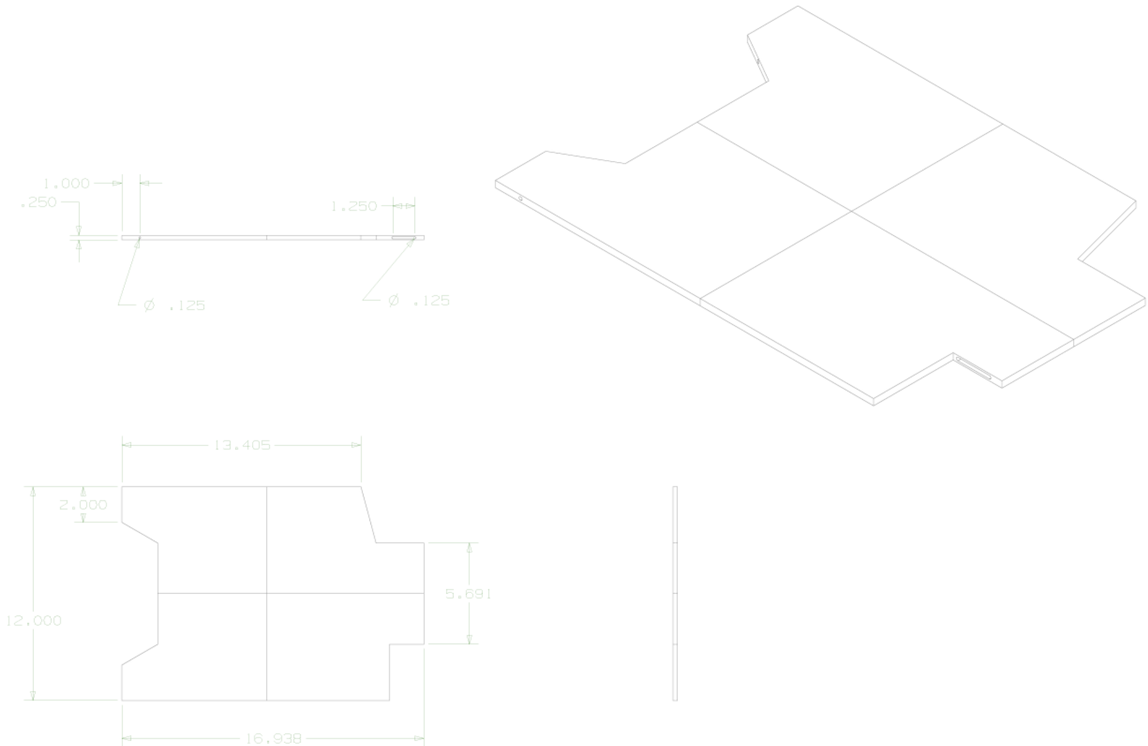
6. Codes and standards

The 3D printer we reserved cannot print a model of our size. We have decided to break up the model into four sections then glue them together using epoxy. We also require more funds then we previously anticipated. To lower costs we decided to only make 2 panels, instead of 8. This will cut the price by a factor of 4. Do so will also have the benefit of saving time on the 3D printer.

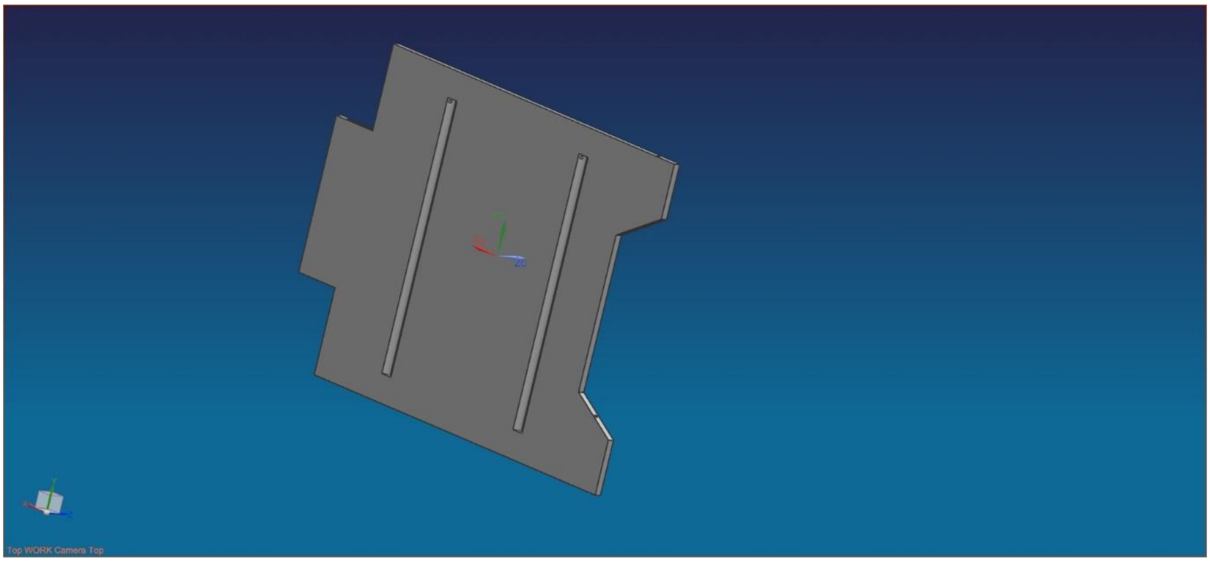
14 IX C – COMPLETE LIST OF ENGINEERING DRAWINGS



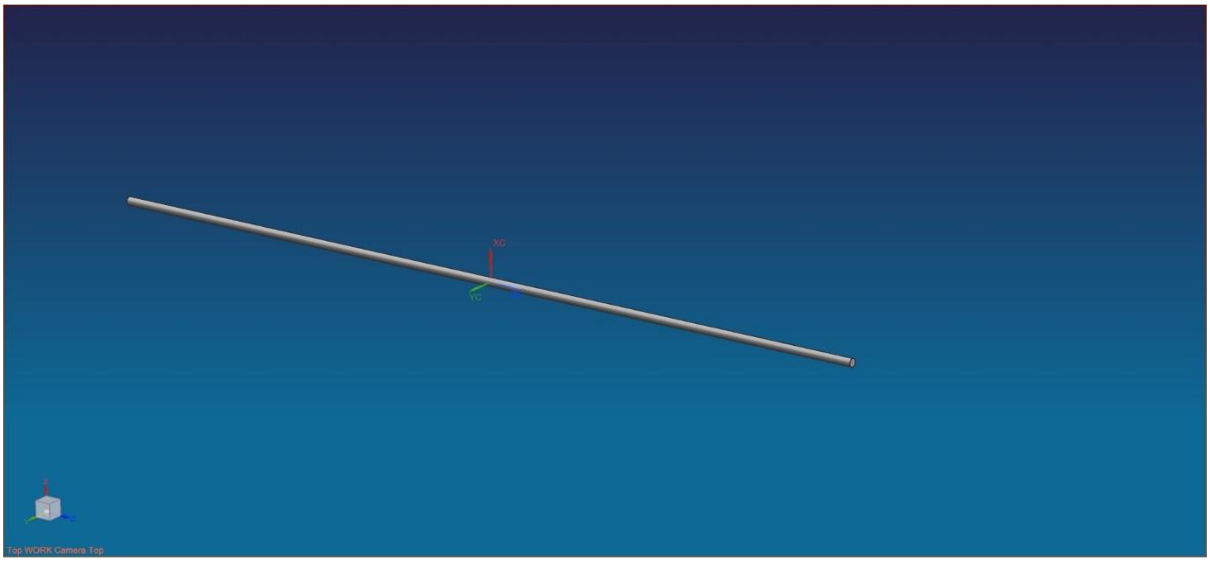
Flood Panel ASSY



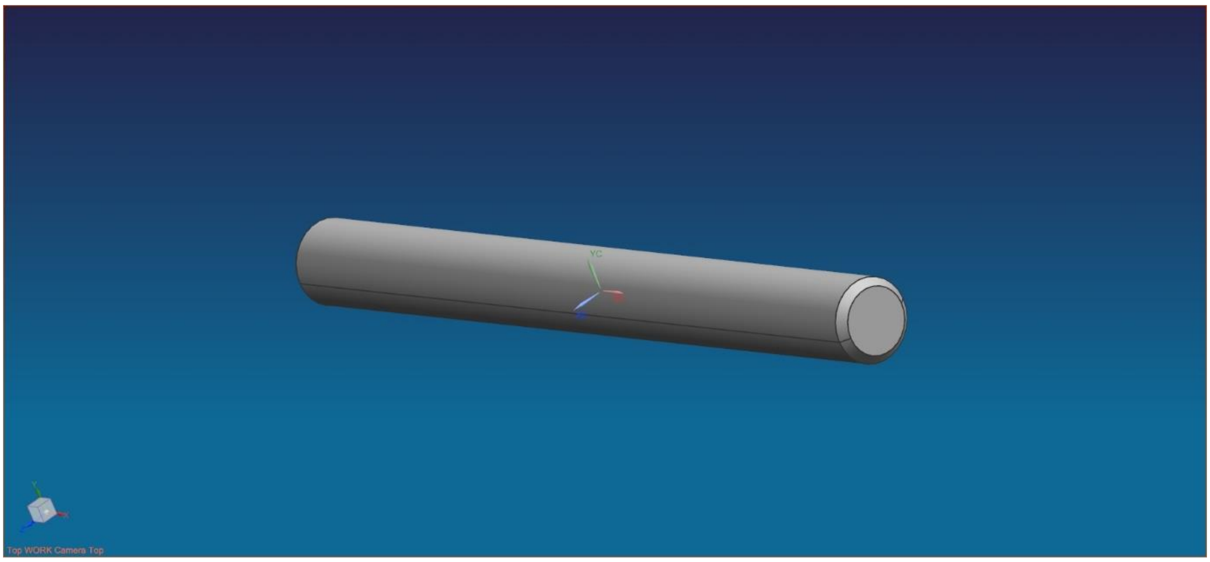
Flood Panel Drawing



Flood Panel Model



.125” dowel stock



.09375 dowel pin

15 ANNOTATED BIBLIOGRAPHY

Codes and Standards Source

United States, Congress, U.S. Army Corps of Engineers. “Flood Proofing Regulations.” *Flood Proofing Regulations*, 2nd ed., vol. 1165, ser. 314, 1995, pp. 1–85. *314*.

Barrier Inspiration

http://www.floodcontrolinternational.com/PRODUCTS/FLOOD-BARRIERS/flood-barriers.php