

Final Report: Design Updates

Cinthia Hai Young Kim hk625

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1 Introduction

AguaClara Design Team refines and updates the current research and findings by the AguaClara research teams to provide most current details of the AguaClara technology and its components to the public. Some responsibilities include creating a tool that allows engineers to enter desired parameters and receive AutoCAD drawings and detailed reports of the plant. The Design team develops and tests its design tool to accurately display our current designs and the various specifications needed to build a functioning plant.

The report includes drafting AutoCAD shop drawings of the OStARS molds and updating OStARS filter updates of assembly spacer and platform in MathCAD. Documenting the fabrication specifications is useful for future reproduction. A backwash lagoon system was also designed to store backwash water in a lagoon and redirect the water to the entrance tank for water conservation. The lagoon design has to be refined in areas of the storage conditions, pump selection, lagoon maintenance system and other alternatives to a backwash lagoon.

2 StaRS Mold Fabrication Documentation

The molds used to shape the ends of the PVC pipes for the injection and extraction manifolds need to be fully documented in our design. A student team helped create the design for the mold and fabrication methods for the manifolds as documented in the "Stacked Rapid Sand Filtration - Full Scale Progress Report" by Michelle Wang, Steph Lohnberg, Chris Holmes (May 11, 2012). The research team organized an instruction manual for molding pipes, drilling holes in the trunk line and end lines and assembling all the parts together. They also detailed a table of material specifications for stacking layers. The current molds utilized in Honduras were created under their instructions and one of the challenges this semester is to create detailed shop drawings of the molds under the advisory of Paul Charles, the CEE shop specialist who originally fabricated the molds. The molds are currently in use at Honduras and could not be shipped to Cornell for accurate measurements. Therefore, the APP engineers measured the molds in Honduras and provided dimension layouts and photos of the various molds. After completion, the AutoCAD drawings were saved in the Drawings and Templates folder of Final Designs folder under their mold type specifications. Dimension layouts of the mold drafted by the APP engineers were also uploaded to the same folder.

2.a Challenge Details

The first step to drafting AutoCAD shop drawings was to acquire the dimensions and the specifications of the various molds utilized in StaRS by contacting Jon Christensen and Walker Grimshaw, the engineers at Honduras. The molds require AutoCAD chamfer commands and dimensions that require cursor-clicks. Cursor-clicks cannot be coded into the AutoCAD scripts drafted in MathCAD, and therefore the drawing cannot be successfully drawn. Thus, the shop drawings were directly drafted in AutoCAD and partly dimensioned directly on the sheet.

Since the goal for this challenge was to draft a transparent shop drawing for a fabrication specialist, it was important to consult a shop specialist over the shop drawing layout and fabrication details of the mold. Paul Charles, the CEE shop specialist who fabricated the molds, provided direction over the fabrication process and helped determine the unknown specifications necessary to faithfully replicate the designs.

There were four mold types: 1" flat number 2 mold, 1.5" flat mold, 1" curved mold, and 1.5" curved mold. After consulting with Paul, the flat mold shop drawings were deemed unnecessary due to the relatively fewer design specifications and lower levels of difficulty. The 1.5" curved mold was to be the reference for the other three mold types. Monroe Weber-Shirk, the AguaClara director, however further advised that all four shop drawings were needed to relay the design specifications. Therefore, all four mold types were drafted in AutoCAD.



Figure 1: 1.5" Curved Mold currently in use in Honduras. There is only one copy of this mold and therefore it is necessary to document its fabrication details.

The 1.5" curved mold as shown in figure 1 was examined closely because the mold is composed of two horizontally oriented cylinders that make it difficult to determine and measure the dimensions accurately. Thus several safe guesses were made in setting the dimensions by first unifying the measurements to the metric system. The measurements are annotated with both metric and customary units for all of the mold drawing. The mold was separated into two layers for the 1.5" curved mold: the upper cylinder and the bottom cylinder. The upper cylinder is a horizontally oriented cylinder that was cut with a 1.25" radius on the flat end when first vertically oriented. The vertically oriented cylinder was then rotated to be horizontally oriented. The convex-like outer side of the cylinder was then cut with a 1.9" diameter at the center point for the first pipe insertion. The mold inner diameter must also be less than or equal to the diameter of the hole created by the hole saw used to drill the holes in the manifold. The horizontally oriented bottom cylinder was also cut with a 1.75" diameter at the center point and given an additional flat bottom cut of an arbitrary 1" cut from the outermost curve when the bottom cylinder is vertically oriented. In addition to the cuts, a 1/8" radius was chamfered around the edge of the bottom cylinder 1.75" opening to smoothly guide the pipes to obtain a narrower opening. The upper and bottom cylinders are fastened together with two 1/4" cap screws on both sides on the center radius. They are equally spaced from the center and at the center from the flat sides and the center cuts. As for the length of the cap screws that hold the two parts together, Paul suggested using 1/4" typical cap screws and Tim Brock, CEE Shop specialist, further advised using 1/4"-20 X 1 3/4" to ensure a 1/2" connection to the bottom cylinder from the upper cylinder. The 1/2" connection into the bottom mold from the upper mold is essential and therefore the cap screw and screw cavity height can range from a minimum length of 1/2" connection and height of the upper mold to the maximum length of total upper and bottom mold heights. Stock images of the cap screws were downloaded from Tracepartsonline and inserted as block images into the drawing and then scaled to fit the screw cavities. Please note that due to scaling and the dimension variability, the inserted screw images are not drawn to scale and therefore the user should use discretion in selecting the height of the total screw cavities and the length of the screws during fabrication.

The rest of the mold drawings were drawn in a similar way with the same method for the cap screw selection and location, cap screw inserts, the flat bottom cuts. For example, the 1" flat mold has an upper and bottom parts as well that are connected by the cap screws located equidistant from the center of the cylinder. The flat molds however were cut differently in the way to maintain its vertical orientation. Just like the curved molds, the flat molds have upper and bottom cylinders. The upper cylinder was cut in the center with the first pipe diameter and truncated from the bottom flat end up. The bottom cylinder was also cut in the center with a smaller pipe diameter and given the same 1/8" radius chamfer around its opening. The two cylinders are fastened together by cap screws as done with the curved molds. Figure 4 shows a 1" flat mold drawn with the method described.

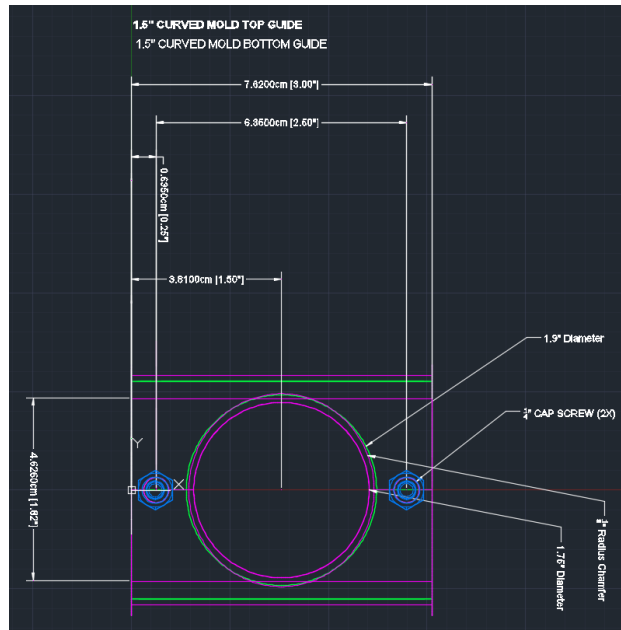


Figure 2: Top View of 1.5" Curved Mold drafted in AutoCAD.

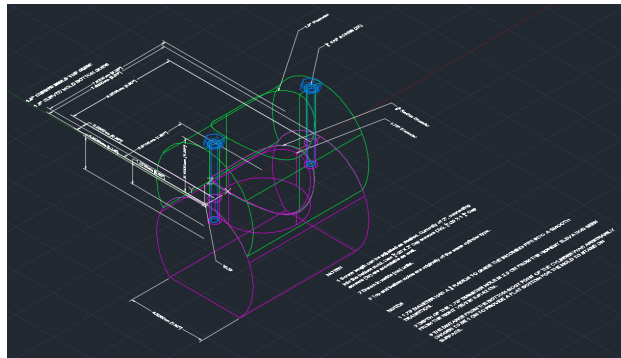


Figure 3: SW Isometric View of 1.5" Curved Mold in AutoCAD

All the AutoCAD drawings can be found in the Drawings and Templates folders under names such as "1.5 in Curved Mold". Inserted cap screw drawings saved as "Cap Screw 2x20" and the dimension layout provided by the APP engineers saved as "OStARS Mold Dimension Layout" can be found in the same folder as well. The 1.5" curved mold has the most dimensions and annotations and the upper and bottom cylinders were separated into two separate layers. Other three mold types, however are only dimensioned in the x axis and do not have separate layers for the upper and bottom layers. It is not necessary to have the two cylinder parts in separate layers because the parts can be isolated to show only one part on the AutoCAD workspace without affecting the isolated object.

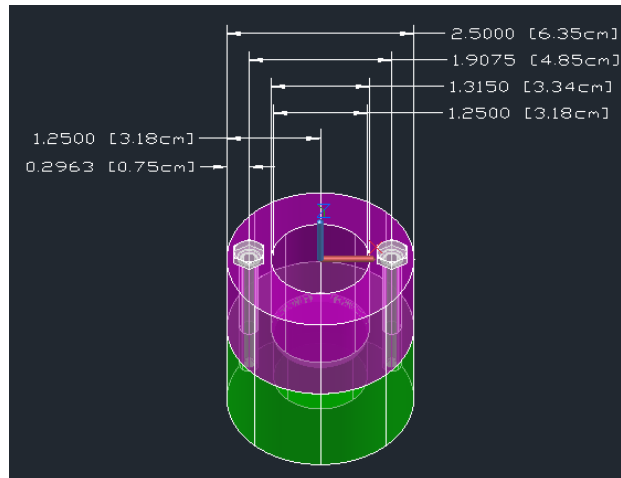


Figure 4: 1" Flat Mold AutoCAD drawing drawn with the flat mold method. Flat molds are vertically oriented and therefore have more simple cuts in the center and the ends. They share similar methods with curved molds in connecting the upper and bottom cylinders.

3 Backwash Lagoon

In anticipation of low flow rate seasons and a need for conservation of water, backwash lagoons was researched and drafted in MathCAD to slowly pump water from a lagoon or holding tank below the plant to the entrance tank. This challenge was a new addition to the AguaClara design tool and is saved as "Backwash Lagoon" in Underdevelopment folder of the Final Designs folder. Since the APP engineers were planning on building waste lagoons at Zanmorano, their design specifications and layout were considered. Their designs included a secondary clarifier and a drying patio as one option and two large sludge lagoons as the second. Albeit the waste systems will not be implemented due to insufficient funds, the second option will be considered in this backwash lagoon design.

3.a Challenge Details

Several options were considered for the backwash lagoon system. One option was designing a system for a low head, low flow pump that could be used to slowly pump water from a lagoon or holding tank below the plant to the entrance tank. Another option was a high flow rate pump that would be located in the drain channel to pump all the backwash water to the holding tank uphill from the entrance tank. The first option was chosen to allow some sedimentation in the holding lagoon to reduce solids management that would be required for a holding tank.

In order to figure out the dimension of the backwash lagoon, it was first necessary to set the volume capacity of the lagoon to store a set number of backwash frequency or a maximum amount of daily backwash water volume. Using inputs such as the number of filters, filter flow rate, minimum filter runtime, backwash duration, and other factors to calculate the volume of wasted water after one backwash cycle in the MathCAD file. It was difficult to make a decision setting the maximum number of backwash cycles the lagoon could hold since the pump frequency or power were yet to be defined. Since the lagoon will have sedimentation, the sludge will accumulate in the bottom and therefore the operator would have to remove the sediment buildup every few weeks. The lagoon will have to be positioned below the drain channel and a clay layer or an alternate coating on the bottom-most elevation of the lagoon. This lagoon design is very similar to that at the Cornell water treatment plant. Walker did not suggest a clay layer, however the goal of this challenge is to conserve water and to do so, there should be a more sealable layer and maybe a protective cover on the top of the lagoon to inhibit evaporation. Calculations of sedimentation buildup and the mechanical pump specifications will have to be further researched.

4 OStaRS Filter Upgrade

This challenge started late in the semester to allow the fabrication team, Subhani Katugampala and Mengqi Jiang, to update any new components for the filter design that are ready to be incorporated. They worked on filter assembly using spacers and platforms. The fabrication team relayed their progress to the design team to draft AutoCAD scripts in MathCAD. This includes but is not limited to filter slots, hinged platform for filter assembly and new filter module spacers. The Fabrication team provided preliminary AutoCAD drawings for hinged platform and filter modular spacers that need new updates and revisions. Figure 5 and 6 show the AutoCAD drawings of the filter spacer and the platform. In addition to the AutoCAD drawings, the fabrication team provided a MathCAD file that draws an outdated version of the filter modular spacers as shown in figure 7.

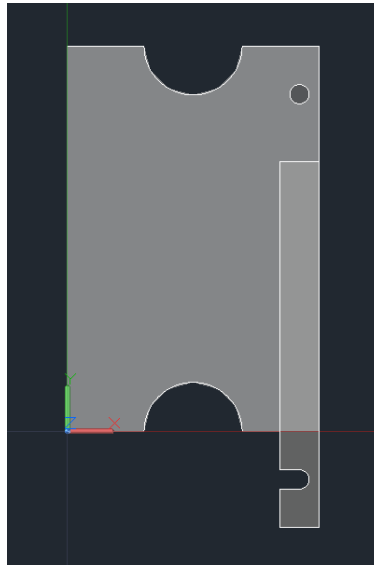


Figure 5: Filter Modular Spacer AutoCAD DWG provided by the Fabrication Team was more updated than the MathCAD produced drawing. However, this AutoCAD drawing was not updated because MathCAD can produce AutoCAD scripts.

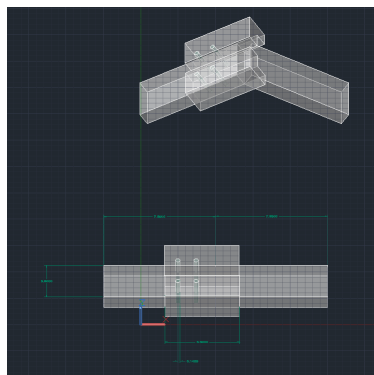


Figure 6: Filter Platform AutoCAD DWG provided by the Fabrication Team. The Dimensions for this drawing however were very disproportionate and therefore its MathCAD codes were heavily relied on dummy dimensions.

AutoCAD drawings were not updated because MathCAD files can output documents of AutoCAD scripts that are copied and pasted into the AutoCAD command line to draw figure 7. The purpose of MathCAD

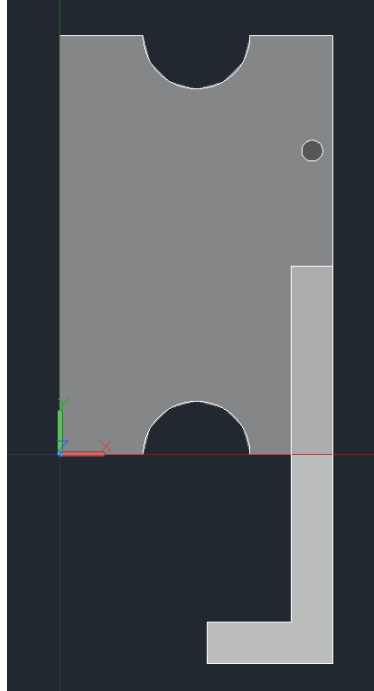


Figure 7: Filter Modular Spacer AutoCAD DWG drafted in MathCAD provided by the Fabrication Team. MathCAD file outputted an AutoCAD script that was inserted into the AutoCAD command line to draw the image. Compared to figure 5, this drawing was less up to date and one of the main differences was the L-shaped latch.

scripts is to print strings of AutoCAD commands that can draw the design when inserted into the AutoCAD command line. Thus, it is only necessary to revise the MathCAD scripts and the AutoCAD drawings were used as references for dimensions and the general location of parts. As for dimensions that were not clear, variable names were assigned and coded into MathCAD. Throughout the process, there were multiple meetings with the fabrication team for further clarification and updates on the progress of the spacer and platform. After a few weeks of starting this project, the fabrication team provided a set of computer-drawn drawings of the filter spacer and the platform as shown in figures 8 and 9.

4.a Challenge Details

MathCAD and AutoCAD files on filter modular spacer were provided by the Fabrication team, however both were outdated in terms of dimensions, location and inclusion of new additional parts. It was difficult to envision the updates to be made and so at an additional meeting with the Fabrication team, they demonstrated the 3 part filter spacer assembly and the platform functionality as well. After the first meeting, certain aspects such as the location of the pin and the off-centered cuts of filter holes of the filter spacer were yet to be finalized and therefore it was decided that they will provide accurate dimensions and locations of the various parts in the upcoming weeks. Since the dimensions and the locations can be substituted with variables and arbitrary numbers, it was possible to draft a rudimentary MathCAD script of various layers and drawing functions to represent the parts. After the few weeks since the meeting, the fabrication team sent the schematics of their pieces as shown in figures 8 and 9

The filter spacer has two layers: steel and PVC. The PVC layer has three separate objects to match the three bodies shown in the spacer schematic: top, middle, bottom. The middle and top bodies have PVC latches that connect the three bodies together with cavities and cotter pin insertions. All three bodies have an vertically and horizontally off-centered pipe cavities. The large pipe cavities have a U-shape to allow the pipes to be inserted smoothly. A box was first drawn from the horizontal centerline of the pipe cavity and subtracted from the body to create this radius. The bottom body also has a small U-shaped cavity below

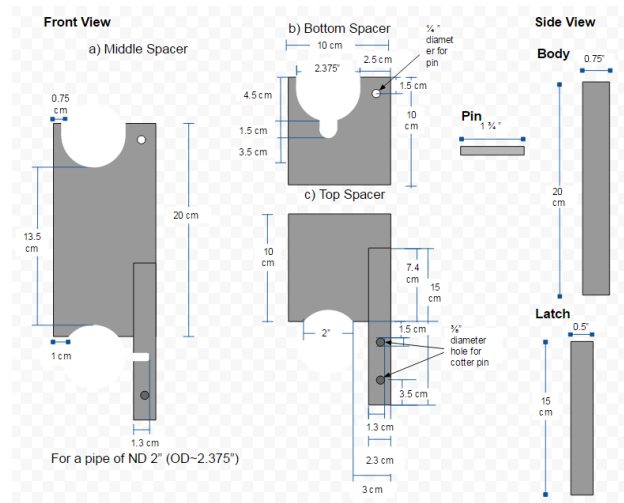


Figure 8: Filter Modular Spacer Schematic later provided by the Fabrication Team. Albeit quite comprehensive, there are still many unclear and unknown dimensions that need to be further clarified.

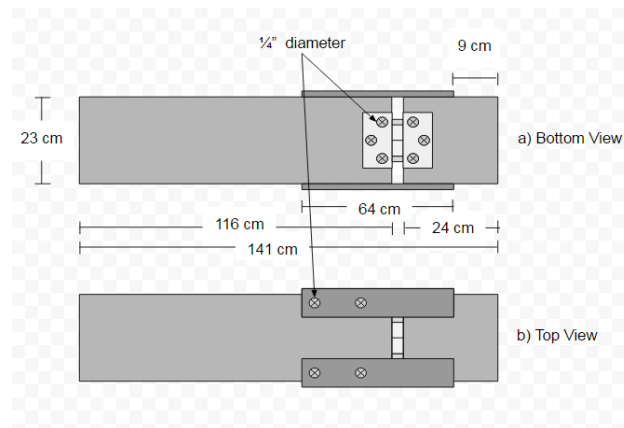


Figure 9: Filter Platform Schematic later provided by the Fabrication Team. Albeit quite comprehensive, there are still many unclear and unknown dimensions that need to be further clarified.

the large pipe cavity.

There are two separate latches attached to the middle and the top bodies. These latches have rotated U-shaped openings for the pins to slide in. The three bodies also have pin holes for the cotter pins to be fixed onto the bodies. Certain points that are still unclear from the spacer schematic include the existence of cotter pins and the cotter pin specifications. There are two cotter pin holes in the top body and when a pin is fixed to the pin hole of the middle body, the lower cotter pin hole will be blocked by the middle spacer body. It is unclear how the Fabrication team will utilize the lower cotter pin holes and therefore the lower cotter pin holes were omitted from MathCAD. If the cotter pin holes only exist on the latches, then these holes can be easily cut using the cylinderF and RemoveSteel functions. Figuring out the purposes for the regular 1/4" pin hole and a 3/8" cotter pin hole is also important to draw a more accurate drawing. Also, pins and cotter pins can be inserted into the drawing if given more specifications to find public stock drawings. Figure 10 shows the current filter modular spacer available in the AutoCAD script folder.

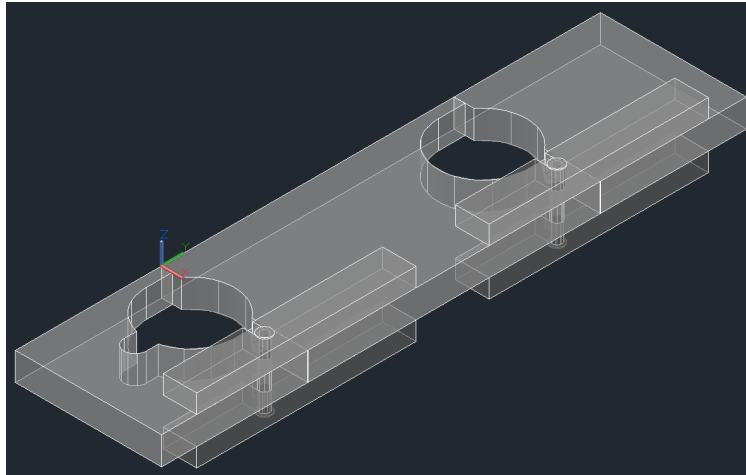


Figure 10: Current Filter Modular Spacer MathCAD DWG with the updates. The view is SouthEast Isometric.

The hinged platform, on the other hand, only had an AutoCAD drawing that needed a new MathCAD design script. The AutoCAD drawing however are outdated and inaccurately show the hinge sizes which are much thinner and longer than the actual model. The Fabrication team recently provided platform schematics and the platform most of the correct dimensions. In drafting in MathCAD, the hinged platform was given three separate layers: wood, steel and hardware. In the wood layer, the platform was divided into left and right body connected with a hinge drawn in the hardware layer. The left body has a longer width and has steel sides that wrap the wooden bodies together. The steel strips are in the steel layer and the screws are also included in the hardware layer. Currently, the MathCAD file draws figure 11. Certain figures that still need clarification are the locations of the screws that connect the steel strips to the wooden board and the dimensions of the steel strip. The the steel strip screws are located at the center height of the steel strips, however even the height of the steel strips are unclear. Assuming the height of the steel strips are the same from the top and front views and less than the thickness of the wooden bodies, the steel strips were drawn slightly above the sides of the wooden body.

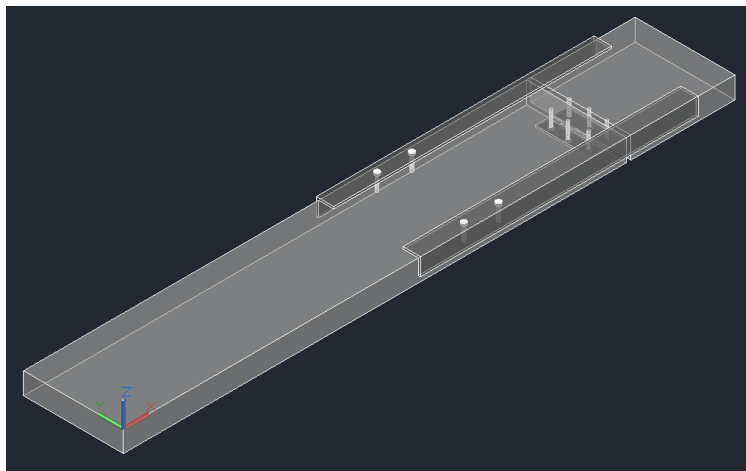


Figure 11: Current filter platform DWG

5 Conclusion

1.5" curved mold has been drawn and annotated in AutoCAD to guide future users in fabrication of the OStaRS mold. The 1" number 2 flat mold and the 1.5" flat molds were also drafted in AutoCAD and all the drawings can be found in the Final Designs, Drawings and Templates folder. Both flat mold drawings however need to be fully annotated using the dimensions also saved in the same folder. Adding dimensions to the drawings were a challenge because AutoCAD typically does not allow z-axis dimensioning in 3-D drawings. The Backwash Lagoon system was designed as shown in the Backwash Lagoon file saved in the Final Designs, Under Development folder. The number of backwashes possible and the possible volume of backwash water per cycle were calculated and certain parameters that were considered in this design are also detailed. After continuous communication with the Fabrication team, the filter modular spacers and the filter platforms were drafted in MathCAD to produce AutoCAD scripts that draw the figures that closely represent the dimensions and specifications of the pieces. These MathCAD files are in the AutoCAD scripts folder of the Final Designs folder.

6 Future Work

The 1.5" curved mold has dimensions and notes to guide the user during fabrication. However, the other three mold types do not show complete dimensions because AutoCAD does not typically allow z axis dimensions. However, z-axis dimensioning is possible since the 1.5" curved mold has such dimensions. Nevertheless, it is unclear how the level of precision from the two significant figures of measurements and the level of accuracy from the unit conversion will affect the mold fittings. Additionally, it is unclear whether there would be any copyright issues concerning the cap screws, hinge, and screws downloaded from Tracepartsonline. The backwash lagoon would have to be further researched and designed before drafting the specifications and layout in MathCAD and AutoCAD. If there any further filter updates in the future, the MathCAD codes will have to updated to reflect the accurate design specifications.

7 Task Map

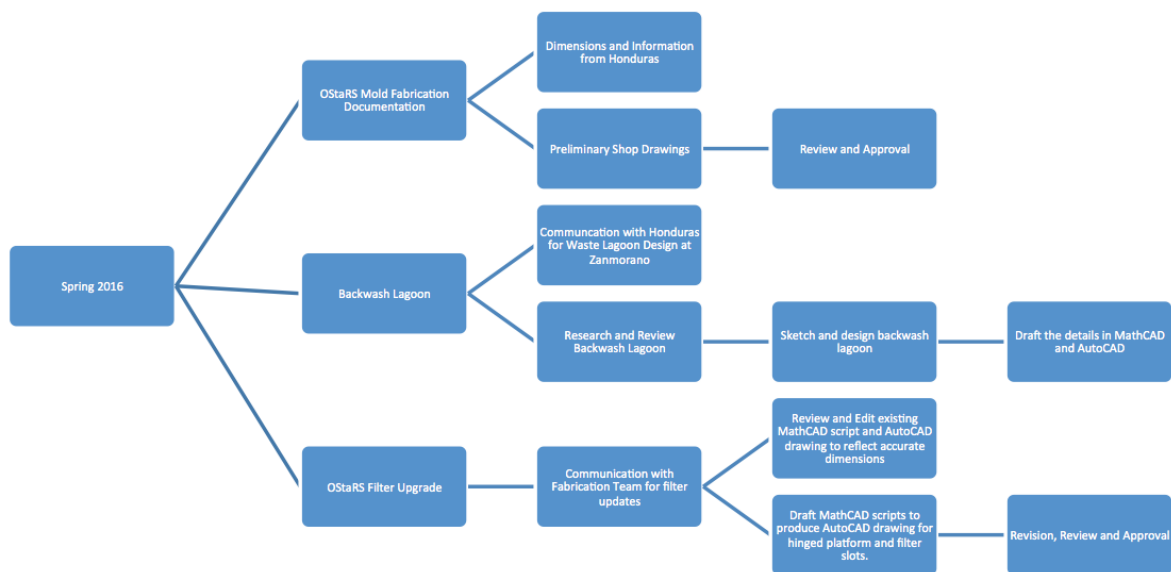


Figure 12: Task Map

7.a Task Map Details

- StaRS Mold Fabrication Documentation
 - Currently, the only existing copies of the mold exist in Honduras, therefore it is important to prepare for unforeseeable events such as loss or need for multiple copies.
 - * Communicate with Paul Charles, the CEE shop specialist and the mold fabricator, and the APP engineers for the dimensions of the mold and the various other details needed to fully document the fabrication process.
 - * Draft preliminary shop drawings to be reviewed and approved by Paul Charles. Final review was done by Tim Brock and shared with the APP engineers. The AutoCAD 3-D drawings as well as the dimensions document provided by the APP engineers were saved in the Finals Design, Drawing and Templates folder.
- Backwash Lagoon
 - The backwash lagoon system is to provide an additional water source during dry seasons or low water levels in Honduras. This system will conserve the backwash water in a small lagoon near the drain channel to be pumped back to the entrance tank of the water treatment plant when needed. Essentially the lagoon will allow water to be recycled with additional sedimentation.
 - Research and design a storage space for the backwash water storage with a mechanical pump to direct the water to the entrance tank of the plant. The following calculations were saved as a MathCAD file in the Finals Design, Under Development folder.
 - * Review and draft a preliminary design of a backwash lagoon. Consider and state all the assumptions and the conditions for this task.
 - * Analyze the constraining variables and design specifications in MathCAD to be reviewed with the advisor and Monroe. AutoCAD drawings are supplementary.
- OStaRS Filter Updates
 - Throughout this semester, Fabrication team has made filter upgrades that need to be drafted in MathCAD scripts to produce AutoCAD drawings.
 - * Communicate with Fabrication OStaRS Filter Subteam members, Subhani Katugampala and Mengqi Jiang to receive their most recent MathCAD and AutoCAD files on filter slots, hinged platform for filter assembly and new filter modular spacers.
 - * Draft MathCAD drawings for designs with no existing MathCAD scripts or AutoCAD drawings.
 - * Revise existing MathCAD scripts to reflect its corresponding AutoCAD drawing.
 - * Continually revise the drawings and review the drawings and its dimension with the Fabrication team for most current updates.