Deliverable E: Project Plan and Cost Estimate

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Abstract

The following report outlines the project schedule and cost for a raft cleaner machine for group A11 of GNG 1103. In the report we demonstrate a detailed CAD design of a finished concept with all parts included. The cost of the project prototype has been based on the materials needed to create a successful outcome based on the clients need and feedback. Additionally, a risk and contiguity plan has been created to assure this project follows upcoming deadlines. Finally, a prototype testing plan will allow the group to complete work in a timely manner and follow a set schedule.

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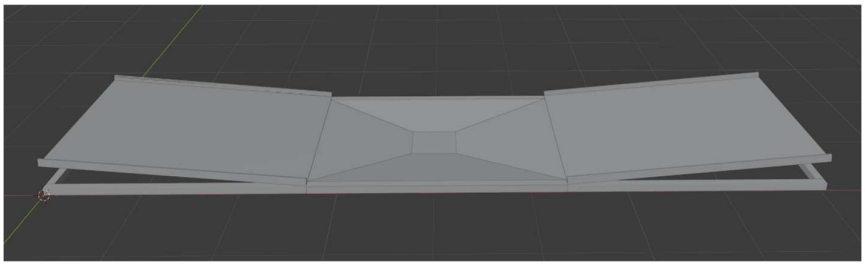
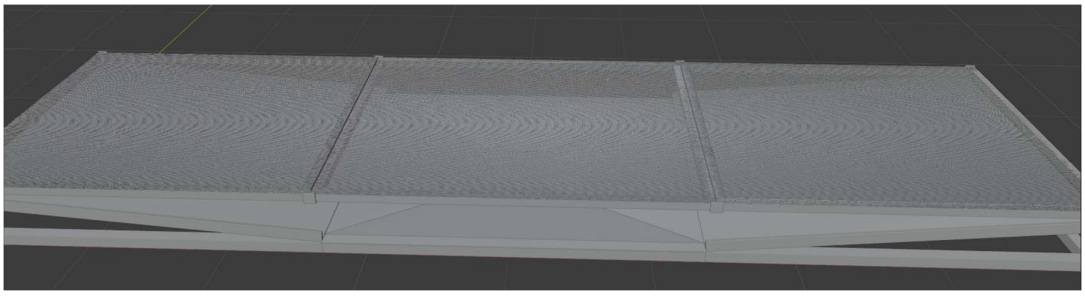
1. Introduction

The purpose of this document is to refine the concept developed in deliverable D and to create a detailed CAD Design. Our current solution is a floor mounted machine that uses a stack loading method, linear actuators, rollers, high pressure water jets, and sensors. It cleans one board at a time, and uses a motorized collection plate to stack the clean boards. This concept has been modified slightly due to the feedback provided in the first client meeting; we have updated the loading mechanism to better reflect the client's needs from their feedback, where they stated some safety hazards and a need for a start / stop button. To refine our concept we will use detailed drawings made with computer-aided design (CAD), create a cost spreadsheet, a list of equipment and materials, develop risk and contingency plans, and a prototype testing plan. These items will be outlined in this document and drive our progress during the next few weeks.

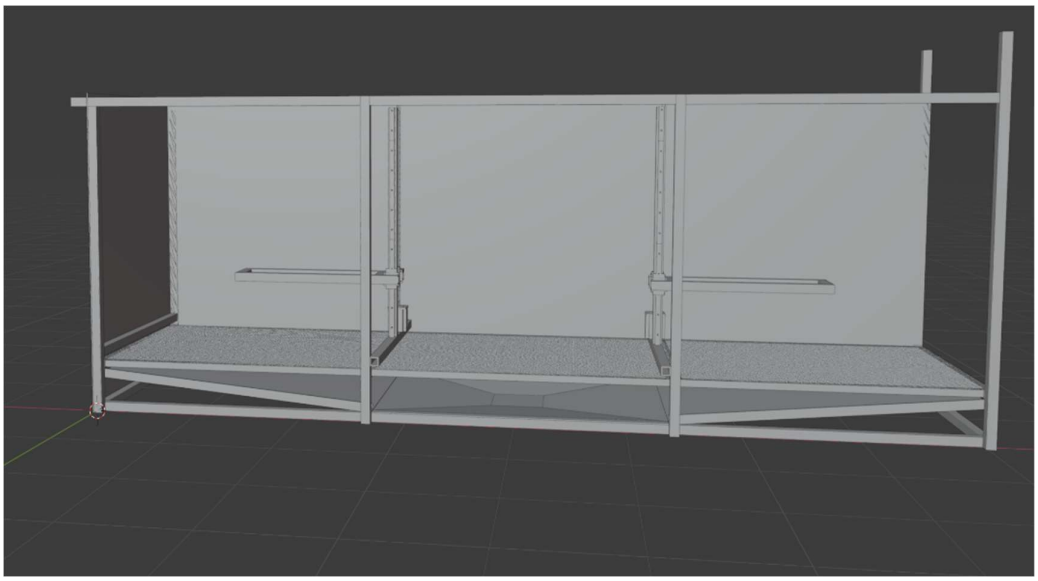
2. Detailed Design Drawing



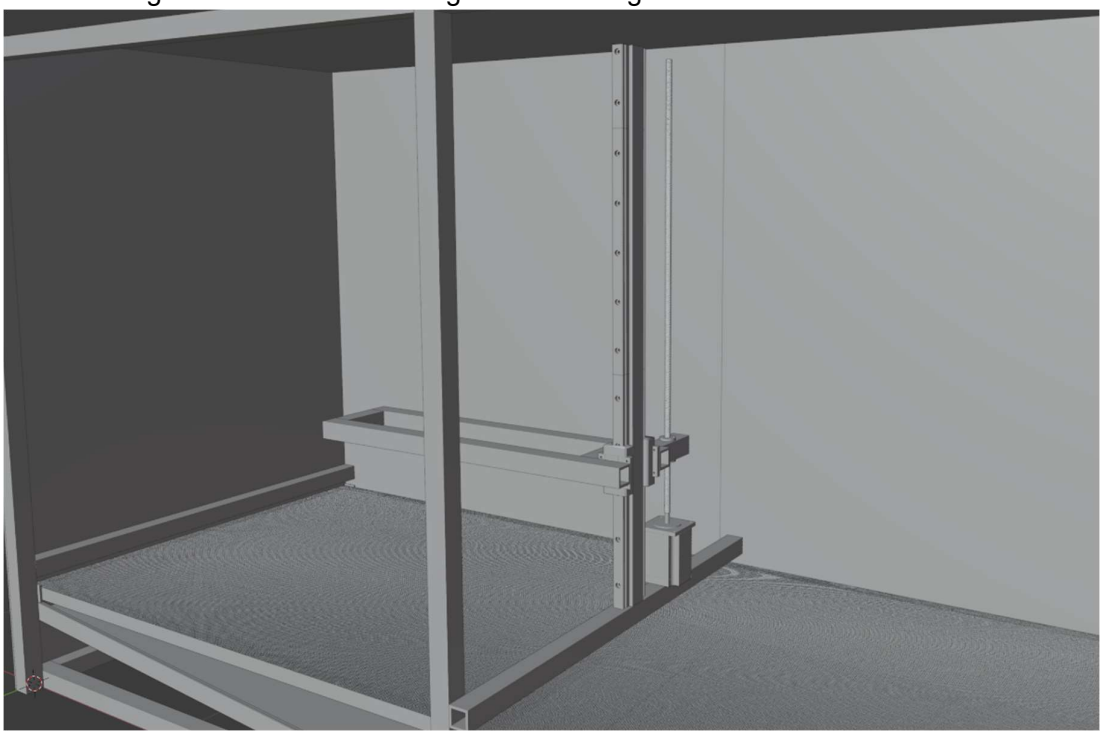
Base of machine with slanted panelling for wastewater collection. Waste water pump sits in the center and pumps away.



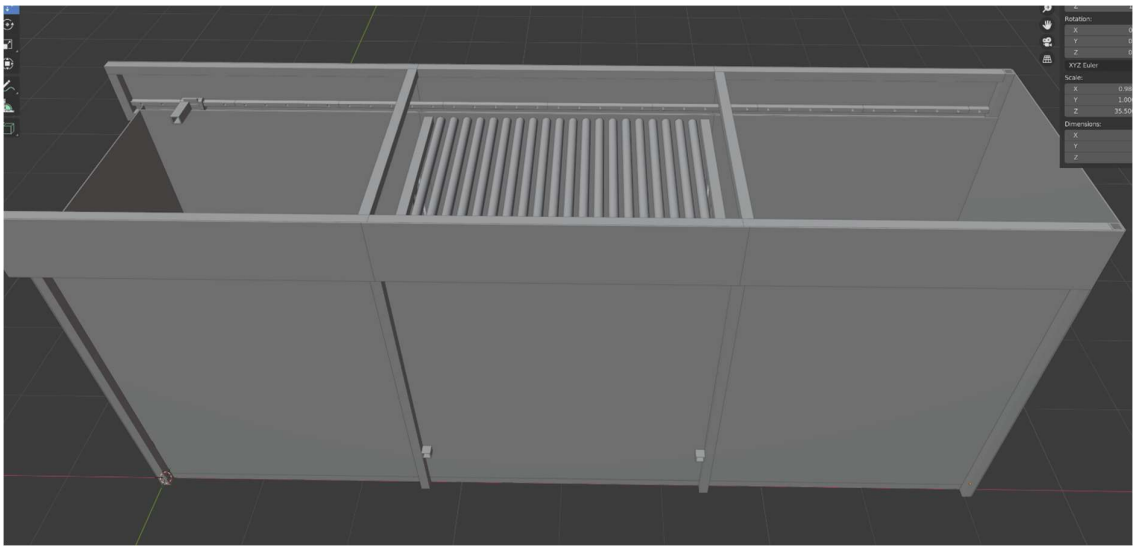
3 removable wire mesh filters with aluminum frames to remove large debris from the water before being pumped.



Machine is shown with more framing and panelling. The L shaped objects on either side are the raft lifting mechanisms for loading and unloading stacks of rafts.



The Nema 23 stepper motor pictured on the bottom right on top of the horizontal steel beam is connected to a lead screw which is threaded through a nut in the lifting platform. The lifting platform is on 2 rails using a carriage block with ball bearings. After reviewing parts cost and feasibility it was opted to use 2020 aluminum extrusion and v slot as an alternative for the rails and a belt drive instead of lead screws.



Pictured with most framing and panelling shown. The rail on the back is missing the belt drive and will also be v slot rail. The rail pushes a block of steel tube which will go behind boards before they lift up. Once a board is lifted up it will be pushed through the machine. The rollers in the middle are non powered now and are only to help with friction. The following previous design drawings are missing all water and electronics systems as well as some paneling and access doors. Joints are all touching each other without a decided means of connections. Welding or bolts will be decided upon for most joints.

Brief Description of how electronic and water systems work:
The machine is loaded then a start button is pressed. An arduino uno will open a solenoid using a 24v relay with a 24v power line coming from a power supply. The solenoid will be opened on a timer to fill the machine with water. An infrared sensor will tell the arduino when the water level is appropriate. If the water level is good and it has not been used more than a set amount of time the waste pump will pump water to the pressure washer. The pressure washer will be turned on with a relay by the arduino. The water will flow through a high pressure hose into a ring of pipes with jet nozzles in it which will surround the board when in the cleaning portion of the machine. The stack of dirty boards will get lifted until an infrared sensor tells the arduino that one board is at the correct height to be pushed through the cleaning stage onto the rollers. The arduino pusing the board with a stepper motor using a stepper motor driver and the 24 volt power supply. Meanwhile the stepper motor on the other side along with an infrared sensor makes sure that the collection stack is low enough to receive enough boards but not too low so the next board doesn't fall far. The board will be pushed all the way through the cleaning stage then the actuator will reach an endstop and return to the opposite end waiting for the next board. If the Collection stack gets full or the loading stack goes empty everything shuts off. There is also a manual off button. After a predetermined number of cycles the waste water pump will divert water to a drain hose using solenoids.

Then the water will refill. The machine is expected to have a capacity of about 20 boards with dimensions being 8 feet by 2 feet by 3.5 feet +/-6”. Each board is expected to be completely cleaned within 90 seconds. Water usage will be at most 1.2 Gallons per minute without recycling water and at least 0.4 Gallons per minute when wastewater is reused.

Power consumption is expected to be between 1000 watts and 1600 watts. Noise levels could be as high as 80db.

All dimensions are available in more detail within the CAD File. It is easiest to use in blender however an OBJ file will be provided as an optional reference.

3. Cost Spreadsheet and List of Equipment for final high fidelity design

To be able to create or recreate a successful prototype, it is vital to document all of the materials and components used. Therefore, the table below expresses the bill of materials of all the materials and components that are necessary for our prototype.

Item Name	Description	Units of Measure	Quantity	Unit Cost	Extended Cost	Link
Plastic for Panels (Plexiglass)	3'*3'*0.125"	PCS	N/A	N/A	N/A	N/A
Bearings	8x22x7mm Double Rubber Sealed Deep Groove Wheel Bearings	PCS	100	$0.2699	$26.99	Link
Motor	Nema 23 Stepper Motor 2.8A 1.26Nm(178.5oz.in)	PCS	3	$26.66	$79.99	Link
Silicon Sealant	100 Percent Silicone Sealant Caulk, All Purpose, Waterproof, 10oz/295ml Cartridge	PCS	1	$12.99	$12.99	Link
Pressure Washer	Greenworks 1700 PSI 1.2-Gallon-GPM 13 Amp Cold Water Electric Pressure Washer	PCS	1	$119	$119	Link
Waste Water Pump	Aquarium 320 GPH	PCS	1	$20.99	$20.99	Link

	Submersible and Inline Water Pump AC 120 V					
Infrared Sensor	5-Pack IR Infrared Obstacle Avoidance Sensor Module	PCS	5	$1.78	$8.89	Link
GT2 Timing Belt Pulley	20 Teeth Bore 8mm	PCS	5	$2.198	$10.99	Link
GT2 Timing Belt	5 Meters GT2 Timing Belt & 4 Pcs 20 Teeth Timing Pulleys & 1 Pcs Hexagon Wrench & 4 Pcs Mount Blocks	Meters	5	$3.998	$19.99	Link
Arduino	ELEGOO UNO R3 Board ATmega328P ATMEGA16U2 with USB Cable	PCS		$23.99	$23.99	Link
Wire	100-Feet 14-Gauge Primary Wire Bulk Spool (Green)	Feet	1	$0.2172	$21.72	Link
Solenoid	G1/2" DC 24V Normally Closed Brass Electric Solenoid Magnetic Valve for Water Control	PCS	1	$17.08	$17.08	Link
24V Power Supply	Retafe 24V Power Supply AC 110V-220V to DC Wide Voltage Universal Voltage stabilized Switching Power	PCS	1	$31.47	$31.47	Link

	Transformer 12.5A					
Welding electrodes	US Forge Welding Electrode E6013 1/8-Inch by 14-Inch 10-Pound Box No.51334	PCS	1	$32.98	$32.98	Link
DM542 Stepper Motor Driver	DM542 DC 24V~50V Stepper Motor Driver Controller Driver Board for 2-Phase 4-Phase Motors	PCS	3	$14.90	$44.70	Link
Wire Filter Mesh	40 Mesh Screen Stainless Steel Metal Woven Wire Mesh 11.8"x47.2"	PCS	6	$14.00	$84	Link
Buck Converter	Adjustable DC Input 8-80V to Optional DC Output 3.3V/5V/6V/9V /12V/15V Max 2.1A High Efficiency Conversion Voltage Regulator Module	PCS	1	$12.78	$12.78	Link
Rail Connectors	Straight Line Connector Length 3.9inch Joint Bracket with M5 Screws for 2020 Series T Slot 6mm Aluminum Extrusion Profile	PCS	10	$1.933	$19.33	Link
V Slot Gantry Plate	LANTRO JS V Slot Gantry	PCS	3	$18.99	$56.97	Link

	Plate, Small V Wheel with Plate, Aluminum Profiles EU Standard 2020					
V Slot Rail	2020 Aluminum Extrusion 1000MM(1M), V-Slot European Standard Anodized Linear Rail	PCS	10	$11.699	$116.99	Link
Steel Tubing	1”*1” 0.065” Wall Thickness Mild Structural Steel 100” Length	PCS	9	$32.85	$295.65	Link
Corrosion resistant paint	Protect the metal	PCS	1	$34.99	$34.99	Link
Rollers	3/4” Diameter PVC Pipe 24” Length	PCS	8	$3.49	$27.92	Link
Total Product Cost (Without taxes)					$1120.4	
Total Product Cost (Including taxes)					$1266.05	

Notes:
- No shipping costs
- There are other materials required to create this product, however the group is not certain about certain aspects of them.
- The group already has some of these materials; so the total after subtracting the cost of items we already have is $828.93.

Additional requirements:
Definitely: Drill with bits for drilling and screwing($150), Angle Grinder and discs($50),Computer($200+), Arduino IDE(Free)
Possibly:Arc welder and rods + protective equipment($350), CNC machine($400+++)

The following list shows the hardware and software equipment needed to build intermediary prototypes.

Item name	Description	Prototype #	Source
3d printer filament	For 3d printing	1	Maker Lab/already have at home
3d printer	For 3d printing	1	Maker Lab/already have at home
3d modelling software	For 3d printing	1	Maker Lab/already have at home
wood	Construction material	1	Maker Lab/already have at home
plastic	Construction material	1	Maker Lab/already have at home
Cardboard	Construction material	1	Maker Lab/already have at home
Scissors	For cutting material	1	Maker Lab/already have at home
V Slot Rail	2020 Aluminum Extrusion 1000MM(1M),V-Slot European Standard Anodized Linear Rail	2	Amazon see previous Table for link
V Slot Gantry Plate	LANTRO JS V Slot Gantry Plate, Small V Wheel with Plate, Aluminum Profiles EU Standard 2020	2	Amazon see previous Table for link
Steel Tubing	1”*1” 0.065” Wall Thickness Mild Structural Steel 100” Length	2	Amazon see previous Table for link
DM542 Stepper Motor Driver	DM542 DC 24V~50V Stepper Motor Driver Controller Driver Board for 2-Phase 4-Phase Motors	2	Amazon see previous Table for link
GT2 Timing	20 Teeth Bore	2	Amazon see previous

Belt Pulley	8mm		Table for link
Rail Connectors	Straight Line Connector Length 3.9inch Joint Bracket with M5 Screws for 2020 Series T Slot 6mm Aluminum Extrusion	2	Amazon see previous Table for link
24V Power Supply	Retafe 24V Power Supply AC 110V-220V to DC Wide Voltage Universal Voltage stabilized Switching Power Transformer 12.5A	2	Amazon see previous Table for link
Arduino	ELEGOO UNO R3 Board ATmega328P ATMEGA16U2 with USB Cable	2	Amazon see previous Table for link
Infrared Sensor	5-Pack IR Infrared Obstacle Avoidance Sensor Module	2	Amazon see previous Table for link
Motor	Nema 23 Stepper Motor 2.8A 1.26Nm(178.5oz.in)	2	Amazon see previous Table for link
Plastic for Panels (Plexiglass)	3'*3'*0.125"	3	Undecided
Hinge		3	Hardware store
Door Sealant	Rubber seal for weatherproofing doors	3	Hardware store
Latch	Keep Door shut firmly	3	Hardware store
Pressure Washer	Greenworks 1700 PSI 1.2-Gallon-GPM 13 Amp Cold	4	Amazon see previous Table for link

	Water Electric Pressure Washer		
Pipe		4	Hardware store
Drill and bits		4	Already have at home
Nozzles		4	Already have at home
Tap and die		4	Already have at home
Fittings and adapters		4	Hardware store
Clamps and hoses		4	Hardware store

4. Risks and Contingency Plans

Knowing the upcoming deadlines concerning the solution concept we must present to our client, we have developed a list of risks associated with our work as a team, our work on this project as a whole, and our upcoming prototyping deliverables. The contingency plans for each risk will benefit our team, because if the risk arises, we will have a straightforward and predetermined plan of action to follow and focus on.

Risk	**Severity**	**Likelihood**	**Mitigation / Contingency**
Delayed equipment acquisition time	Medium, would negatively impact prototype development	Medium, due to unreliable delivery drivers or missing stock in stores	Determine an effective and reliable replacement for the missing equipment, if none are found then modify our prototype around the equipment we possess
Extra help and/or more feedback from a client at Growcer	High, if feedback is something we haven't yet taken into consideration	Low, feedback is usually kept within client meetings	Review our past deliverables to include this feedback, potentially modifying our problem statement and solution concept
Inability to make a group meeting due to other obligations	Low, there are multiple ways to communicate besides a group meeting	High, varying situations between group members and reading week is an added obstacle	Increase communication levels by sending updates through Whats-app and comments on Deliverable documents, divide the tasks in a series fashion for members who can't attend the meeting rather than parallel for the week
Prototype test plan does not provide expected / useful results	High, with only 3 prototyping stages we should aim to make each one count	Medium, the results will be used to optimize our solution concept for the client	Inspect reasons why the results were not expected, including the test method and the prototype model. If testing for a specific property, alter the test or model for the second round of testing or choose

			a different aspect of the solution concept to test.

5. Prototyping Test Plan

Throughout the next two weeks, we will be preparing and carrying out our first rounds of prototype testing. The following table outlines our test plans, including our two main objectives - communication and analyzing the loading mechanism - as well as the testing methods and timelines.

Test ID	Test Objective (Why)	Prototype Used & Basic Test Method (What)	Expected Results and How They will be Used (How)	Test Duration & Start Date (When)
1	Building a small scale, simplified version of the product to communicate the solution concept with the team and ensure everyone is on the same page	Using cardboard, craft materials, and potentially a few 3D printed parts, we will create a low fidelity, comprehensive and physical scaled down model of the desired final product. It should communicate the function and appearance of the product.	This prototype should clearly show what the product will look like and how it will work. Its main use is communication, and it is expected that the team uses this model to base future prototyping.	Monday October 31st, 2022.
2	Analyze the loading subsystem to see how it works and if it can properly load one raft at a time, because it has the highest level of uncertainty due to client feedback changing our original concept.	Create a focused, medium fidelity loading mechanism to test the feasibility of the loading mechanism. Our loading device involves sensor activation, so using mock-up cardboard rafts and the loading mechanism we can analyze whether the rafts can be loaded and separated properly without sticking together.	This prototype should provide data to determine if this loading mechanism is feasible and where it needs improvement. With that information we will make the appropriate changes to the concept, keeping the user needs in mind.	Saturday November 5th, 2022.
3	Creating doors for access to machine cleaning and raft loading. Doors have a high likelihood for leaking, and in user benchmarking machines which leak were the poorest rated.	Create a medium fidelity prototype of the doors, which are a portion of the loading subsystem but more focused. We will be testing the amount of leakage that occurs if water were to be sprayed at them to ensure a clean and structured environment.	We will determine the cheapest and simplest ways to seal the doors while ensuring no water leakage. We expect that no water will leak through, and if that is the case we will implement these doors in our solution concept.	Monday October 31st, 2022

4	Test Creating Water Jet system. There is not yet a fully designed water jet system and it is difficult to design. It is likely to have issues with even coverage of the water and low pressure	Create a medium fidelity prototype of the water jet system. This prototype will be tested by running a cycle with water and then analyzing the system to collect data.	The water jets will likely have poor water distribution and low pressure. The data from the tests will be used to improve nozzle design and fix leaks.	Saturday November 5th, 2022.
5	Building a high fidelity, comprehensive product prototype. We will use this prototype to run through the entire process from loading, to cleaning, to collecting, both for visual aids	Create a high fidelity prototype of the product to allow for testing of the system integration. This test will include running the whole machine through the entire process.	Machine should work there will likely be small issues fixed along the way. Any issues that arise will show us what need to be improved upon. If there are no issues then it is ready for more serious finished design and getting ready for partnership with Growcer if selected.	2+ weeks from now, during the last prototyping deliverable.

6. Conclusion and Future Plans

After our one-on-one meeting with the client, we obtained valuable feedback about our loading system and the design of the rafts. Our original method had the boards being pushed onto the mechanism from the bottom of a stack, however user safety and the interlocking raft design prevented this from being a feasible option. Our new loading system will take the boards from the top of the stack, rather than from the bottom, and is controlled by a start and stop button so users have complete control over the system. Taking these changes into account, we created a realistic CAD model of our machine and used this to create a detailed list of equipment, including links to purchasing sites. Our next steps regarding our model is to prototype. We've created multiple prototyping test plans that include both focused and comprehensive prototypes that range in levels of fidelity. We will meet as a team after reading week to put these plans in place and create prototypes that will guide us to a more refined solution. If any risks are to arise during this process, we will refer to our table of risks and contingency plans. This deliverable brings us one step closer to a defined raft cleaning solution for Growcer, and we will continue to work for our clients best interests.