lifewall

A modular emergency water storage and wellness system.

An exegesis presented in partial fulfilment of the requirements for the degree of Masters of Design (198.800) at Massey University, Wellington, New Zealand.

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Abstract

New Zealand is situated in the Pacific Ring of Fire at a junction of three tectonic plates generating steep mountainous topographies that create an environment susceptible to earthquakes, tsunamis, landslides, floods, and other natural disaster events.

The New Zealand Ministry of Civil Defence and Emergency Management supports and enables communities to manage when emergencies strike, and encourages preparedness across the country.

The Ministry recommends a list of emergency survival items for the home, including a supply of potable water. Specifically, three litres of water per person per day for three days.

The Ministry also recommends stocking enough food and water for up to two weeks in the home for prolonged emergencies.

A natural disaster event such as an earthquake can disrupt mains supplied potable water. The resilience of the water network systems during and after events is vital for the response and recovery of the community. Providing safe drinking water, in the initial days after a natural disaster event is crucial to maintaining the health, well-being and resilience of isolated and affected disaster victims.

Conventional approaches to supplying water in a post natural disaster event zone have been proven logistically challenging, cumbersome and costly to maintain for extended periods of time. These issues provide an opportunity for new product innovation to address the emergency water supply scenario.

Lifewall, the result of this research project, seeks to ameliorate many of the issues faced in emergency potable water supply due to a natural disaster event. Lifewall has been achieved through an iterative cycle of research through design, building an understanding of the disaster scenario and the latent performance needs required by users.

By taking a human centred industrial design approach, key performance features such as manual handling, usability, integration into the local environment and resilience along with desirability have been addressed. This has involved a range of methods including: ideation, computer assisted design, task analysis, physical prototyping and testing throughout the project. This heuristic design approach has led to an emergency water storage system with a modular product architecture, which maximises water resource survivability and improves utility before and after a disaster event.

The Lifewall system consists of four main components:

Lifewall Unibody

Lifecell

Lifepod

BIQC (Bottle integrated quick coupler)

The Lifewall system sources water from the municipal supply. It filters and stores a volume of water for emergency purposes which renews and refreshes itself. It does this through the daily use of the living space that it is connected to. In a seismic event it automatically isolates itself to protect stored water, supporting resilience in the community.

During this research degree, New Zealand experienced the third biggest earthquake ever in its recorded history, a poignant reminder of the need for products of this type and design research in this area.

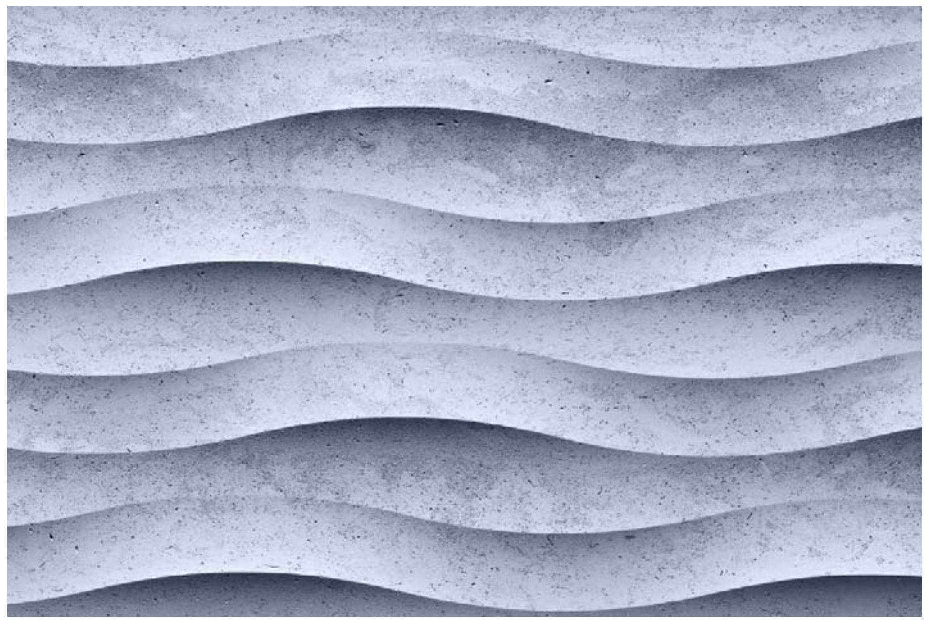

Fig. 1. Texture inspiration for the final Lifewall system.

Acknowledgements

I am indebted to these incredible people who have provided assistance and support for me to reach this research achievement. Thank you to Associate Professor Rodney Adank and Associate Pro Vice-Chancellor Tony Parker for their academic support this year. Additionally, my partner in crime, Gemma Fleetwood. Also, Ray, Louise, Kelly, Christina, Shane, Ruby, Lilly, Sophie Rogers-Brander, Bazza, Erin Collins, Lyn, Glenn, Yueyun, Natalie, Wendy, Craig, Uli Thie, Gus Donaldson, Ken Howe, Rachael Hall, Klaus Kremer and Karl Partsch for their continued support during this incredible year.

Fig. 2. Lifecell detail.

"constantly think about how you could be doing things better"
– Elon Musk

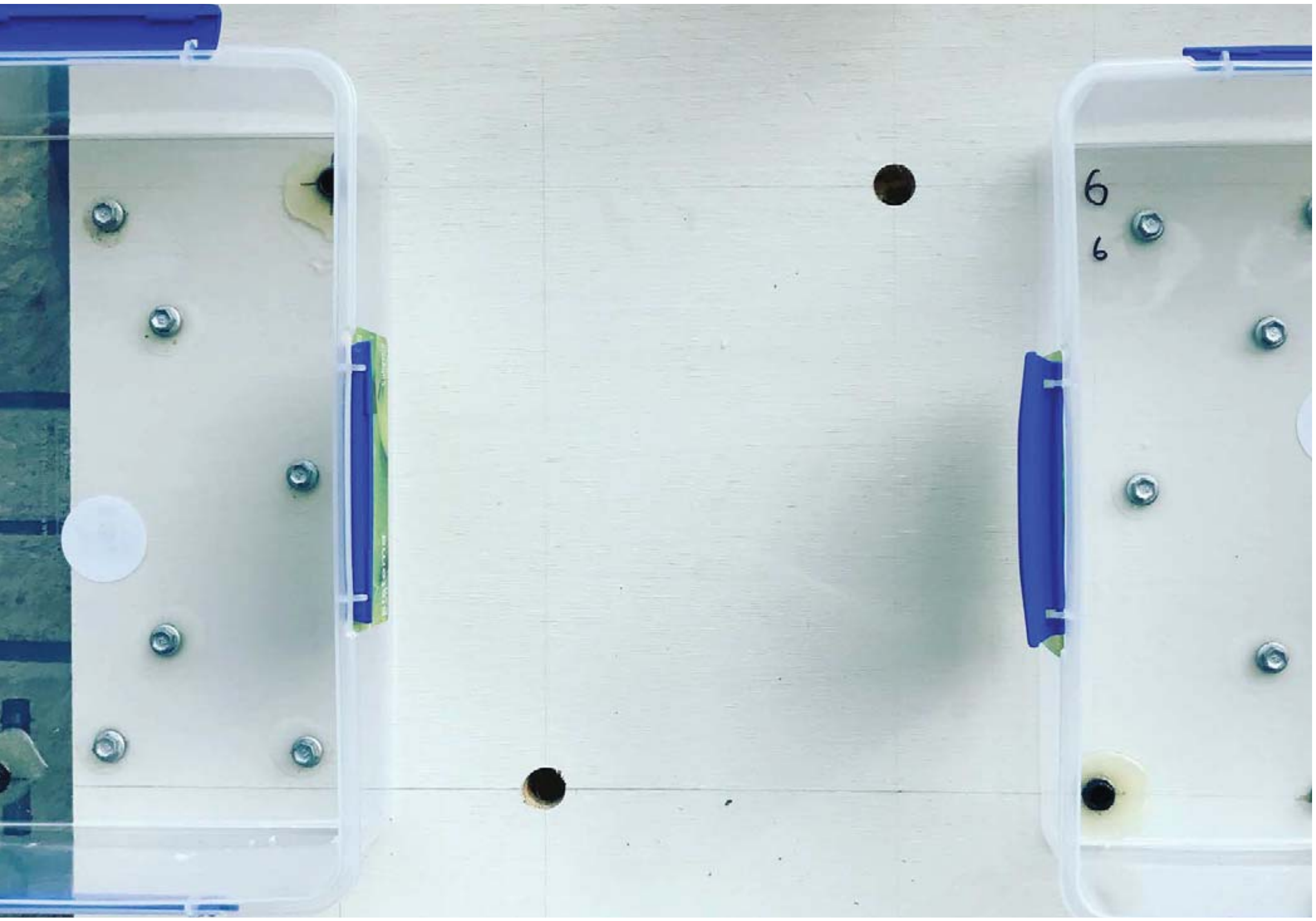

Fig. 3. Hydraulic prototype configuration 1.0 in construction.

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Fig. 4. The Christchurch Town Hall where the original Affect workshop was undertaken was destroyed by earthquake in 2011.

Preface

Following the 2004 Indian Ocean earthquake and tsunami, Affect – the Centre for Affective Design at Massey University, conducted a workshop at the Christchurch Town Hall. It was attended by design and product development professionals, designing product responses for a disaster scenario.

After the Christchurch workshop, an undergraduate paper was developed for third-year Industrial Design students in 2006. This was my opportunity to design a product for a disaster scenario.

My design outcome was a heavy-duty glove with integrated lighting to assist rescue searchers, removing the need to hold a torch in extremely confined spaces.

What fascinated me about the disaster scenario was how the systems we rely on to make many products function, are suddenly damaged or rendered useless. You could not depend on any power supply; communication lines would be down in various areas; water supply could be disrupted or damaged to the extent it was unsafe to drink.

The disaster scenario has provided an enduring fascination for me as a product designer. Living through the third largest earthquake in New Zealand's recorded history (Culverden, Kaikoura) was an affecting experience and left me considering how design could respond.

Introduction

Natural disaster events pose a significant threat to humanity, national and global infrastructures and economies.

A 2016 global overview of the human impact recorded by the Centre for Research on the Epidemiology of Disasters (CRED), reports 301 disasters in 102 countries resulting in 7,628 deaths, 411 million people affected and an estimated $132NZD billion of financial loss (CRED, 2016. p. 1). After the 2016 Culverden (Kaikoura) earthquake, the Insurance Council of New Zealand stated business claims had reached a total of $900 million. Approximately $600 million of that figure was claimed in the Wellington city region, over 225km away from the epicentre (ICNZ, 2017).

The post-disaster effects on people and places can extend for a significant period of time after the main disaster event. Four buildings were immediately flagged for demolition in Wellington, days after the 2016 Culverden earthquake including the BNZ Harbour Quays "Earthquake-Proof" building still permanently closed ("CentrePort confirms demolition of four Wellington wharf buildings", 2017).

Deloitte Touche Tohmatsu Limited has estimated the effects of this workplace destruction as affecting the Gross Domestic Profit (GDP) by 1.25 million per week as Wellingtonians work from home, or not at all (Meade, 2017. p. 6).

Piped Infrastructure

Providing safe drinking water, in the initial days after a natural disaster event is vital to maintaining the health and well-being of isolated and affected disaster victims (Pritchard, 2009).

Supplies can be affected through broken and damaged underground infrastructure causing contamination through the entire city-wide system. A prime example being the cholera outbreak after Haiti's earthquake in 2010 (Global Health, 2016). Even in first world highly developed cities such as in the state of California, the potential for contaminants to enter the complex network is high (Davis, 2014. p. 6).

Fig. 5. PVC-O demonstration of crush resilience.

In Wellington, the buried piping infrastructure used to supply water and remove waste services (stormwater and sewage) is a combination of decades-old piping technology from clay, cast iron, polyvinyl chloride (PVC), to more recent and earthquake resilient systems of molecularly oriented polyvinyl chloride (PVC-O). Wellington has only 35% of the potable water network and 16% of the wastewater network in PVC-O piping ("News – Protecting our water supply," 2011). With such a low percentage of the network in the latest resilient piping technology, there is a high chance that the network will fail (due to cross-contamination with waste services and pipe breakages) in a major disaster event such as an earthquake.

Recommendations for Emergency Water Supply.

Access to post-disaster emergency water supplies will vary widely depending on the level of preparedness, the reticulated water systems in use, and where you are during and after a disaster event. Provisions in a high-rise office block will be very different to a well prepared domestic home.

The New Zealand Ministry of Civil Defence & Emergency Management (MCDEM) recommends in its list of emergency survival items, a supply of drinkable water, and at least 3 litres of water per person per day for three days ('GetThru', 2017). For a family of four, this figure is 36 litres for three days. If we increase this number to a two-week water supply as mentioned earlier, a family of four would need to store 168 litres of water. For a small office environment of twelve people, that figure for only three days is 108 litres, 504 litres for two weeks.

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Context for research

Domestic hot water cylinders (HWC) and supermarket bought water containers are the recommended next day supply after a natural disaster event (MCDEM, 2017).

HWC can become contaminated due to infrastructure damage if not disconnected from mains water supply during or immediately after the event. Califont, gas water heaters and their derivatives provide on-demand hot water without the need for a HWC. While these systems may have advantages in space planning and building costs they provide no residual emergency water storage capacity.

Emergency container water supplies held within the home, need annual cleaning, replenishing and space for storage. Stored unfiltered water placed in an unsterilised bottle has a rate of bacterial growth that is affected significantly by weather and environment changes, especially if exposed to ultraviolet light. Bottled water will eventually stagnate due to the bacterial and pathogen growth (Raj, 2005. p. 5). Purchased bottled water, after a disaster event, relies on access to operating point of purchase stores and supermarkets. At any moment bottled water supply can sell out or be disrupted ("Water Kaikoura's most pressing need," 2016. p. 2,11,12).

Further potentials from a human-centred, industrial design approach to post-disaster management are advanced by Franco, Fennessy, & Glover (2017), noting industrial design as crucial in the development of systems and products that effectively solve ill-defined post-disaster management problems, such as water, sustainably and holistically.

Various manufacturers, Rainline, Marley and The Tank Guy, have developed retrofit products and do-it-yourself (DIY) approach to address water storage concerns in the event of a natural disaster event.

Community Resilience

The capacity of a community to respond and recover from a natural disaster event is connected with the communities' resilience.

The United Nations Sendai Framework for Disaster Risk Reduction (2015–2030) defines resilience as:

"The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions." (United Nations Office for Disaster Risk Reduction (UNISDR), 2009).

Fig. 6. Havelock North business disruption to water services in 2016.

In our geographic region, the 2017 Queensland Strategy for Disaster Resilience defines Resilience as:

"A system or community's ability to rapidly accommodate and recover from the impacts of hazards, restore essential structures and desired functionality, and adapt to new circumstances." ("Queensland Strategy for Disaster Resilience", 2017).

In New Zealand 'resilience' has been operationally expressed by aims to build a research capacity that;

Enables avoidance or mitigation of risks that have potential for significant consequences for New Zealand's economy, environment, or social well-being; and

Develops community, organisational, and infrastructural resilience to those consequences; and

Supports the dissemination of knowledge and advice, and their application by CDEM practitioners.

(National Civil Defence Emergency Management Plan Order (2015, amended July 14th, 2017).

The consequence for design is clear. Design solutions and approaches addressing the disaster scenario should engender and enable a resilient community.

Research aim, objectives and questions

Develop a product concept that addresses emergency water supply (EWS) improving community preparedness for a natural disaster scenario. Develop this concept to address elevated levels of usability and benefit to engender a more resilient community response following a disruptive disaster event.

To address this aim, specific research objectives were identified. These objectives evolved throughout this study as information was assessed and knowledge gained.

Research Objectives:

- Discover the current product availability for EWS.
- Discover innovative technologies and materials which may benefit a new way of thinking about an EWS.
- Gain an understanding of current market products, and how they benefit water security.
- Identify the performance criteria needed to enable the design of a better EWS system.
- Identify the likely product architecture solution for such a product that could produce clean water and be mobile.
- Develop an understanding of contemporary building codes and practices.

Research questions

Initial research questions arose from my preliminary investigation and formed the basis of my design heuristic approach, providing information and answers informing the process. Design methods including ideation and concept generation as well as focused physical prototyping and experimentation focused the design investigation into these research questions.

This was undertaken concurrently with a fuller literature and design context review. Further questions presented themselves as a consequence of this and were integrated into the overall research plan.

These first questions aided in the establishment of the initial products design criteria.

What benefits could a new EWS system provide end users?

- Could a new EWS design provide a source of clean water daily?
- Could a EWS design, produce more potable water independently from a municipal supply?
- Could a new EWS concept be designed in a way that requires no additional architectural considerations, i.e., be designed to fit within existing basic parameters such as a standing refrigerator, kitchen cabinet cavity?
- How little maintenance could this product require?
- How would a new EWS concept integrate into existing domestic spaces?
- How would a new EWS design integrate into new domestic homes?
- What would be the human factors consideration be for this new EWS product concept: manual handling, usability, and desirability?
- Can the product guarantee an isolated clean water supply in the event of a disaster?
- How could the product architecture of the new EWS product concept, deliver water storage, allow for removal and transportation, and maintain product function?

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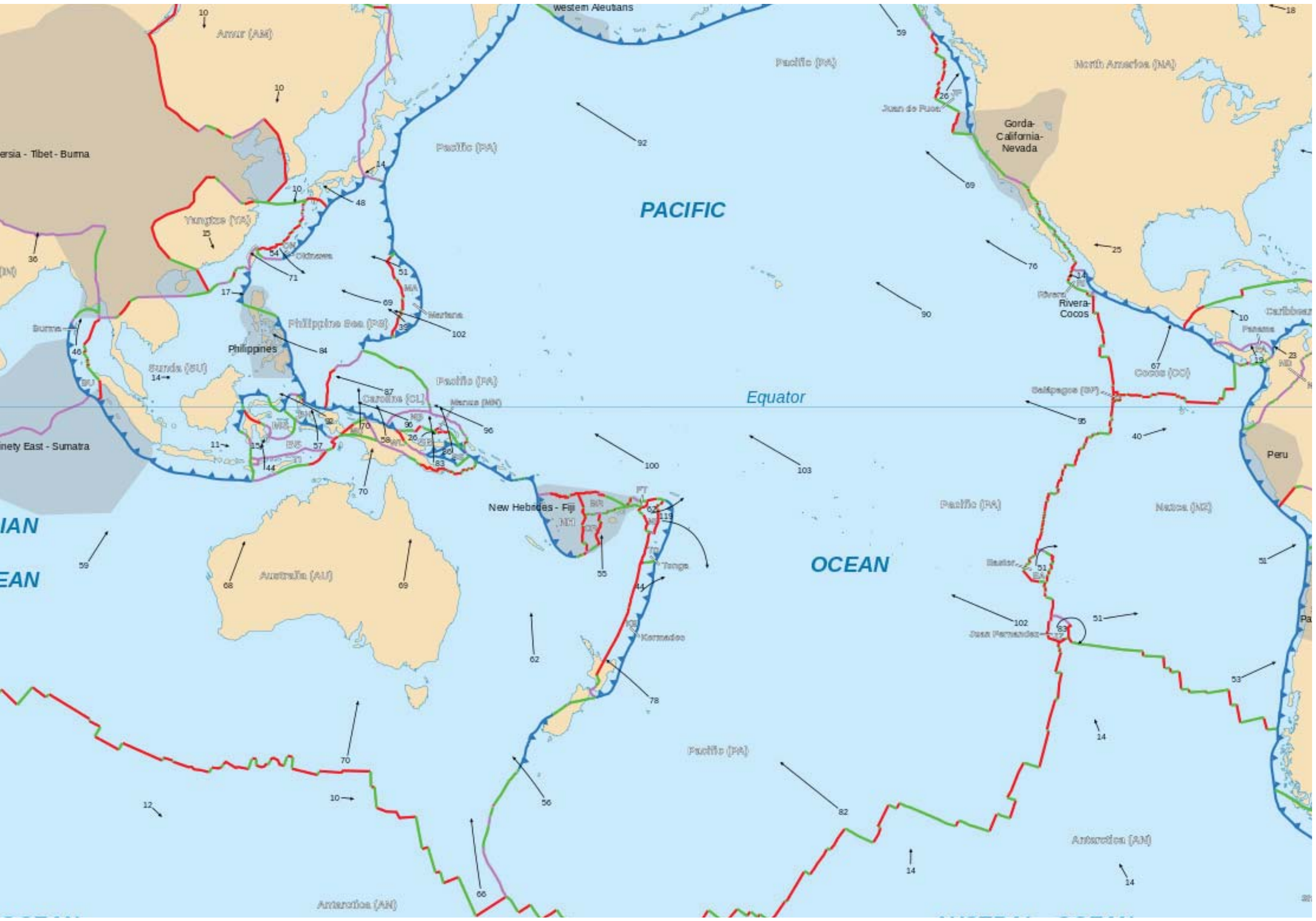

Fig. 7. The circum-Pacific seismic belt.

Scene setting

The Ring of Fire

New Zealand is located in the circum-Pacific seismic belt (the Pacific Ring of Fire). Recorded events show that 90 per cent of the world's earthquakes, and 81 per cent of its largest earthquakes, occur within the Pacific Ring of Fire.

New Zealand contains steep topographies, has long coastlines and experiences heavy rainfall, and is therefore susceptible to earthquakes, tsunamis, landslides, floods, storms and other natural disaster events.

As Shane describes in his text The Southern End of the Pacific Ring of Fire: Quaternary Volcanism in New Zealand, every part of New Zealand has been affected by Volcanic and Tectonic activity in some way (Jang, Wang, Paton and Tsai. 2016, p.329; Shane, 2017).

During this master's project, two of the biggest quakes in New Zealand history took place on 2nd Sept and 14th Nov 2016.

The November earthquake was the largest earthquake in 190 years.

The reported number of disasters and the severity of the impacts these are causing continue to rise steadily. (CRED, 2015. p. 2).

Research by Cameron and Shah (2015), discusses three critical categories of a natural disaster event over the last decade, floods, earthquakes and tropical cyclones. People who have experienced a traumatic natural disaster event are likely to exhibit risk-averse behaviour. Risk adversity lowers the effective resilience of people and places to become an entrepreneurial society. Aid money distribution to natural disaster event zones can promote complacency instead of proactiveness.

Cameron and Shah (2015) also examine how approximately $350 Billion was lost in the post disaster economy, could be lower with appropriate reactions and preparation for natural disaster events.

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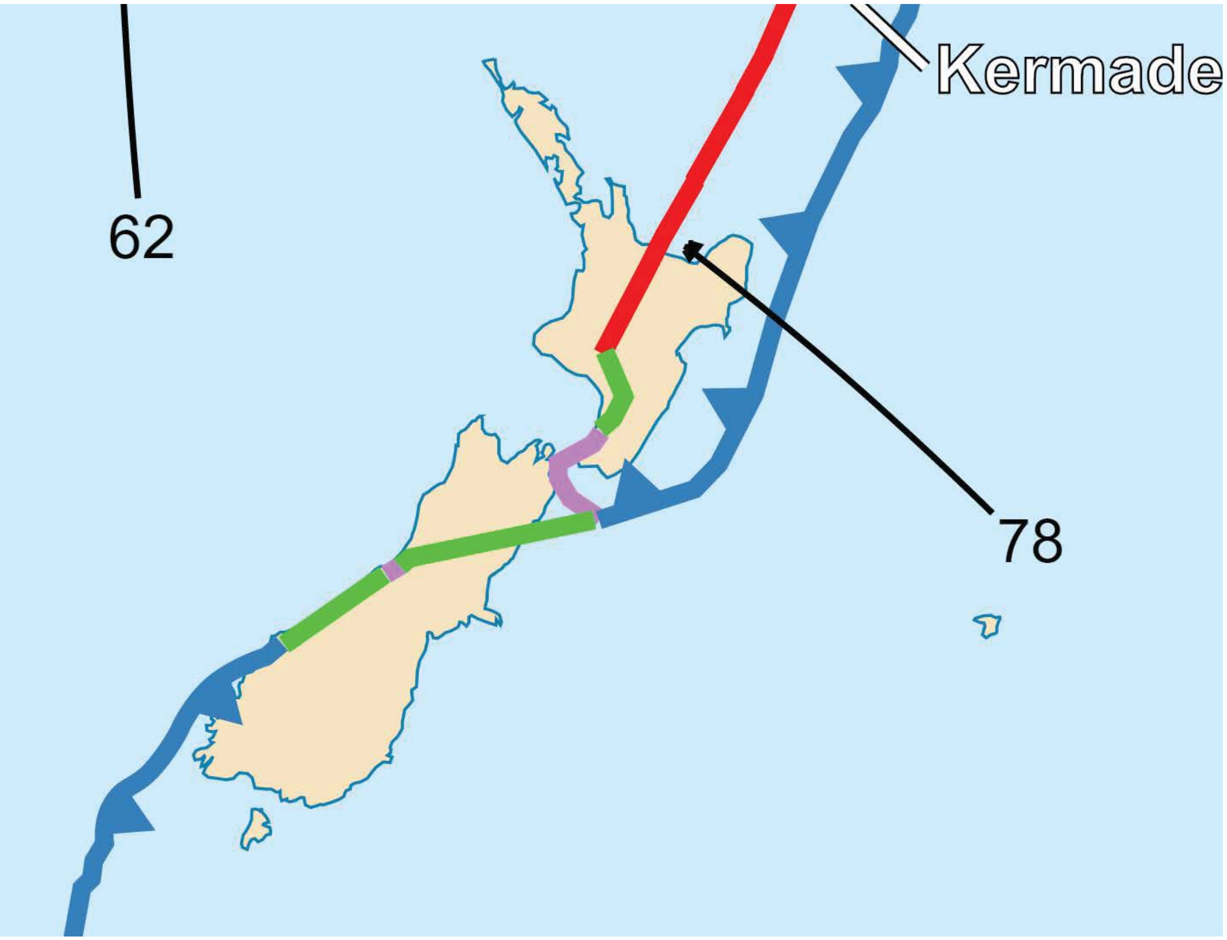

Fig. 8. New Zealand's tectonic plate boundaries. The numbers are distance (mm) travelled per year.

New Zealand.

New Zealand is a relatively small economy globally which trends towards small to medium sized business.

This size of organisation is at risk of collapse due to sudden market changes. The Civil Defence Emergency Management Act of 2002 aims at encouraging the business sector to take steps to improve organisational adaptability to reduce the severity of a natural disaster event (Chang-Richards, Vargo, Seville, 2013).

By creating a resilient community that is prepared, recovery funds are less likely to be squandered, and instead, focused into productive recovery.

Water, electricity and telecommunications networks are restored quickly after a disaster event, most of these repairs are to infrastructure we can see. Underground or buried service disruption can extend for much longer (Gomez).

Underground

There are difficulties in finding underground faults which can go unnoticed for months. A example of this was seen recently during the large sinkhole repair underneath Featherston Street, one of Wellingtons busiest streets (Swinnen).

The worst case scenario for Wellington would be a severed water supply to the southern coastal suburbs of over one hundred days ("Wellington suburbs face a 100-day wait for water reconnection after quake," 2016, p. 4).

Connectivity could cause issues as well. The water supply network relies on electrically powered pumping stations. If the electrical supply network is damaged, this cross network reliance places the water supply network at risk regardless of the integrity of the water supply network's plumbing (Rosen, 2016).

The Wellington regional emergency water storage system plans for 50 sites storing up to 25,000L of water each. Only 32 of these sites are complete so far; the remainder are due by 2019. The planned 50 sites aim to deliver 1.25 million litres of water storage ("Council's emergency water plans," 2016. p. 1).

Emergency water sites.

The council's 2019 population forecast for Wellington is 213,847 people ("Population forecasts | Wellington City | forecast.id," 2017).

A simple calculation of the current emergency water supply shows,

800000 ÷ 213847 = 3.7L / Per person

A one-time amount just over a single person daily supply of water, far short of the minimum three days to two week supply.

By 2043, projections show Wellington supporting 250,000 people. \

1250000 ÷ 250000 = 5L/Per person (calculation assumes all planned sites fully installed).

These calculations show that the emergency water supply cannot provide enough water beyond a two-day supply following a disaster event.

The Wellington City Council (WCC) has planned to build a $10 million dollar, 35 million litre underground reservoir and bury it near Prince of Wales Park. The reservoir will serve Wellington Hospital's emergency needs and provide some water for the southern suburbs. Burying it, aims to minimise the impact on the environmental aesthetic that such a large object could disrupt.

Resilience in Wellington.

As Noubactep (2016) states:

"The science of self-reliance should be developed worldwide, there is no argument against self-reliance."

Noubactep's point is affirmed within the WCC resilience strategy (Goal 3) which proposes plans for every new home to have an emergency water supply, moving directly towards a self reliant community ("Wellington Resilience Strategy," 2017. p. 84).

As of 24th July 2017 the WCC is investigating four new deep water bore wells in the Wellington harbour in an attempt to tap into a fresh water aquifer source below.

The water is now being tested to assure the quality of drinking water ("Exploratory harbour bores – Wellington Water," 2017).

Fig. 9. Featherston Street sinkhole.

Fig. 10. Goal 3 of the Wellington Resilience Strategy.

Market overview

The range of potable water supply products vary from $10.00NZD to $100,000USD. These products consist of simple bottles, complex bottles, over-engineered machines, and simple ad-hoc solutions.

Of particular interest to this research are four products available in New Zealand.

EWS products pertinent to this study are listed below:

The way in which they filter water and the benefits they provide an end user is critiqued following a Polar chart analysis.

Investigation into each products performance characteristics allowed the choice of the best filtration technology for the Lifewall concept. Further details of these are in Appendix A, p. 98.

Michael Pritchard (Icon Lifesaver Ltd), United Kingdom.

Lifesaver water purification bottle – $259.85

LIFESAVER Cube - $259.85

LIFESAVER jerrycan 10000UF – $441.70

LIFESAVER C2 Community- $3500.00 + Extras and installation tools.

Vestergaard Frandsen, Switzerland.

Lifestraw® Personal - $59.49

Lifestraw® STEEL - $130.00

Lifestraw® Go - $81.83

Lifestraw® Mission 5L - $297.75

Lifestraw® Home/Family 2.0 - $268.00

Dean Kamen, United States of America.

SlingShot vapour compression distiller

$TBA, Prototype build cost $100,000.00. (Schonfeld, 2006).

The Tank Guy, New Zealand.

WREMO 200L. - $105.00

Storage Box, New Zealand.

Non-branded 20L rotationally moulded containers - $14.00

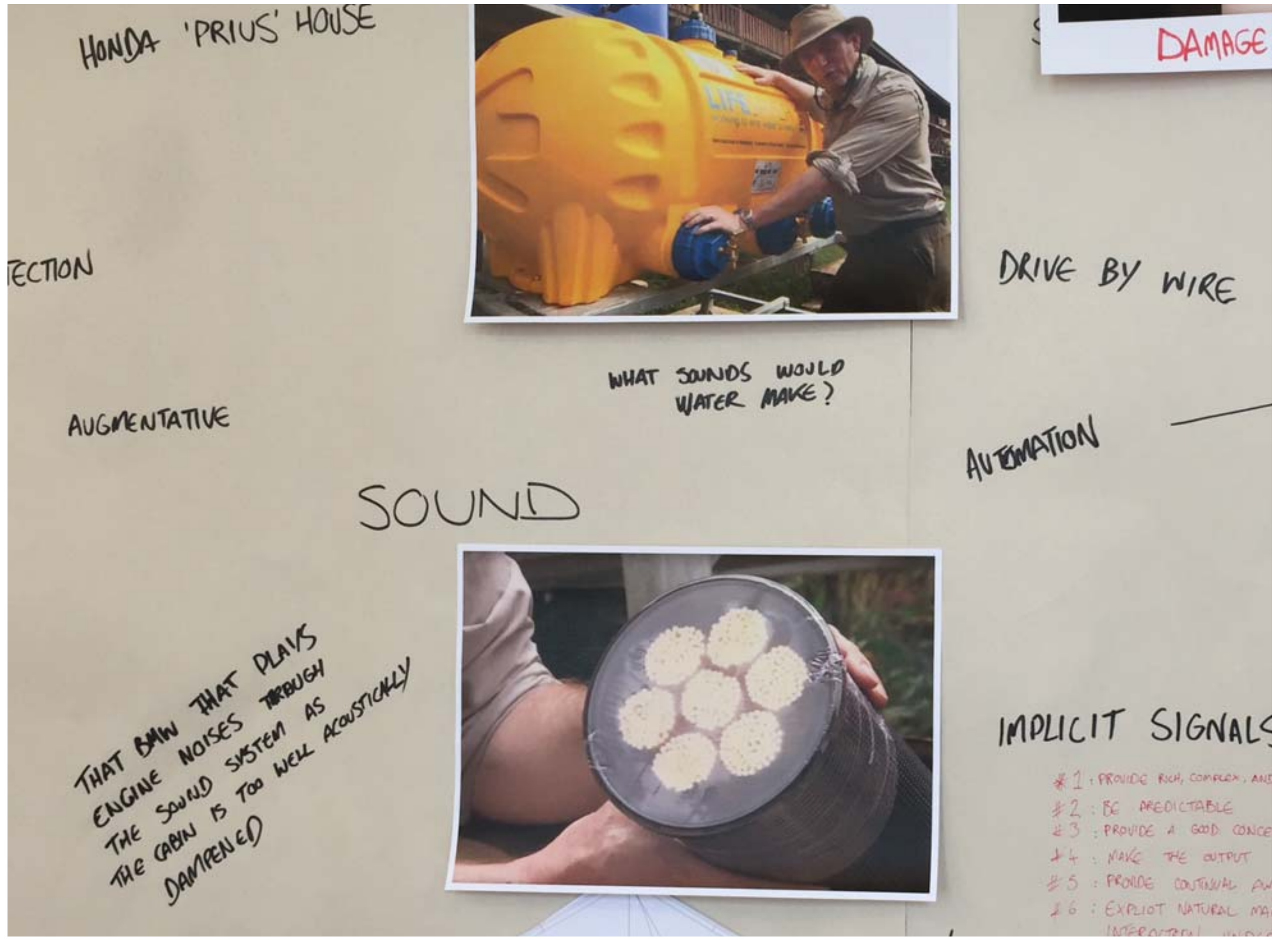

Fig. 11. Examination of the LifeSaver C2 Community filter unit.

Case Study: Technologies

The challenge is discovering the most efficient and beneficial combination of available technologies to implement.

Understanding the relevant technologies about the product position is needed to inform the development of design criteria.

To do this, I examined several technology case studies previously mentioned as well as new water filtration methods to find the most appropriate design for Lifewall's requirements.

Approach

Several technologies case studies were undertaken (Appendix B, p. 104.) and analysed with considerations as to their strengths, weaknesses and opportunities.

A summary of the salient findings follows:

Fig. 12. AMBHF water filtration fibres.

Water filtration technology

The most appropriate filter technology for the Lifewall system was selected after examining ten examples of water filtration techniques. (Appendix B)

Asymmetric Multi-Bore Hollow Fibre Membranes (AMBHF) fibres offer the most performance benefit for the Lifewall design criteria and direction. This filter is seen in the 'LifeSaver C2 Community', Appendix A p. 98.

AMBHF are a much denser rigid variation of polymer micro-pore tubes, manufactured by a proprietary dry-jet wet spinning process.

Technology strengths

- High flow rate
- More durable
- Easy to manufacture
- Recyclable

Technology weakness

- Requires linear product form as the fibres can not be bent or curved. (Required design consideration).
- Sealed at one end and held in place with a resin cap. (Required design consideration).

Technology opportunity

- The volume of water filtered to number of fibres is very high.
- Summary of water filtration technologies.

The physical size to filtration capacity volume ratio of this technology is very high. AMBHF also have a higher flow rate and are more durable than the other systems detailed in Appendix B.

These were decided as crucial key points when looking for the most resilient technology possible that would not impact the performance of the water pressure inside the house when connected to the Lifewall concept.

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Emergency water supply products

Four locally available products from the product list on p. 24 were investigated consisting of:

- The Tank Guy – 'WREMO 200L'
- Lifestraw Personal
- RotopaX Waterpac
- Rotationally moulded 20L containers

The designs range from large scale community supplies to small personal, immediate water supply products to cover a range of users and scenarios.

The Tank Guy – WREMO 200L

Full analysis of the following products is in Appendix L, p. 154.

The Tank Guy's WREMO 200L tank is a practical ad-hoc response with a DIY solution to provide as much water storage as possible across the Wellington region.

Despite its installation difficulties and performance that is lower than described, the company has sold well over half a million dollars of the product (Swinnen, 2017. p. 2).

The most concerning aspect is the top heaviness of the form which is a known flaw, hence the inclusion of a security strap to keep it secured to a wall. If the right ground movement occurred, the small strap would not secure a 200kg weight from falling over and spilling the entire 200L on the ground.

The WREMO 200L does not truly supply 200L unless it is mounted on a DIY rostrum to elevate it high enough off the ground so that a bucket can be placed under the lowest tap install position.

Fig. 13. Wremo 200L.

LifeStraw Personal

The Lifestraw offers some of the best contemporary filtration technology because of its minimal production cost and the flexible material property allowing its use in many different types of product shapes.

The benefit a filtration technology like this could provide a larger scale product is undeniable.

Fig. 14. Lifestraw Personal.

RotopaX Waterpac

A highly durable design, suggests this visually through the form.

The kiss-off is a functional part of the design. Its useful selection of hand grips and minimal profile height means it does not interfere with the surrounding area around a vehicle.

Fig. 15. RotopaX Waterpac.

Rotationally moulded 20L containers

A simple rotationally moulded water storage container available from multiple plastic item retailers and the most basic choice for storing a generous supply of water for an emergency use situation.

Fig. 16. 20L Container.

Valves and Couplers

These two hydraulic components were specifically chosen because of the benefits they could provide to the Lifewall concept.

The full case study is appended to : Appendix M, p. 159.

Fig. 17. Seismic shuttoff valve.

California (Koso) seismic shut-off valves

Seismically actuated shut off valves exist for municipal gas supplies that could be reengineered to automatically stop a water flow during an earthquake.

A demo valve was purchased from Pacific Seismic Products Inc in America to observe the mechanical properties and determine viability.

Dry disconnect stab application quick couplers

The design of the coupler was discovered through an interest in enthusiast gaming laptops. The ASUS GX800 gaming laptop that has a detachable water cooler utilising these same valves.

The water cooling system is attached and the valves engage without releasing any of the coolant during the process.

This coupler could be used in the design to offer a seamless experience of connecting and releasing a vessel to and from the main EWS product.

Summary of case study findings

A combination of these product benefits and technologies will provide and inform design criteria aspects of performance and usability.

Learning the benefits and weaknesses from large products that can not move, to small products that cant store any water, will inform the product position that the Lifewall system can respond to. A product like the stationary WREMO 200L is not useful in an evacuation scenario while the LifeStraw Personal stores no water for immediate emergency use.

Types of hydraulic valves and couplers can seamlessly provide a better user experience and a product that reacts to the environment.

Fig. 18. Quick coupler.

Fig. 19. WREMO 200L on a DIY rostrum.

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Polar chart product comparison

Products previously listed are compared using a series of polar charts Four charts were developed to compare and contrast against a continuum of criteria that included:

Usability vs. Performance cost

Usability vs. Water storage ability

Usability vs. Mobility

Long term storage vs. Water supply reliance.

The full polar chart analysis in Appendix A p. 98.

Polar chart summary

A fascinating discovery was that some products function only within a functional water supply network. When the network fails, the product has no function at all leaving the user in a potentially dire situation with no clean water supply.

Some products can supply water on demand, filtered and clean, in limited amounts. Bigger products tend to store larger quantities of non-potable water over extended periods.

The larger the water storage product, the more likely it is to be immobile. These designs tend to rely on other components that are not part of the original system, i.e. a bucket to move the water around from the larger tank to the point of need.

As the leading regional product, the 'WREMO 200L' is advertised as holding two hundred litres of non-potable water, as such, this volume is the current capacity goal at this point in the research.

The polar chart analysis found a product gap for a design that is not only portable but can be used easily to filter water and store it for an extended period.

A two-hundred-litre capacity storage system that could filter water, and also be portable, could potentially be a very desirable product for domestic, suburban and urban areas.

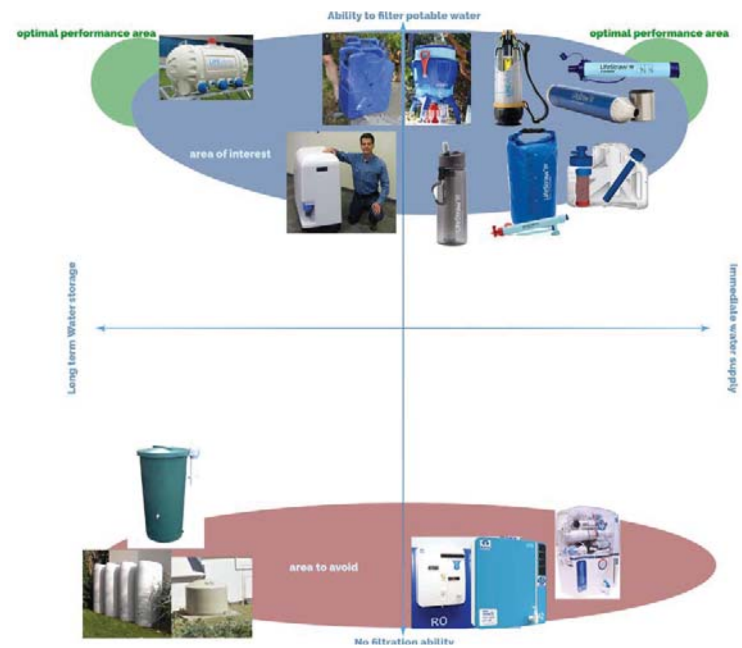

Fig. 20. Polar chart comparison.

Product position for this design

Fig. 21. My design studio post-critique.

This design research project develops an EWS concept named Lifewall.

Lifewall addresses the need for a residential domestic emergency water supply, that seamlessly integrates into new and existing buildings.

The product aims to increase community water resilience and security, minimising the human impacts that follow disaster events due to the disruption of water supply networks.

Lifewall is a portable, long-term storage solution that will always contain filtered fresh (aerated) water.

First design criteria.

These early design criteria are informed by the findings to date.

Performance

Required:

- Remove the need to store and maintain water bottles. (bought from a warehouse).
- Clean and store the water.
- Remove the need to replace the water at set intervals through the daily use of the living space.
- Produce more clean water without a municipal connection.
- Utilise materials that will last as long as possible, 15+ years.
- Be purely kinetic in function, no electricity or sensors.

Desired:

- Secure this water supply against contamination after a natural disaster event.
- Create a mobile solution for emergency transportation.
- Utilize a modular design to allow it to expand to the desired size.
- Survivability during a natural disaster event.
- Utilize a modular design to allow it to expand to the desired size.

Usability

Required:

- Become part of the living space and a feature.
- Be completely concealed.

Desired:

- Minimal installation criteria, work within existing building dimensions.
- Create a sense of well-being and healthy living.
- Utilise appropriate technology to provide long term water filtration.
- Be as low cost as possible for maximum product uptake.
- Provide other benefits to the end user and property.

Fig. 22. Lifewall concept design, shown in critique two.

Qualitative research.

A range of qualitative research methods have been utilised to further refine the Lifewall concept to meet the design criteria.

These include a short questionnaire surveying views on emergency water supplies and preparedness of the general public was undertaken.

Over the course of study, three primary focus groups were organised with different professionals and end users to discuss the product concept. These were arranged with participants when the concept had been developed and visualised to a level that allowed a presentation and explanation of the various performance and user benefits as well as gain insights from end users into the current design developments.

Role-play within a disaster scenario aided design discovery leading to the identification of latent product needs.

Two scenarios were used to roleplay and were initiated immediately after the Magnitude 7.8 Culverden (Kaikoura) earthquake.

Topographic mapping was undertaken to get an understanding of the distances to boundaries and space requirements for the Lifewall system.

Three suburbs analysed with Google Earth mapping and its distance calculator as well as the Wellington City Council interactive property maps. The three areas were chosen based on economic quotable value rating. Very high (Oriental Bay, near the summit facing west. Cresent Street), Moderate (Woburn, Lower Hutt. Nikau Grove) and Low (Wallaceville, Upper Hutt. Rimu Street).

Fig. 23. LifeStraw Personal testing.

Research method – User survey

Objective

Gain a broader understanding of local natural disaster preparedness.

Summary of findings:

Most respondents were interested in a self-maintaining EWS and expressed their frustrations with the known available products. Many of the available EWS products are seen as an undesirable or 'grudge-purchase' bought as a necessity instead of desire.

90% of those surveyed did not know where the Wellington City EWS network is located around the region, but 70% knew where their workplace EWS location.

Responses pointed towards being able to see the water inside the Lifewall system and individual bottles.

The physical location was not necessary for the system at home. However, this would also be affected by the actual final design.

The full survey results are available in Appendix C, p. 110.

Qualitative research.

Research method – Focus Groups.

Objective.

To critique the design development with industrial designers, spatial designers and end users.

Summary of findings:

Focus group one.

The discussion lead to questioning the form factor of the design. The concept presented (Lifewall version 1.0) protruded from a wall surface a distance of 350mm. The critique suggested that it could be entirely flat against the wall creating a form of cladding with the Lifewall system itself. This was the first instance that the design moved towards a compact form.

Focus group two.

Participants were invited to manually handle existing water containers and discuss in relation to my current water container (Lifecell) development stage.

The discussion critiqued the performance of the Lifewall concepts operation. We identified the manual handling of the individual water containers (Lifecell) mounting and transportation needed consideration due to the weight involved (10Kg).

Focus group three.

The Lifewall system was showcased and explained to an end user group of non-designers.

The group was excited to see that so many technologies and ideas could come together and be concealed inside one minimal design like Lifewall. Lifewall was well received

We discussed what the next steps might be for the design, who would pay for it, how would it be made.

One of the positive notes that came from the presentation was that the participants could not quite understand why a product like Lifewall does not exist right now since it makes clear sense and provides clear benefits.

The full focus group results are available in Appendix D, p. 126.

Research method – Roleplay experience investigation.

Objective.

To experience living with a water supply disruption as it is highly probable after an earthquake event.

These scenarios were:

- Scenario: 1. All water connections to my home have been fully cut off (after an aftershock) for three days. The small amount of water in the bathtub was my only water source over the next three days. Anytime I drank water, it would be through a Lifestraw.
- Scenario: 2. Municipal water supply is cut-off; the nearest body of potable water was 5.0km away. Walk 5.0km and bring 20 litres of water back home over the distance to experience issues with hand grips.

Fig. 24. Soft tissue stress.

Summary of findings:

Scenario: 1. The difficulties faced in these two scenarios are a significant obstruction to the daily routine. Having to rely an awkward place for a supply of water meant my daily routine revolved around the location for water. Running water from a tap is certainly taken for granted.

Scenario: 2. Several images of my hand were taken during the trip from the water supply to physically show the stresses the hand grip was placing on my soft tissue and hands. This method identified the need for multiple hand grip options and well-formed a primary handle for carrying a 10kg weight over distance.

The full roleplay report is available in Appendix E, p. 130.

Research method – Topographic mapping of three local residential land areas.

Objective.

Discover potential placement of the Lifewall system within confined spaces.

Summary of findings:

The current form of the design points to the possibility that there will be issues within some properties. Houses positioned close to fences and boundaries will not cater for the first version of Lifewall form of Lifewall installed as it would block narrow pathways. It could also pose a risk to those in the area walking into it.

This result was the first indication that the system form would need redesigning to a low-profile format which was eventually the final design direction.

The full topographic investigation is in Appendix F, p. 134.

Second design criteria.

The qualitative research investigation informed the next iteration of the design criteria.

Performance

Lifewall should:

- Survive a devastating natural disaster event.
- Store water in a modular architecture.
- Require zero maintenance for three years from average house usage.
- Produce more clean water when Lifewall own storage is depleted.
- Utilise appropriate technology to provide long term water filtration.
- Reliably filter contaminated water.
- Remove need for other transportation products like buckets.
- Add value through design and resilience to the property.
- Continually flow and aerate the water stored.
- Be as low cost as possible for maximum product uptake.

Usability

Lifewall should:

- Operate intuitively and in a logical way.
- Become part of the living space and a feature.
- Be completely concealed.
- Create a sense of well-being and healthy living.

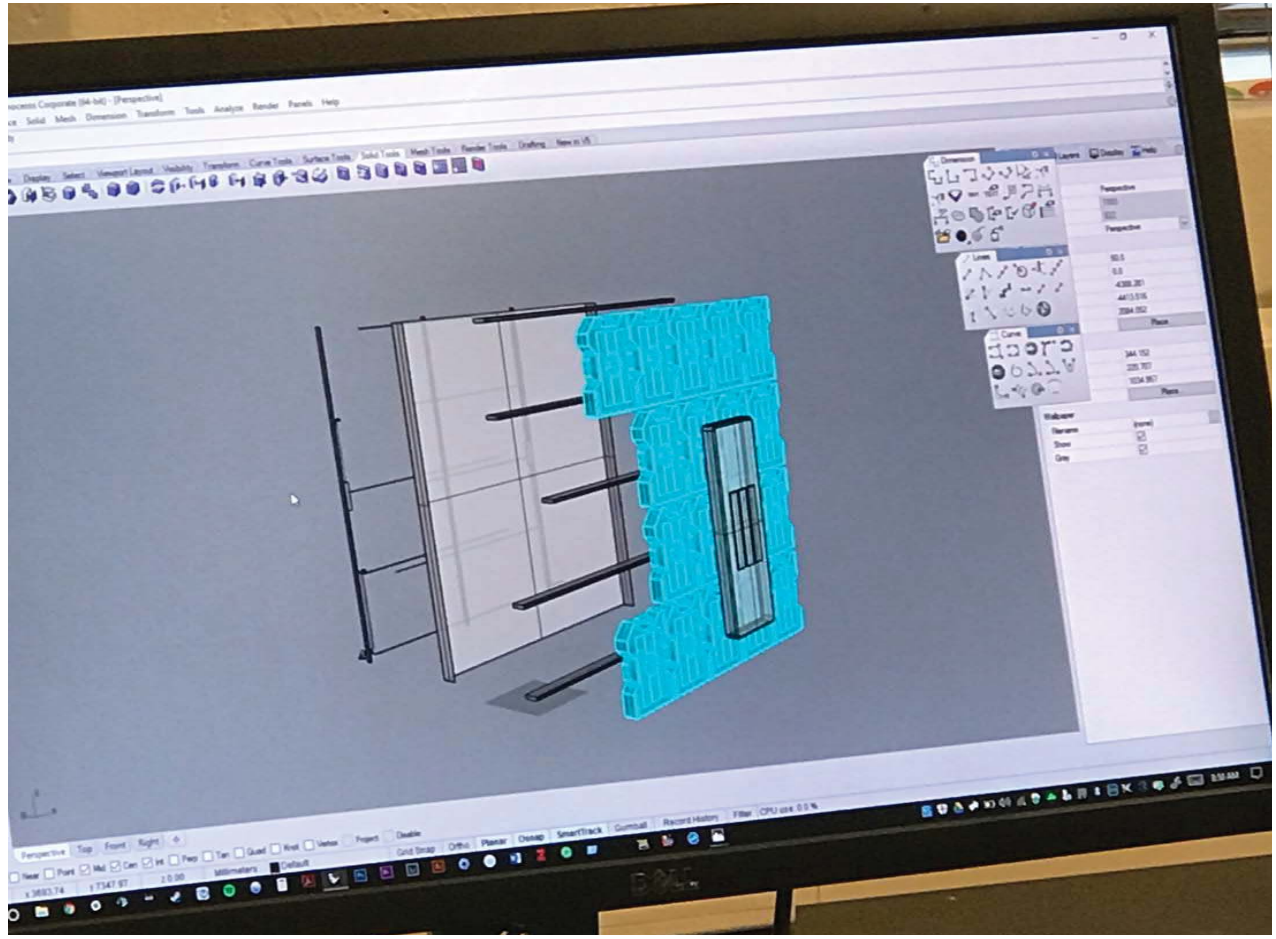

Fig. 25. Rhinocerous 6 modelling of the components necessary for a slimline design.

Research through design

Introduction.

Ulrich and Eppinger (2016), outline iterative research methods in product design to provide understanding and learning of systems, the integration of components, human interaction and usability factors key to successful design development.

Design research methods.

Sketching.

One of the most valuable tools used to develop and shape the Lifewall system and each of the major components was an iterative sketching process used throughout the entire project.

Modelling and Prototyping

Focused physical prototypes were developed to test and refine the physical handling and usability of larger components within the Lifewall system, these include:

- Design modelling water vessels
- Spatial modelling
- Physical water flow & hydraulic systems
- Component integration

This allowed quick testing and validation of the system's intended functions.

Scale test models were utilised to address proportion and function of multiple smaller components through an iterative 3D modelling, drafting and 3D printing development.

Testing theory.

Early analytical prototype construction developed a system for linking all Lifewall water storage containers together to act as one larger supply.

This unique system could be developed to flow water constantly within the household reticulated water supply system.

The constant flow system would end the need to replace the water at certain intervals by not allowing bacteria to build-up inside still water. This eliminates annual stored container renewals and providing a significant identified benefit to the end users (World Health Organization, 2016).

Fig. 26. Ergonomic task analysis.

Task analysis.

Evaluating the Lifecell component first occurred during the role play exercise and was later extensively tested using multiple looks-like, weighs-like prototype models.

This lead to insights and discoveries both positive and negative that were refined to ameliorate further the issues that Lifewall aims to solve.

Salient outcomes such as

Lifecell requiring a slightly larger rounded primary handle the need for a subtle finger recess under the base of the form were discovered through this method. Full analysis is in Appendix J, p. 149).

Brand identity design.

Jennifer Crehan from Eloquence world design was approached to assist with the development of Lifewall as a brand.

The step adds a high level of professionalism to the product.

Details of the method are in Appendix K, p. 150.

Third design criteria.

Research through design discoveries informed the next iteration of the design criteria.

Performance

Lifewall should:

- Remove the need to store and maintain water bottles. (bought from a store).
- Secure this water supply against contamination after a natural disaster event.
- Clean and store the water.
- Remove the need to replace the water at set intervals through the daily use of the living space.
- Create a mobile solution for emergency transportation.
- Utilise a modular design to allow it to expand to the desired size.
- Survivability during a natural disaster event.
- Produce more clean water without a municipal connection.
- The form should be as minimal in profile depth as possible allowing installation in restrictive spaces.
- The design should allow storage for up to 200L that split into smaller 'cells'.
- Utilize materials that will last as long as possible, 15+ years.
- Be purely kinetic in function, no electricity or sensors.

Usability

Lifewall should:

- Become part of the living space and a feature.
- Minimal installation criteria, work within existing building dimensions.
- Be completely concealed.
- Give other benefits to the end user and property.
- Create a sense of well-being and healthy living.

Fig. 27. Lifeweall development applied to exterior wall.

Concept generation

A range of concepts was generated through sketch investigation. Some were general concepts of an EWS solution and were further supported by component and subsystem concept generation as appropriate.

Significant general EWS concepts included:

- The hexagonal module:
  A self-supporting structure of water cells that would slot into a predefined outer shape.
- The office reception wall:
  Creating an architectural feature for improving and promoting resilience within the commercial office space. Extending preparedness responsibility to the work environment.
- A drinking fountain:
  Providing a hidden larger EWS at a point people regularly come for water.
- An emergency cabinet:
  An all-in-one emergency resource.
- Domestic kitchen EWS:
  A kitchenware product for retrofitting with existing cabinet conventions.
- Exterior mounted hydration wall:
  A medium sized product that would mount to an outside wall surface.

Concept selection:

A screening table matrix was used to select the most appropriate concept in conjunction with the critique process of the masters program.

The concept selected "Wall mounted hydration wall" scored higher than all other concepts and addressed all key criteria of assessment.

This will be developed as the Lifewall concept.

	Remove the need to store and maintain water bottles. (bought from a store).	Secure this water supply against contamination after a natural disaster event.	Clean and store the water.	Create a mobile solution for emergency transportation.	Remove the need to replace the water at set intervals through the daily use of the living space.	Utilize a modular design to allow it to expand to the desired size.	Survivability during a natural disaster event.	Utilize materials that will last as long as possible, 15+ years.	Produce more clean water without a municipal connection.	The form should be as minimal in profile depth as possible allowing installation in restrictive spaces.	The design should allow storage for up to 200L.	Be purely kinetic in function, no electricity or sensors.
The hexagonal module	✓	✓		✓	✓		✓					✓
The office reception wall	✓			✓	✓	✓				✓	✓	✓
A drinking fountain				✓	✓	✓	✓			✓	✓	✓
An emergency cabinet	✓			✓			✓	✓			✓	
Domestic kitchen EWS	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓
Exterior mounted hydration wall	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 1: Concept screening.

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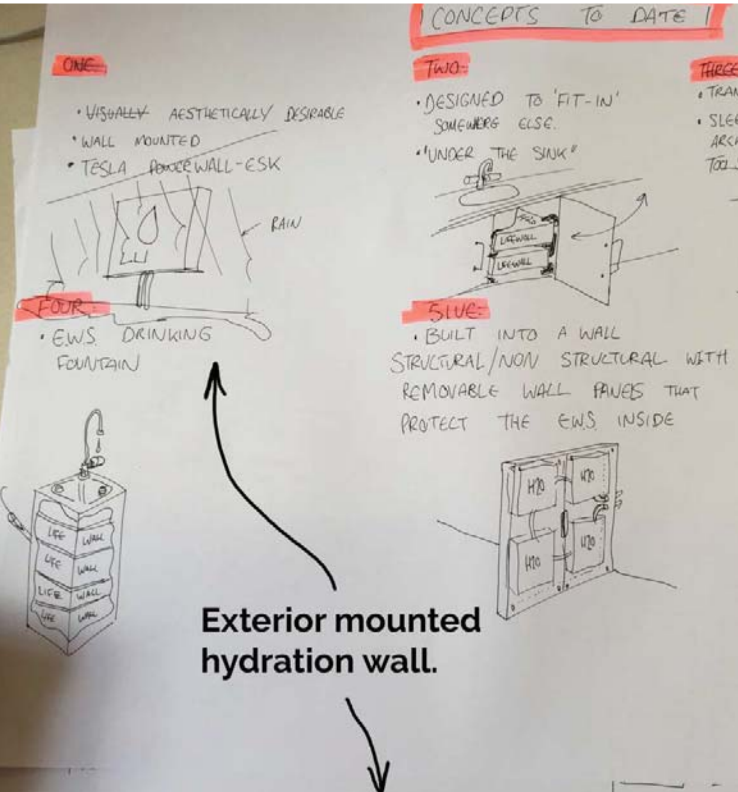
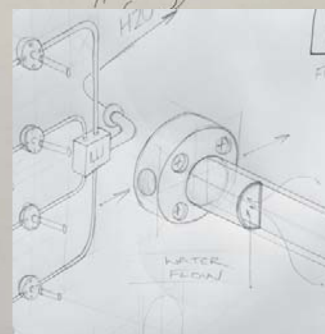
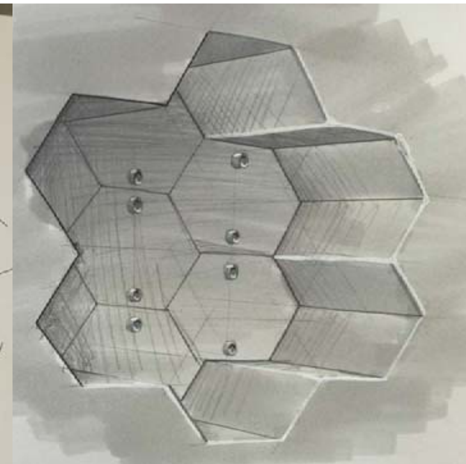
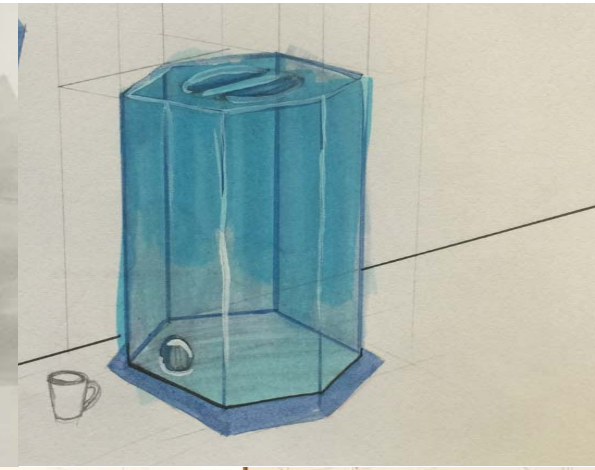
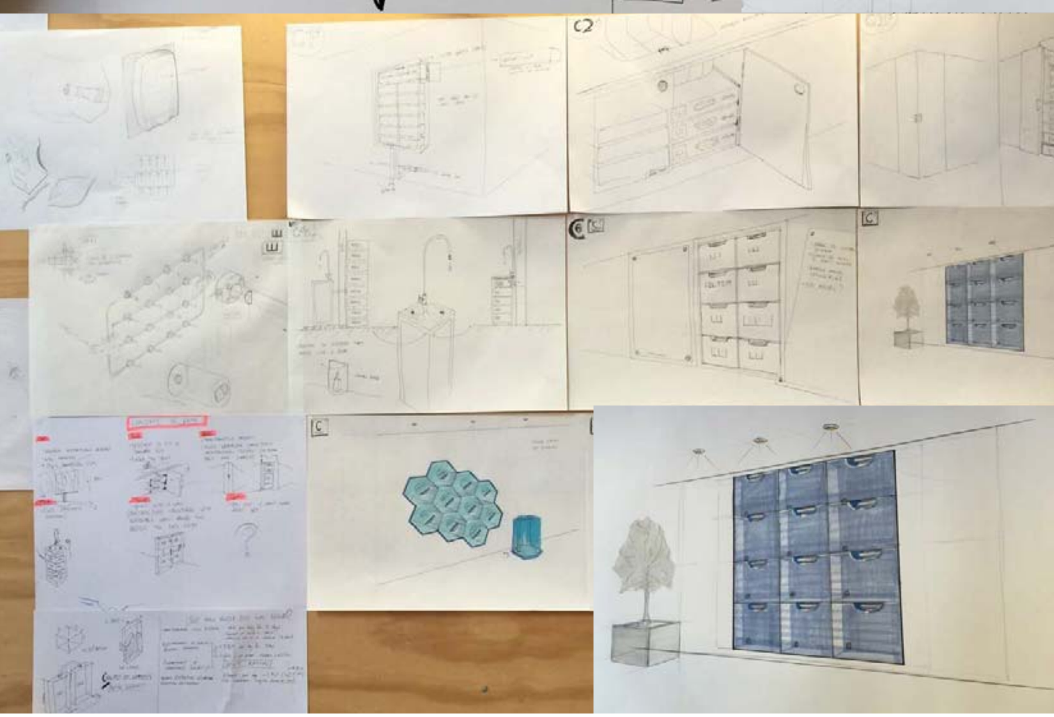


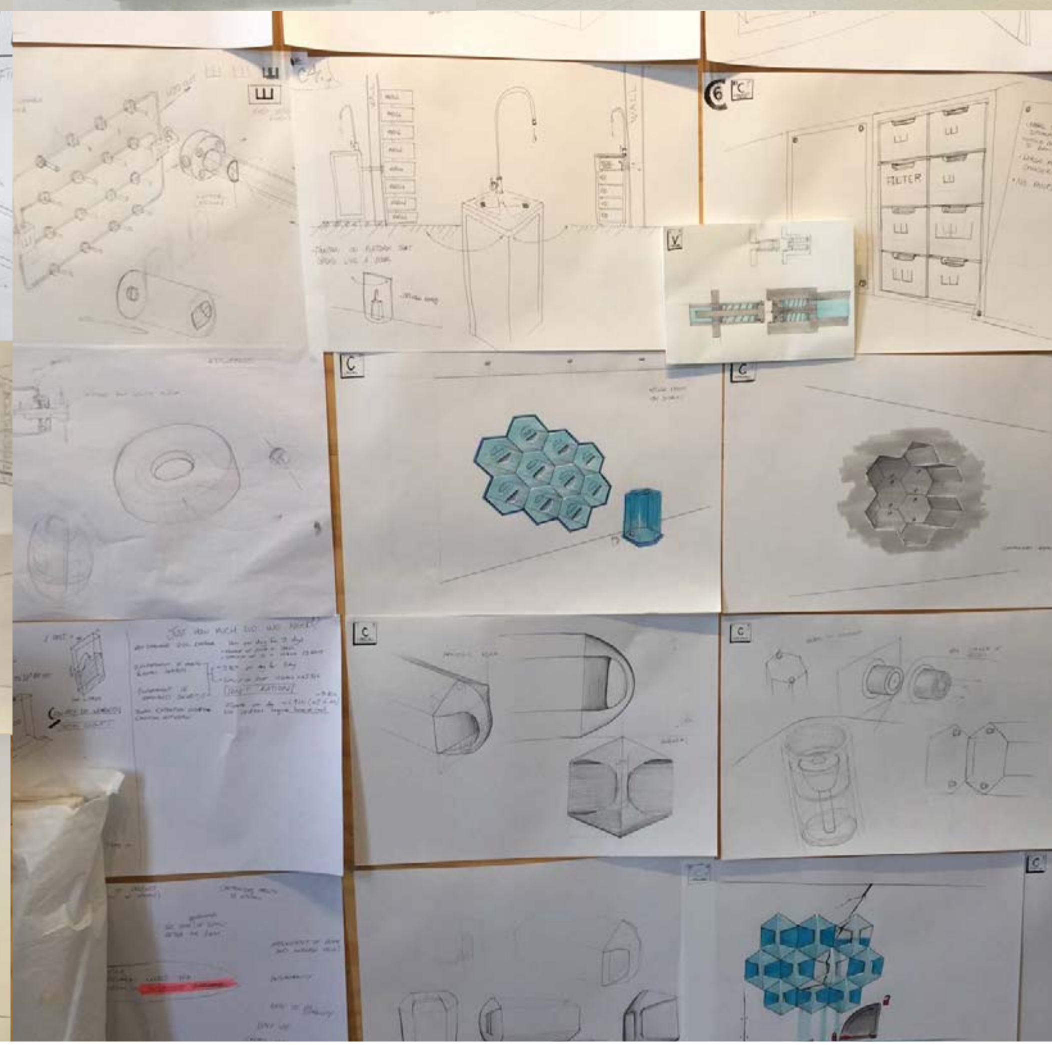
Exterior mounted hydration wall.

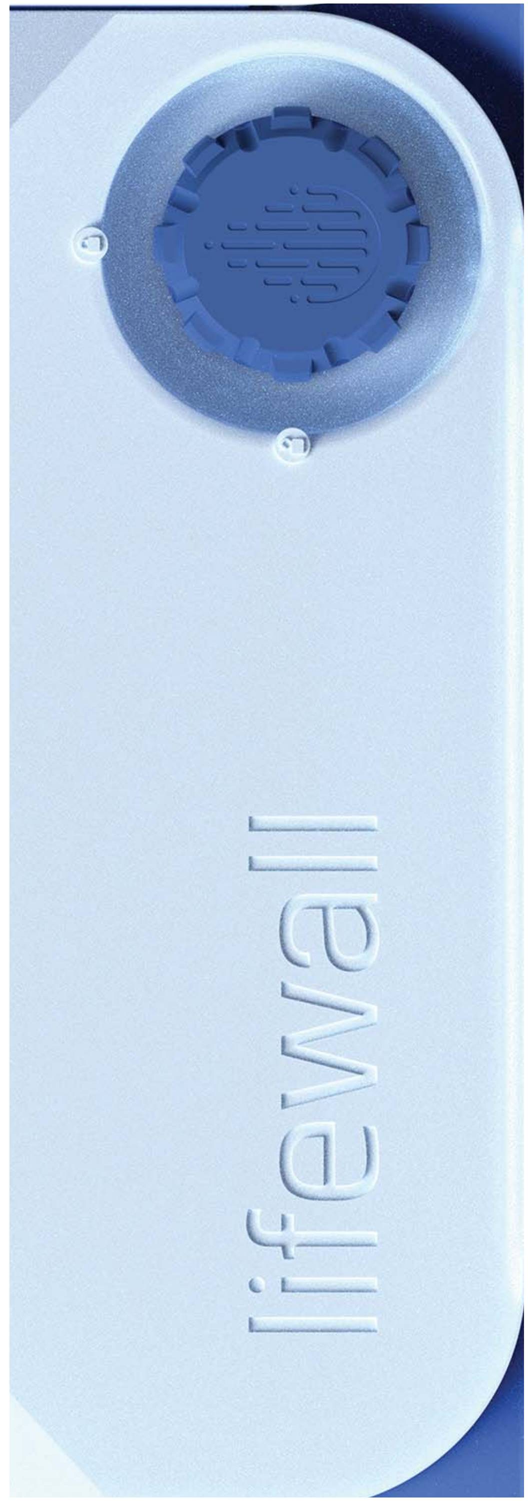












Concept Screening

In light of the product performance and usability requirements, several concepts, as well as Lifewall, were screened and identified as valid for further development.

A concept that would eventually become "Octave" was developed through an advanced level special topic research paper that I provided an active role and contribution too.

The validity of the concept was reinforced when it was awarded a prestigious Red Dot Award: Design Concept in 2017 for Domestic Aid after entry in the Red Dot Design Award competition.

Further details of Octave are in Appendix I, p. 148.

Fig. 28. Lifecell final design detail.

Design development

The Lifewall concept consists of these four primary components:

1. Lifewall Unibody.
2. Lifecell.
3. Lifepod.
4. Bottle integrated quick disconnect hydraulic coupler (BIQC Valve).

My development process covered these four components simultaneously and will be covered in sequential order.

A section covering my hydraulic prototype testing will follow these four points.

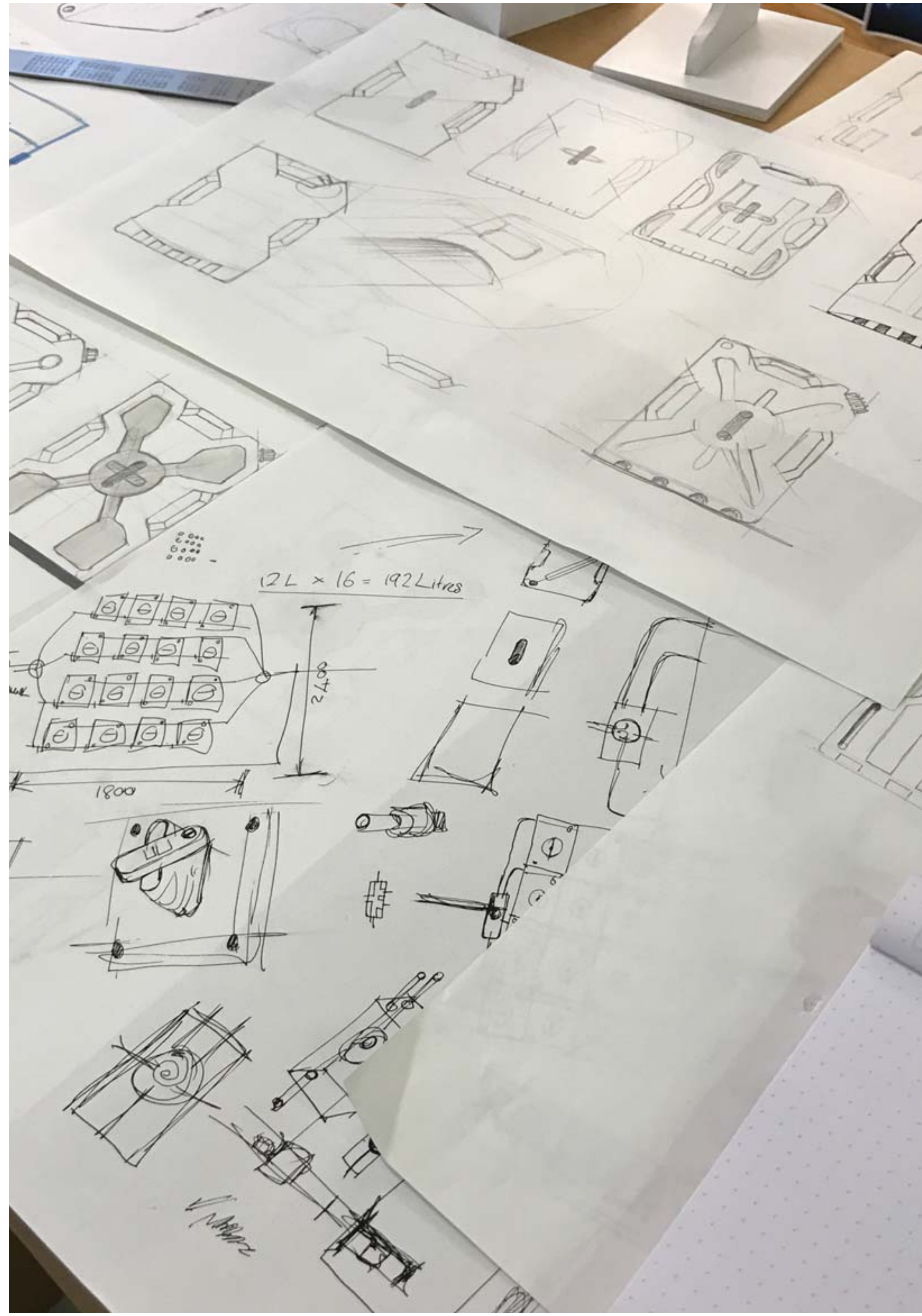


Fig. 29. Development sketches.

Design development

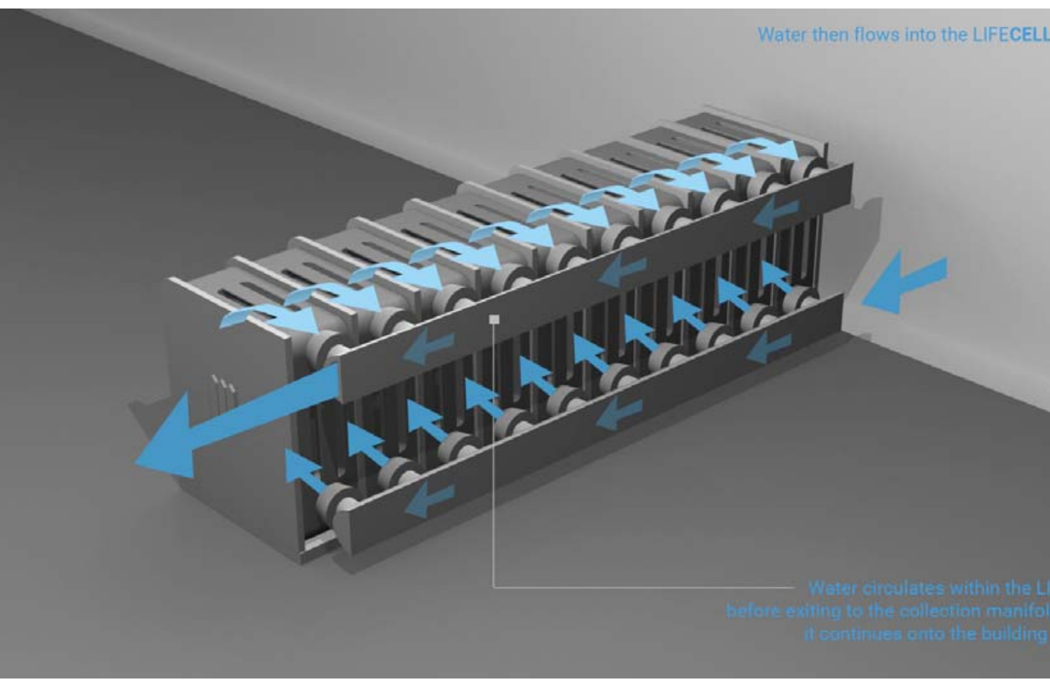
Lifewall Unibody.

The Lifewall Unibody houses subcomponents of the system, Lifecell and Lifepod.

The unibody is effectively the product chassis for mounting to exterior wall surfaces or within timber framing.

A significant investment in prototyping was undertaken to establish the hydraulic operation and flow of water through the Lifewall unibody system.

Experiments and results of this testing are in Appendix G, p. 136.



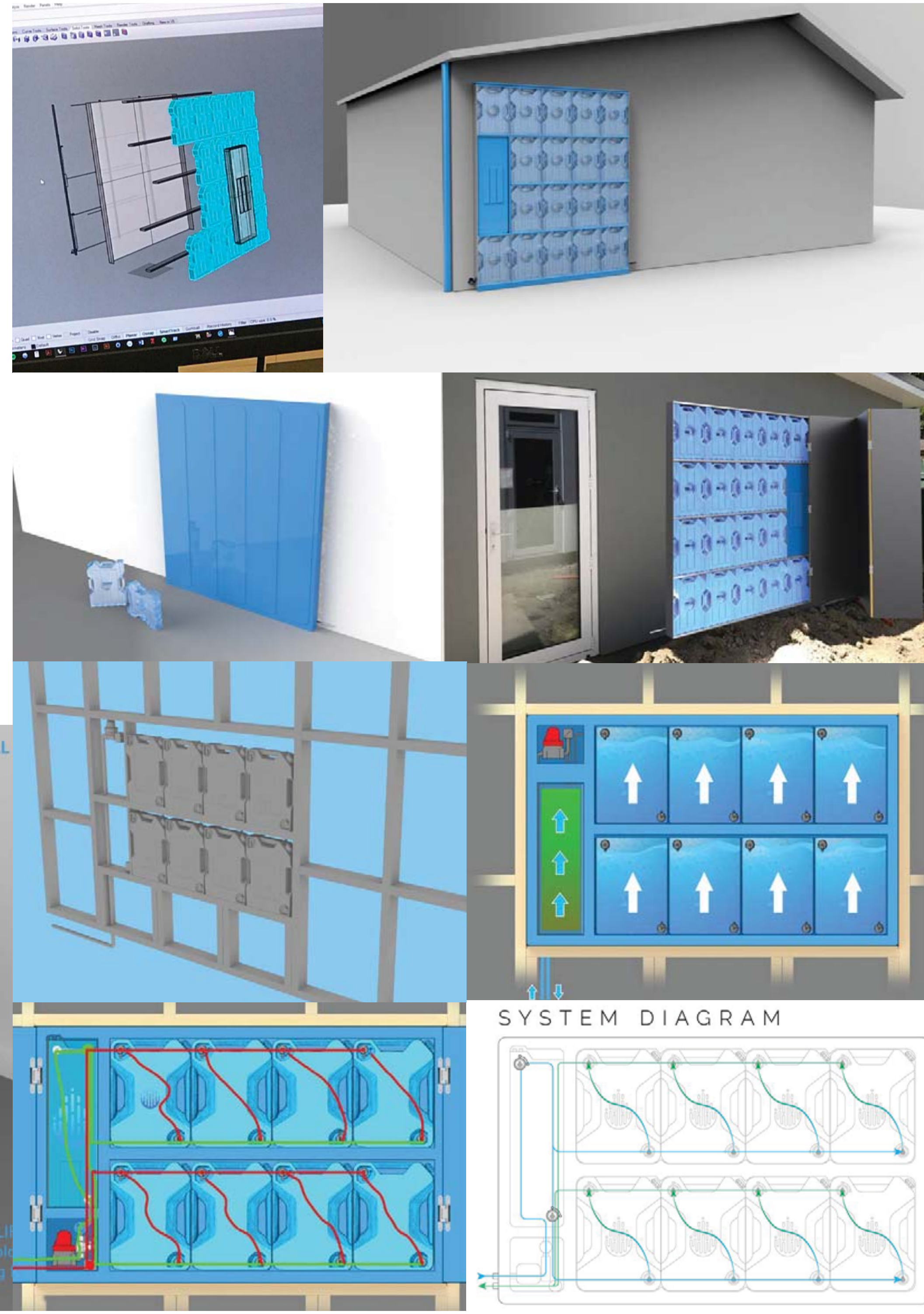


Fig. 30. Lifewall Unibody development.

Design development

Lifecell.

The Lifecell is the workhorse of the Lifewall system. These containers act as the water storage units and connect directly to the valve lock connectors that are connected to the life frame. The original Lifecell design was a square shape with integrated handles.

As this component is manually handled to shift, load and transport (10L) water, critical task analysis is required to ensure comfort, usability and performance.

Lifecell was the primary focus in this research and received a higher share of development.

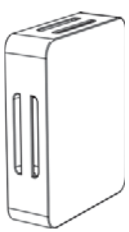


Fig. 31. Lifecell development.

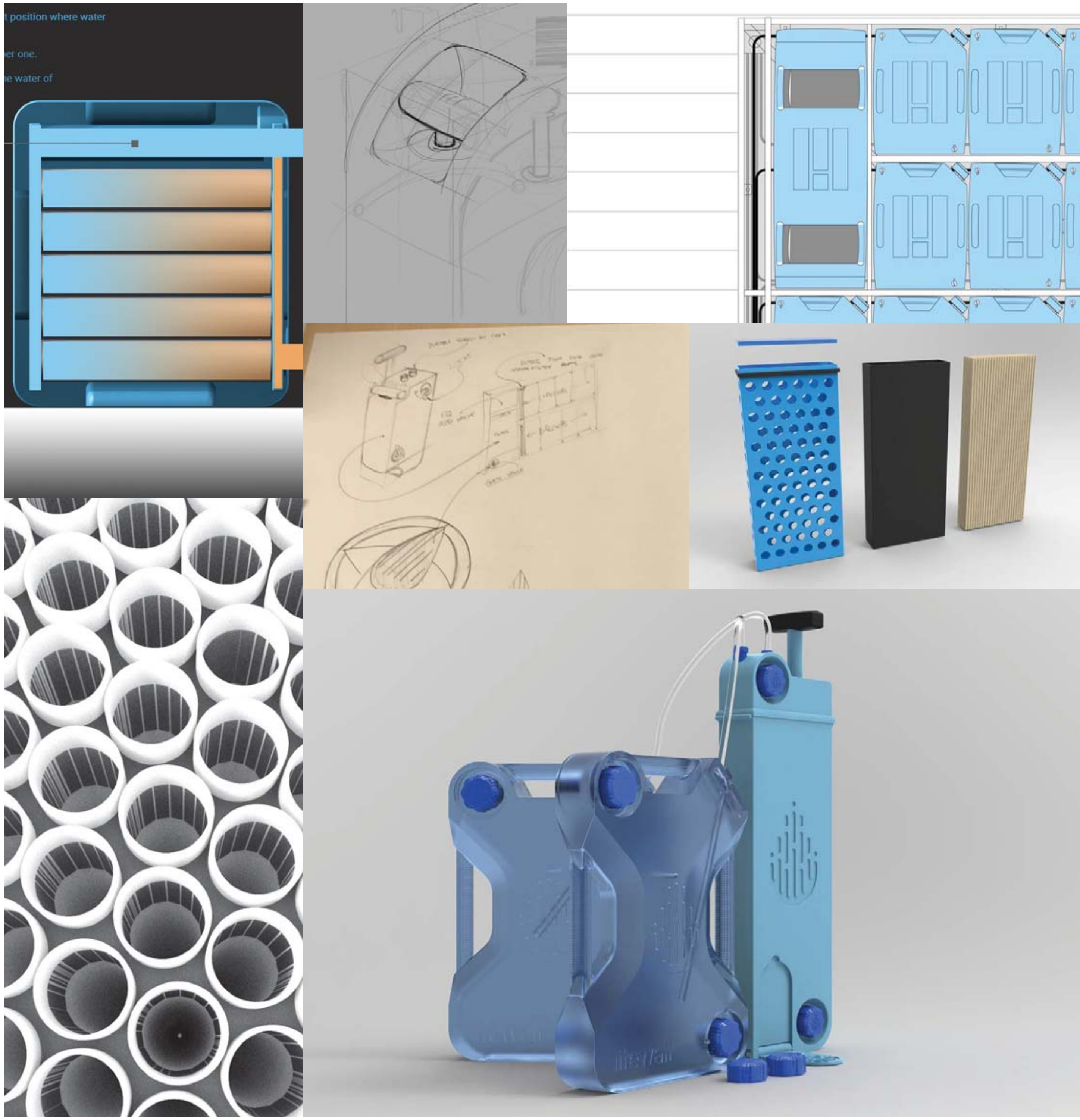
Design development

Lifepod.

The Lifepod component of the system functions as the heart of the Lifewall concept.

Lifepod provides filtration before and after an event.

During normal operation, the Lifepod sits anchored into the Lifewall Unibody, filtering all water that passes through it. Post-disaster, Lifepod can be removed and by releasing the BIQC valves and utilised as a portable filtering station for water, at any location.



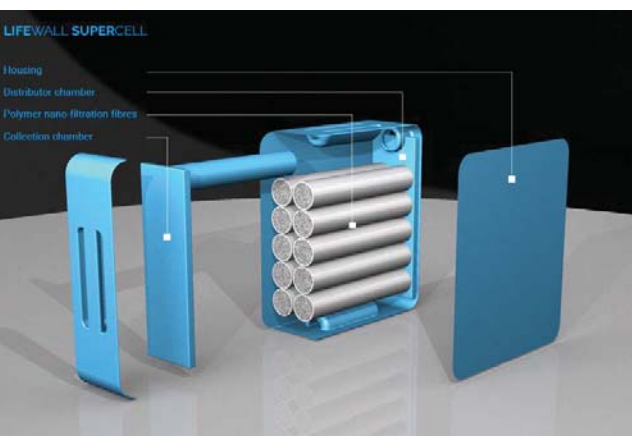


Fig. 32. Lifepod development.

Design development

Bottle integrated quick disconnect hydraulic coupler (BIQC Valve).

This component ensured the security and hydraulic sealing of the Lifecell into the Lifewall Unibody.

By integrating this type of valve the user requires no technical knowledge of how the system works. The user simply pushes the Lifecell into place engaging the BIQC valves, then by turning each front dial to the lock position, the Lifecell is secured.

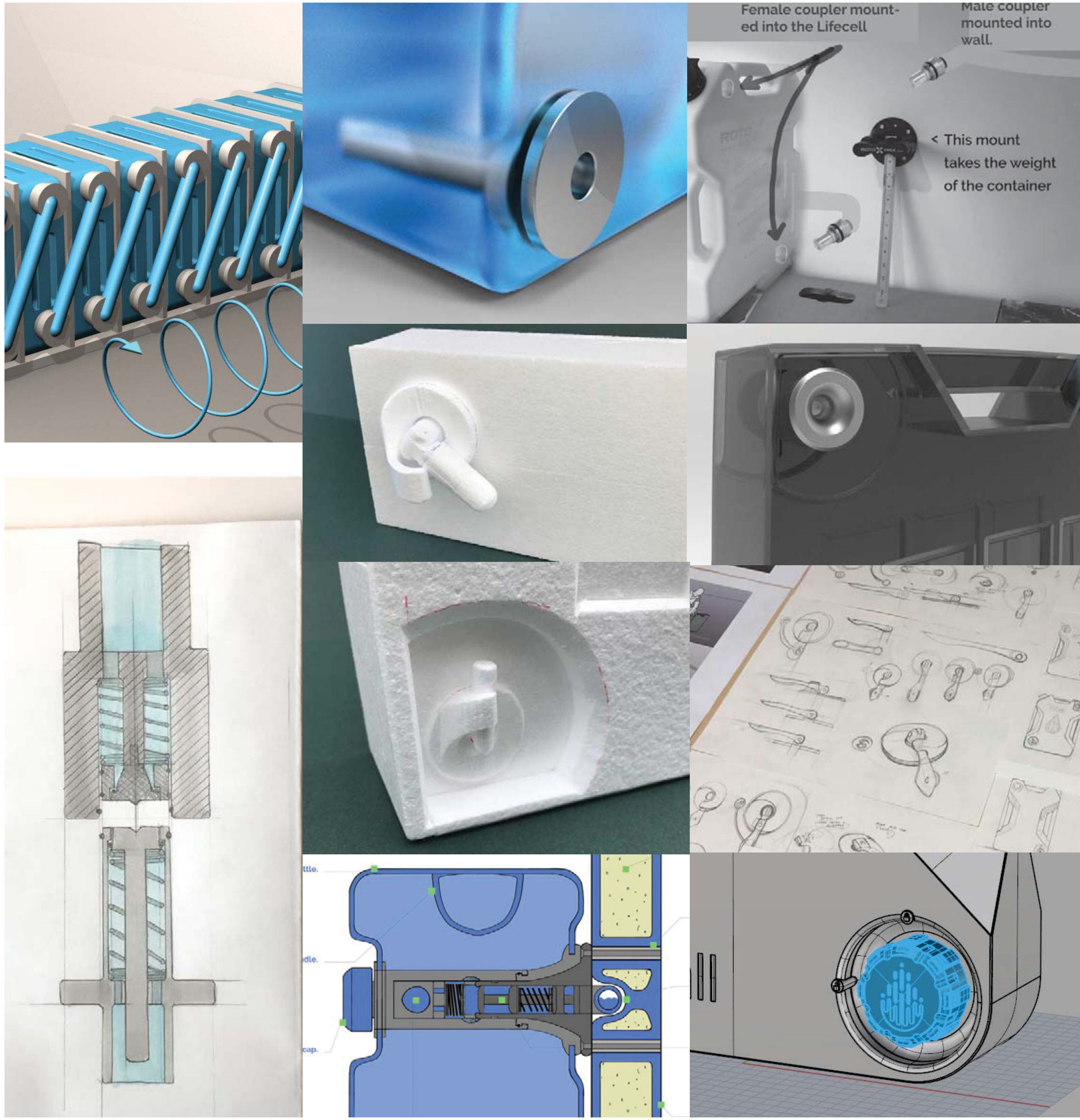


Fig. 33. BIQC development.

Design development

Hydraulic prototype testing

Process

Sistema, 7-litre containers, were used as the water 'cell' and connected with garden irrigation components. The arrangement consisted of, three containers tall and wide.

The irrigation components were fixed in place with an Epoxy resin to simulate a quick disconnect coupling.

Objective

For this experiment a 1:1 scale prototype was built using readily available components from building hardware suppliers and home kitchenware product retailers.

The middle 'cell' was constructed to be functional by using self-sealing garden hose connectors and fittings to test the hydraulic properties of installing and removing the cell while the system was running. The cell can be freely removed and connected back into the system.

The remaining eight cells were permanently fixed into place to minimise the possibility of leaks in this working prototype.

All pipes and cells were chosen in a clear material to observe the water flow unrestricted.

Fig. 35. Aeration testing.

Summary of findings

The hydraulic prototype configuration in test Version 3.0 is the most optimal for this product concept.

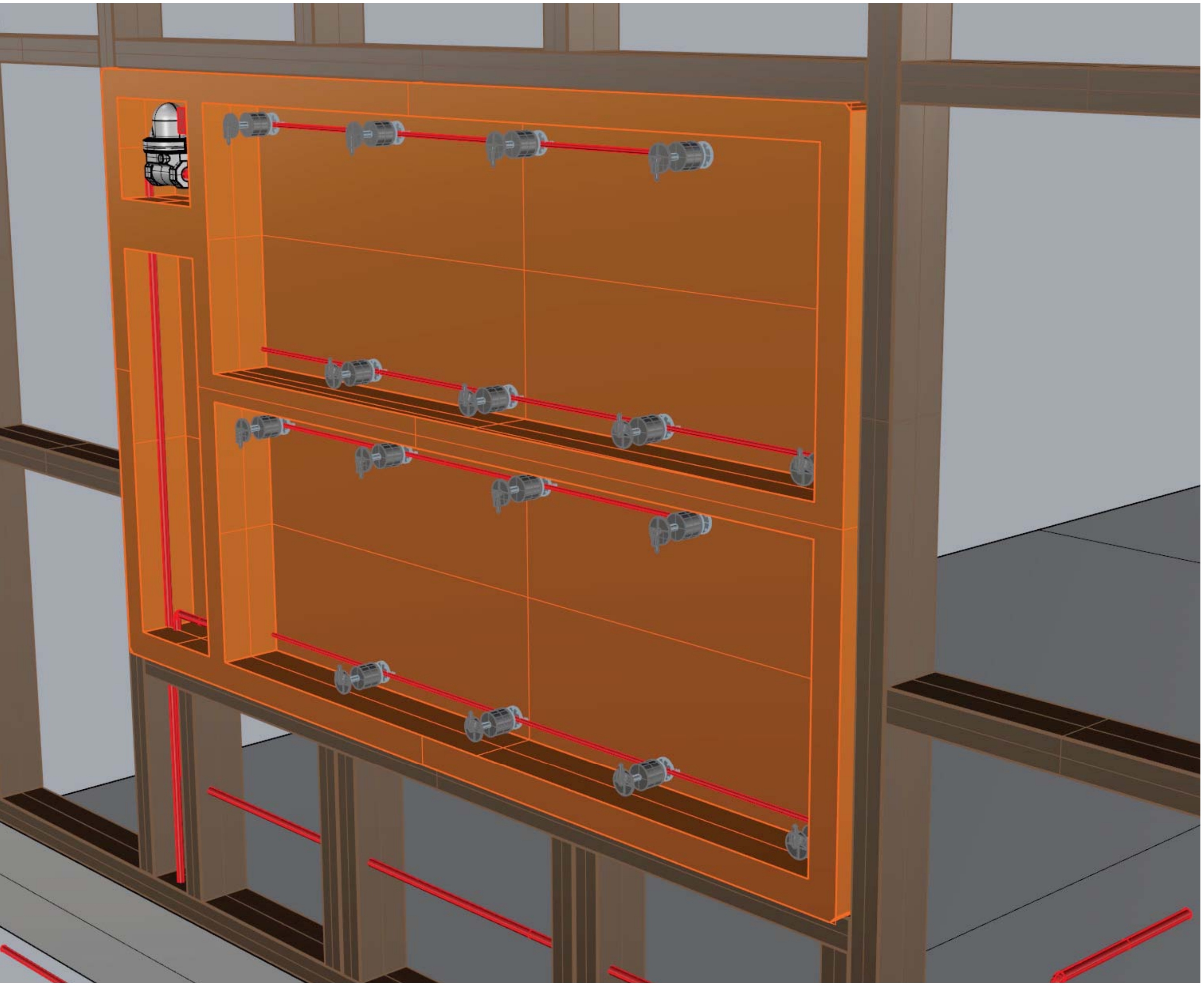
This product system architecture fills the individual Lifecell from the bottom, expelling all air and maintaining a steady flow of water through Lifewall. In addition, it maintained this performance when an individual random Lifecell was removed from the system and reconnected.

Using coloured dye to track the water flow, the system continually replenished itself eliminating annual cleaning and maintenance.

The dye testing report can be found in Appendix H, p. 146.

Fig. 34. Hydraulic prototype iteration.

Fig. 36. First iteration of the Lifewall Unibody



Manufacturing Consideration

A decision is made to move the Lifewall to a one piece unibody rotational mould.

Lifewall until this point was a structural plywood frame that the system components would attach to inside. This allowed room for human error with no precise markings to attach the components to. The final design consists of a single rotationally moulded, foam filled core unibody. The Lifewall Unibody houses the various components and has moulded markings and inserts to allow perfect installation of these components

It also creates a thermal insulation barrier maintaining a warm home.

The thermal conductivity of Water (0.58) Polypropylene (0.1-0.22) and Polyurethane Foam (0.03) are much lower than glass (1.05). ("Thermal Conductivity of common Materials and Gases," n.d.).

Lifewall is installed into a new wall, similar to how a standard domestic window is placed.

Final Lifewall design criteria

Performance

Lifewall should:

- Be purely hydraulically operated with no cross system reliance to operate.
- Be as minimal in profile depth as possible to allow installation into restrictive spaces.
- Store 80L (A four person, 7-day supply) for the purpose of this application but have the capacity to scale for other applications such as multi storey dwellings and commercial buildings.
- Utilize LifeSaver C2 Asymmetric Multi-Bore Hollow Fiber Membrane (AMBHF) filter fibres to give long term durable water filtration.
- Minimal and easy installation criteria, work within existing building dimensions.
- Provide a better and more comfortable mode of transporting 10L of water than any current solution.
- Integrate seismically activated valve technology to protect against contamination after a natural disaster event.
- Filter the water entering the house for daily use.
- Continually flow the water through the system to aerate and refresh.,
- Design should be durable and weather resistant.
- Accessible if damaged.
- Be suitable for new homes and existing ones (retrofit installation).
- Produce clean water from alternative sources using Lifepod.

Usability

Lifewall should:

- Become part of the living space and a feature.
- Assist installation.
- Conceal the technical components.
- Offer benefits to the end user and property.
- Create a sense of wellness and healthy living.

Product statement

Lifewall is an EWS that improves upon any system available today.

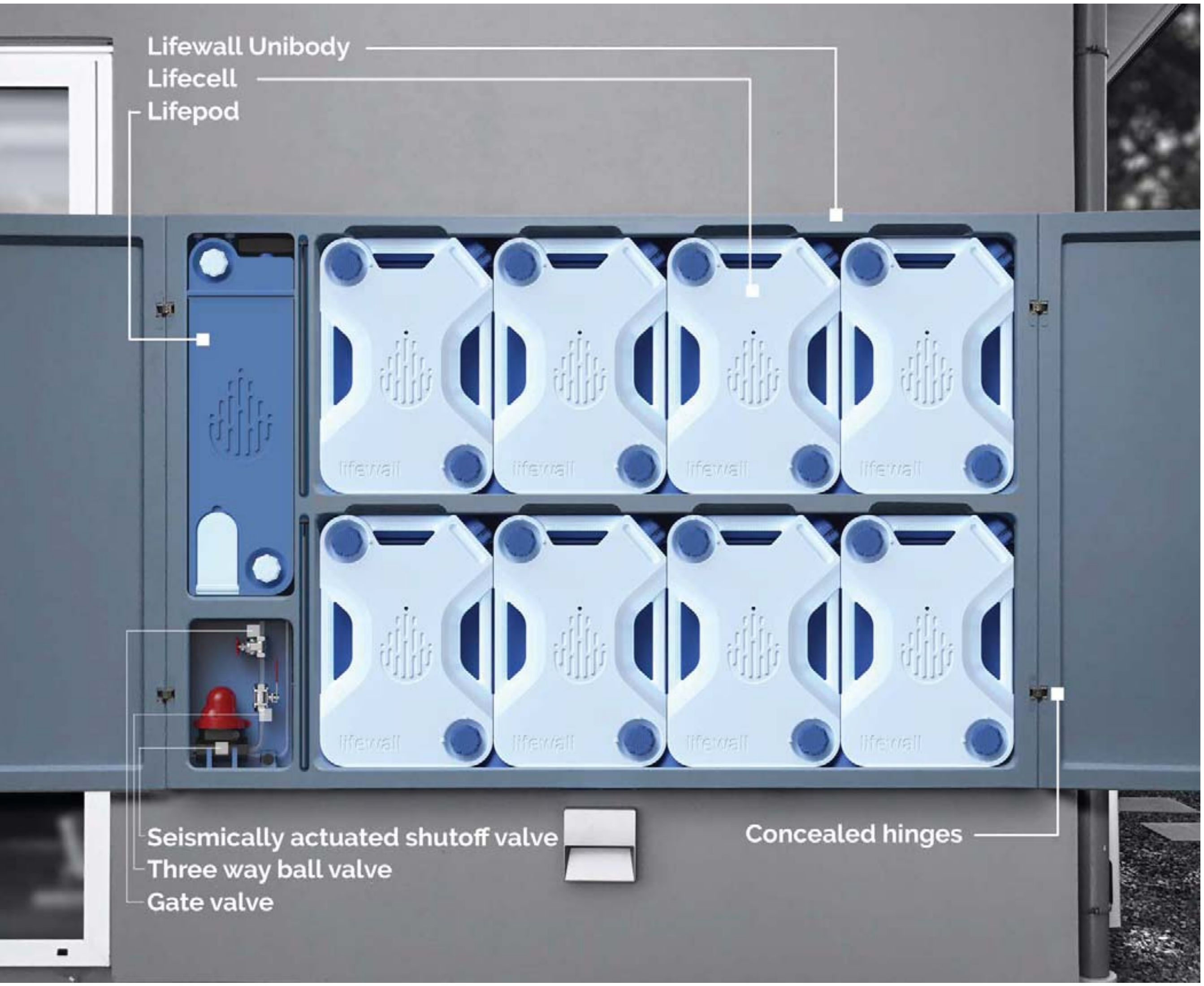
The components have been developed into a system that always provides clean filtered water and work together in a better way to sure an EWS.

Lifewall is designed to be installed in existing houses and integrate in new buildings like a regular glass window.

Lifewall filters all water entering the home before it passes on to a chosen room, typically the kitchen or bathroom. The stored water is automatically renewed by the daily use of the living space.

It reacts automatically to seismic movement, isolating its 80L capacity in eight 10L Lifecell vessels for ease of transportation. When the Lifecells are emptied, Lifepod can be used to filter any available water source.

Fig. 37. Lifewall Unibody component diagram.



Lifewall Unibody

Lifewall and its components fit within the unique unibody design.

A foam filled core unibody, and two doors maintain a high level of thermal insulation to a home. For external installation the unibody foam core can be left out, reducing the weight and end-user cost.

Concealed hinges mount the doors to Lifewall and completely open within the thickness of the door, 20mm.

Water enters Lifewall and passes through three valves before entering the Lifepod.

Valve one is an automatic seismic shut-off valve that will engage the moment the system is shaken with enough force to trigger it.

The second valve is a three-way ball valve that is used to flush divert the underground lines after a major natural disaster event; this is to prevent mass contaminates, sand, mud and other material from entering Lifewall.

The third valve is a manual gate-valve for disabling Lifewall and keeping it isolated from the municipal supply.

This valve is used if the municipal supply is cut off for a significant amount of time.

Fig. 38. Valve layout.

Fig. 39. Lifepod in action.

Lifepod

Water flows into the Lifepod from the plumbed inlet. The water passes through the AMBHF filter to the top of the system. Once cleaned it exits the back and into a distribution manifold before flowing down into the Lifecell's.

The Lifepod can also remove from the system and function as a standalone potable water station. It transforms and operates similarly to a full size standing bicycle air pump for tyres.

The foot pedals fold out, and the hand grip at the top twists 90 degrees to unlock the pump mechanism. From there the pump is connected to two vessels, one unsafe water, one empty to receive the cleaned water.

Then the pump is used to push the water through and into the empty container manually.

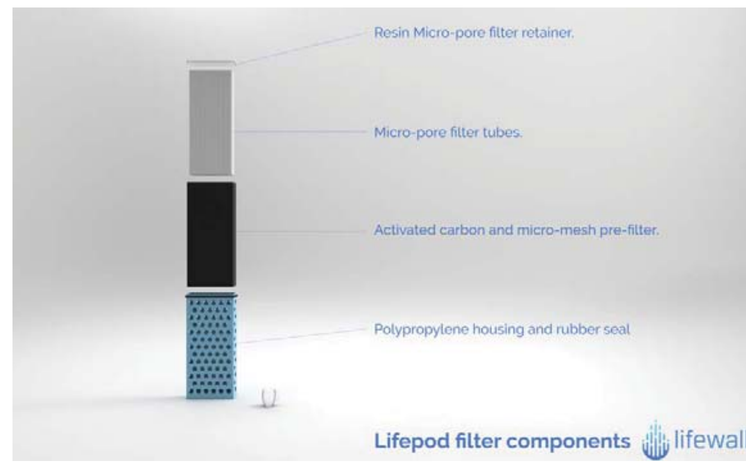


Fig. 40. Lifepod AMBHF cartridge detail.

Fig. 41. BIQC valve integration.

BIQC valves

The BIQC valves hold the Lifecell in place and provide the water supply within Lifewall.

BIQC's are a two-part design that locks together with a simple ninety-degree turn once the Lifecell has been placed into Lifewall. The mechanical function of the hydraulic valves has been hidden within a simple user interface dial. The dial has a high profile ridge and a reductive channel around its edge, ideal for fingertips to lock into and ensuring a secure grip even when wet.

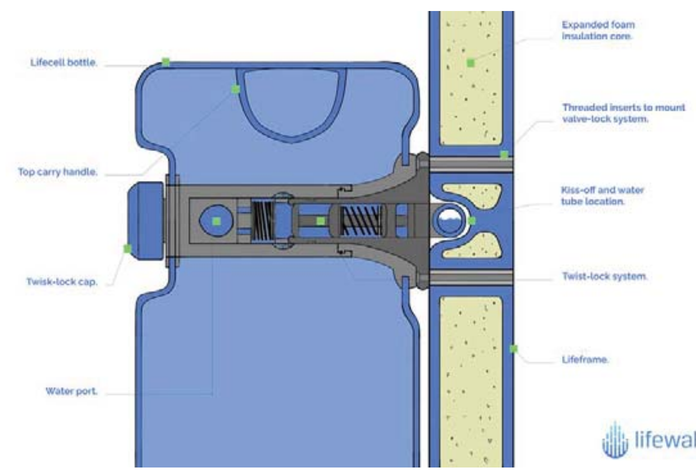
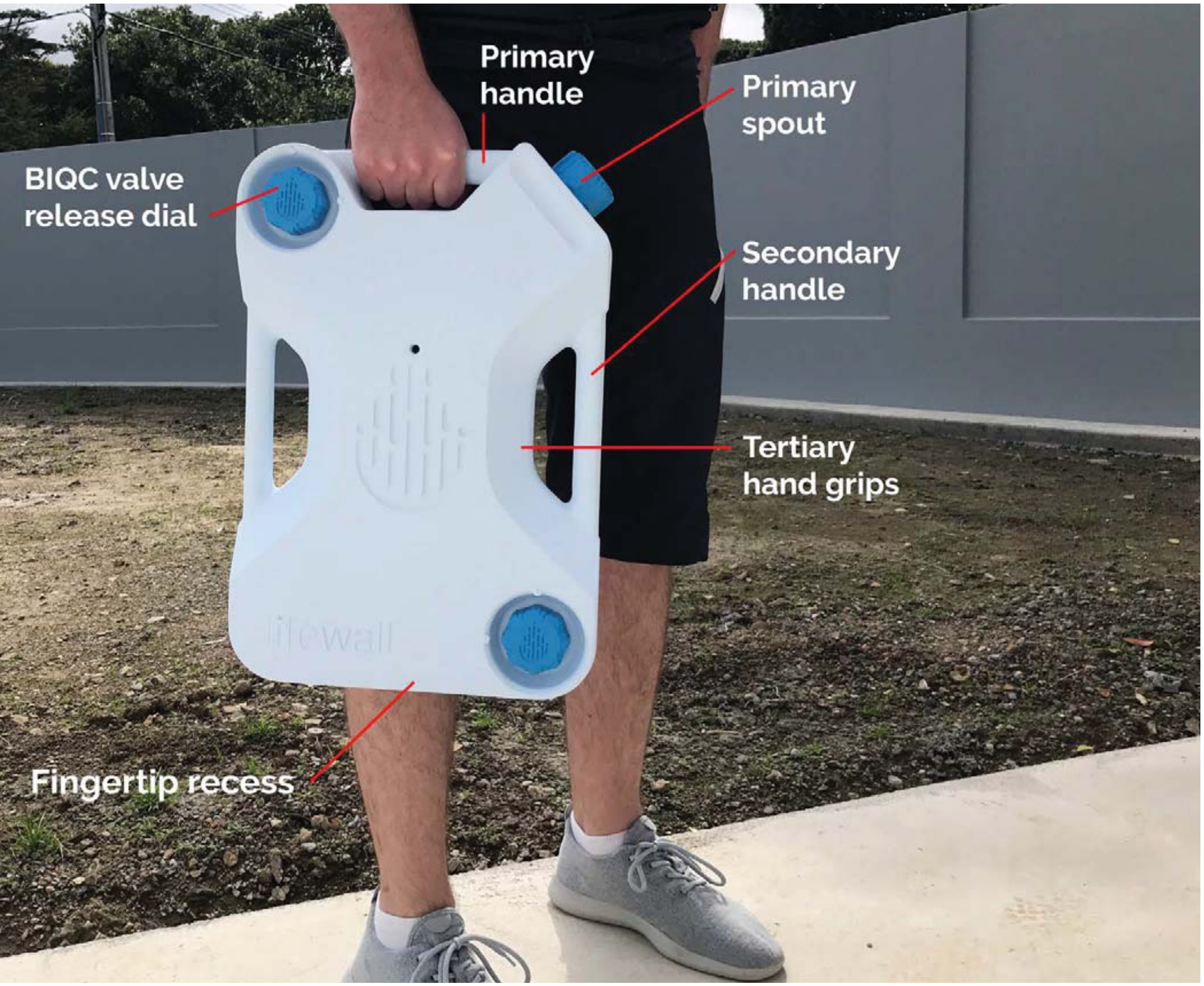


Fig. 42. BIQC valve detail cross-section

Fig. 43. Lifecell details.



Lifecell

The Lifewall logo indicates if the BIQC valves are locked or unlocked.

The storage component of Lifewall. The design holds 9.5L of water for a total weight of 10kg for a full Lifecell.

This weight and size identified by investigating the manual handling aspects of container weights and the seven-day water supply target for Lifewall. A four-person supply for seven days is 84L.

The primary carrying handle is slightly larger and is a slightly angular form that has been heavily blended to form a controllable, long term carrying solution for a 10Kg weight.

The two smaller identical hand grips are to offer a variety of carting and tie down alternatives if needed. They also assist with pouring the water out of the Lifecell.

During the task analysis, users were observed to cradle the bottom of the Lifecell and hold it above their hips.

Due to this interaction, there is a soft concave recess around the entire bottom of the form. This allows for fingertips to get a secure feel for the Lifecell shape when carrying in this manner.

The internal form of the secondary handles provideds a waist form that also acts as a third hand grip to assist with placing the Lifecell into the system. The internal angular form was a necessary design consideration as the Lifecell's are tightly secured, meaning a new set of hand grips were required.

The Lifecell also houses the female BIQC mechanism.

Fig. 44. BIQC valve integration.

Fig. 45. Lifewall installed.

Lifewall

The exterior security doors have a contemporary wave pattern that alludes to the fact that this is a high performing water based product.

Lifewall has a subtle embossed logo placed on a shallow cylinder to separate it from the wave pattern.

The keyhole has been relocated to a central top and bottom position providing a security feature.

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Design scenarios

Typical installation onto a wall (retrofit).

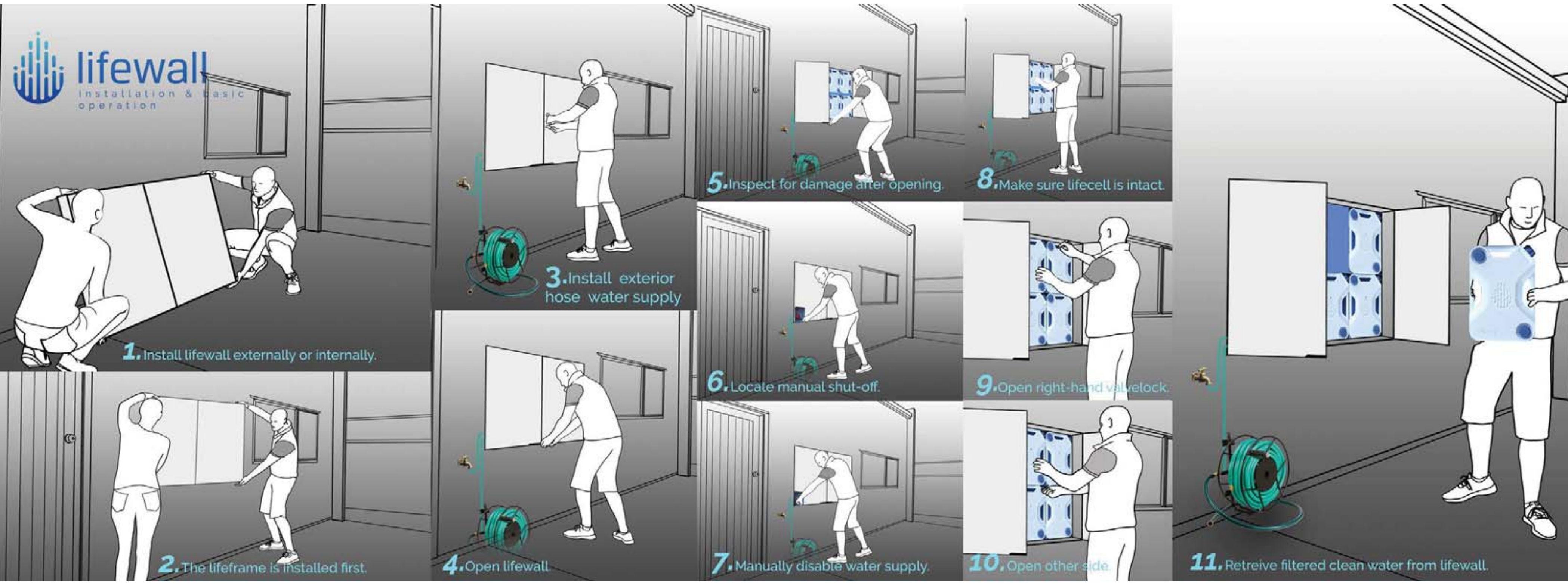

Fig. 46. Lifewall retrofit diagram to an existing house.

Design scenarios

Typical installation into a wall frame.

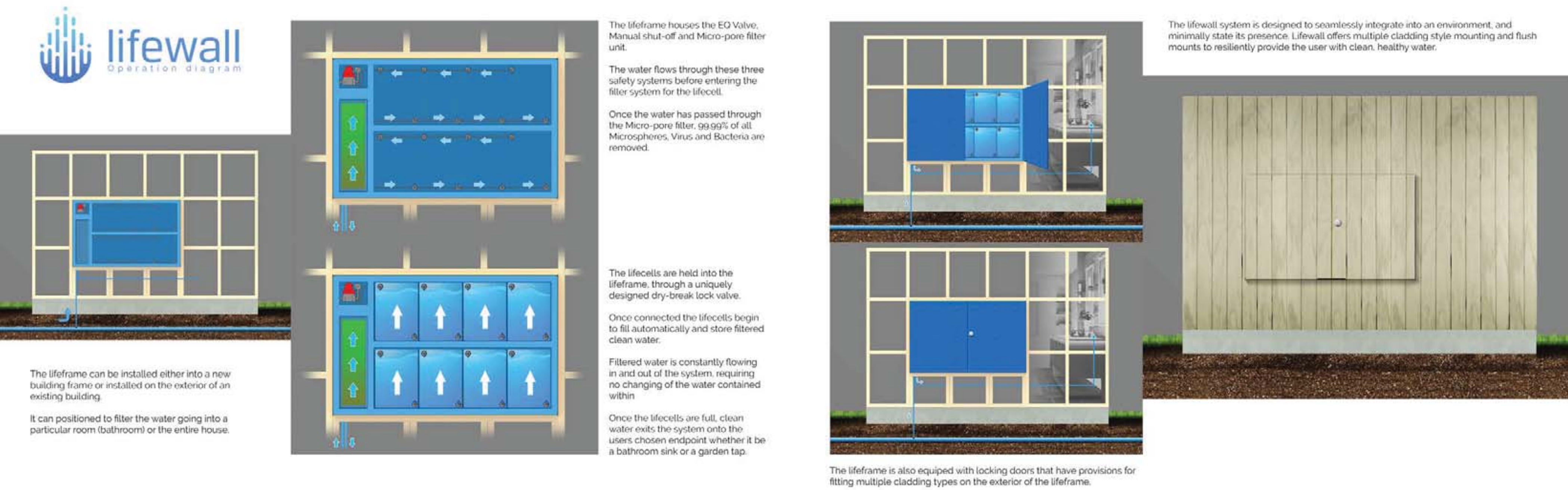

Fig. 47. Lifewall permanent installation into a new building.

Scenarios

Lifepod intended use when municipal water supply has broken down for an extended time.

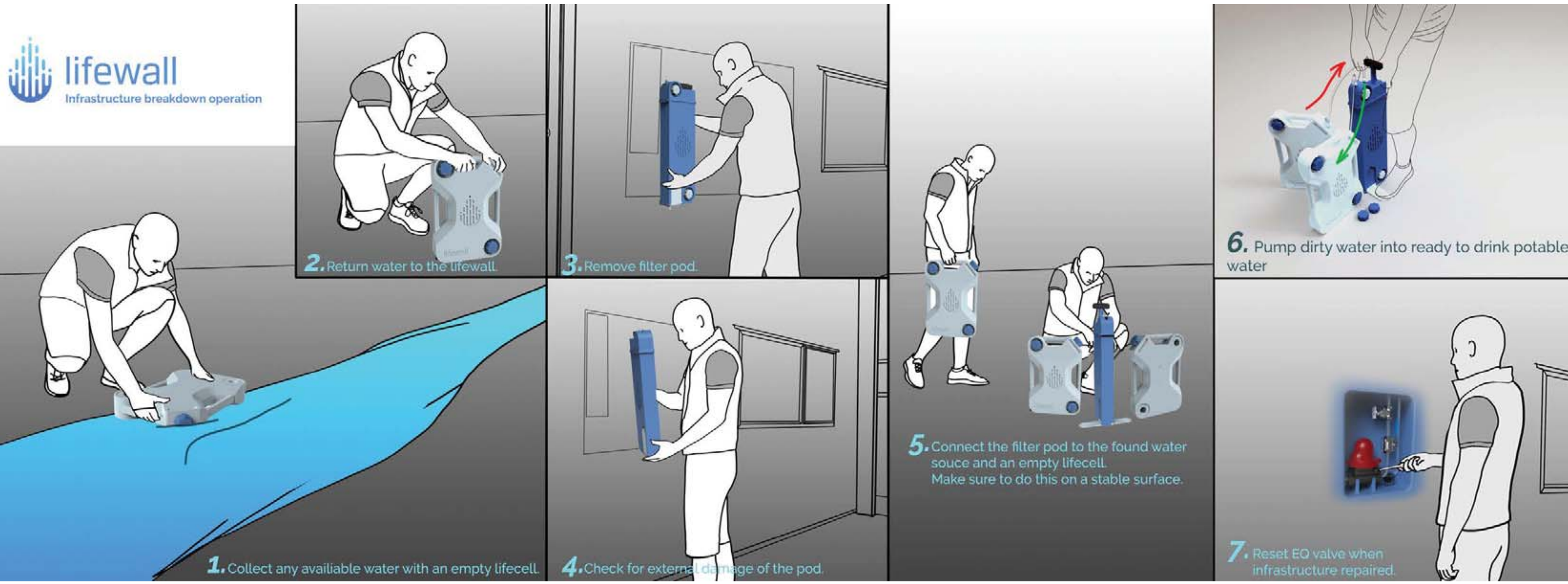

Fig. 48. Infrastructure breakdown operation diagram.

Evaluation – Performance

1. Zero reliance

Lifewall is powered solely by the pressure of a municipal supply when connected. The Lifepod is also a mechanical water filtration device requiring no power. Post-Installation, the Lifewall business structure database would notify users of a filters expiry offer filter cartridge replacement service or purchase. Other than the Lifepod filter there is no other component that needs maintenance.

2. Slimline

If installed into a 140mm wide timber frame the design sits completely flush and even gives space for added insulation, improving it further. In 80mm wide framing, Lifewall stands 25mm from the wall surface. A slimline profile with little visual impact.

3. Storage

Lifewall contains eight Lifecell's, all containing 9.8L each for a total of 78.4L, The system can also produce a three year supply of filtered water through the Lifepod which holds approximately 10L as well.

4. Installation

Lifewall is designed not to interrupt the regular construction of timber framed walls. The timber width was determined as a crucial dimension for Lifewall in working within the building code. Lifewall is installed in the same manner a regular glass window would be but provides better insulation.

Lifewall can be installed where there is space to support the retrofit into. Existing buildings have been a priority since the concept stage. The rear unibody kiss-offs are designed to have anchor bolts placed through and into the wall of an existing residence for mounting.

5. Usability

The manual handling of the Lifecell has been refined to provide an intuitive placement into the Lifewall system. The users handed the Lifecell to place into the physical prototype were observed to have no difficulties in identifying where to place it. The variety of handles also provide multiple ways for end users to do this simple task.

Fig. 49. Lifecell.

6. Water security

Lifewall has a seismically actuated shut-off valve which reacts instantly to a large enough ground movement. This valve is user resettable via the simple slot and will not open unless reset, thus protecting the stored supply.

7. Freshness

The use of the environment allows the water supply to be aerated and renewed before exiting the tap or hose. The water flow though Lifewall has been designed to constantly spin and churn the water passing through it to maximise aeration.

8. Durability

Using a polypropylene material throughout the Lifewall system allows for UV stabilisers to be added to an already durable and waterproof material. The foam filled core of the rotational mould increases this durability by creating a composite of the two materials making it even stronger.

9. Security

The key lock mechanism is strong enough to secure the doors of the Lifewall system and are also able to be removed by force if necessary.

10.Resilience

The primary filter for Lifewall, Lifepod, can be removed and transform into a mobile water purification station. This allows continued community water resilience by offering the opportunity taken to help those in need of clean water.

Multiple Lifewall systems can be simultaneously connected in a chain to expand the storage capacity to a desired size.

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Evaluation - Usability

1. Integration

The Lifewall system design has a total thickness of 110mm allowing installation inside a wall cavity flush with the opposite side.

The foam filled rotational mould offers a thermal barrier so that no internal building heat freely passes through. Installed in this manner, the total system protrusion from the standard wall surface is approximately 40mm making Lifewall a slimline, attractive product.

If the building has 140mm wide timber frames, Lifewall can be completely concealed within this thickness.

When Lifewall installs into an existing building, the foam filling can be left out as it is not needed when the frame is attached to the exterior of a building.

This would reduce the cost of the retrofit design.

Lifewall offers:

- A healthy water and wellness system.
- Superior usability.
- A desirable product that looks after your family in times of need.
- Ability to install in new homes and old.
- Easy installation.
- Simple manufacturing.
- Next generation filtration technology.
- Lower housing rates through adopting Council resiliency strategy.
- A mobile water source in case of evacuation.
- Community support.
- Community resilience.
- A guaranteed source of water in the worst of conditions post-disaster.
- Water security.

Fig. 50. Embossed Lifewall logo.

2. Installation assistance

Standardising allowed the design to incorporate subtle installation aids into the moulding.

For 80mm thick walls, there is a reductive line around the entire outside edge that guides installation to be perfectly flush with the reverse side while still allowing space for a Tyvek moisture barrier sheet to be used.

This groove also acts as a water channel if any water was to leak in behind the moisture barrier, it has an escape route to guide it downward and out the bottom of the flashing and into the environment.

Lifewall Unibody also has an allocation for flush mounting timber anchors to fix the Lifeframe to the timber frame.

3. Concealment

The design minimally intrudes into the existing living space to cause no disturbance. The moulded cladding thread allow multiple exterior finishes. The doors can be painted to match or compliment the wall surface. Designed Lifewall doors are also available with a subtle contemporary wave pattern moulded into the panel surface.

Evaluation - Discussion

Objective

Discuss and critique the final design and prototype model with architectural and scientific professionals.

Participants

Erin Collins
Senior Project Architect
Hayball, Melbourne.

Dr Raj Prasanna
Senior Lecturer
School of Psychology
Massey University
Wellington.

Dr Carol Stewart
Senior research fellow
Joint Centre for Disaster Research
Massey University/GNS Science.

Erin Collins

Water proofing and leaks are the only real concern. Building codes from research facilities like BRANZ have the means to simulate, evaluate and calculate resolutions to issues that this would face.

Fixed with flexible flashing tape that extends over the weather boards.

Think of it compared to a regular glass window. This design would insulate more than a single pane glass window.

- Flexible flashing tape will easily waterproof the design.
- Look at normal window detailing and remember products like Tyvek moisture barriers.
- Recommended contact BRANZ for further research work.
- A reduced size would help with the loading on the internal wall.
- Compare against 600mm to 450 mm stud centres.
- "It's an awesome idea Michael!"
- "This {The Lifepod} is a great idea too so people can keep cleaning their water."

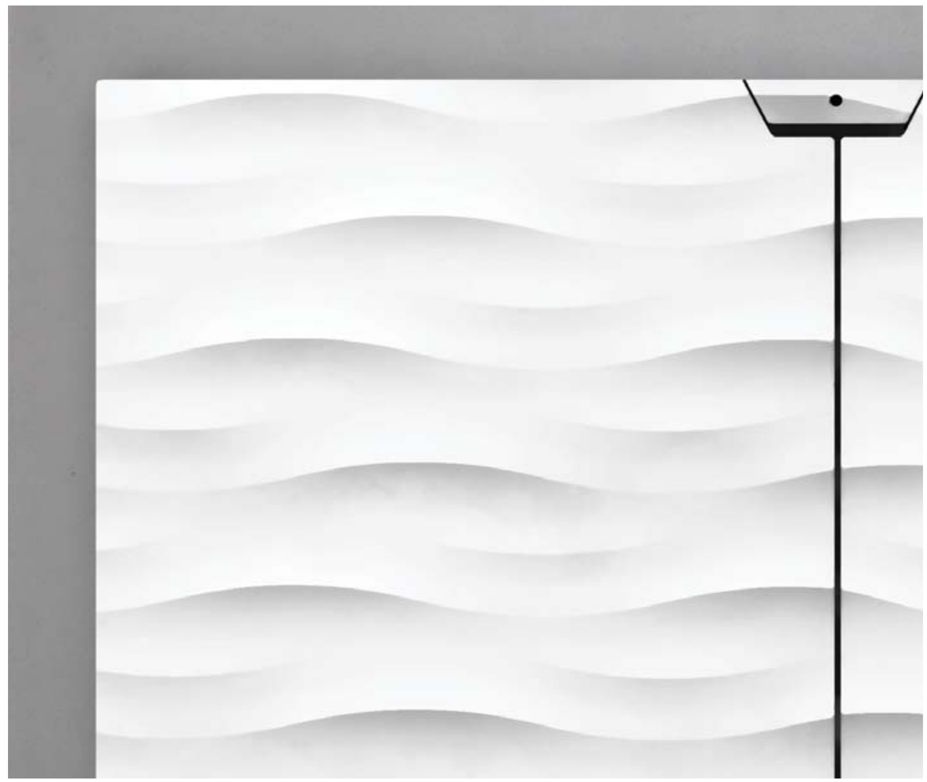

Fig. 51. Lifewall texture detail.

Dr Prasanna & Dr Stewart

Both disaster researchers were highly positive of the Lifewall design presented. They recommended further investigation into the door operation and possibly make them removable to access the system.

- Possibly connecting the Lifecell units together to build a larger water storage and be used with the Lifepod to full.
- Value for money especially desirability features were appreciated.
- Ease of installation is impressive and important. The WREMO tank commonly requires users to buy a downpipe just to install it.
- Very excited about the benefits Lifepod provides in a stressed environment.
- Impressed with the water filtration technology delivered by Lifewall.
- Impressed the hydraulically powered aeration within the system.
- "That's a really cool idea, very impressive".

Conclusion to research

Future areas of investigation

BIQC valve system.

This system proved to be a significant engineering problem. As such the design development is limited to what was observed functioning in existing products and methods of connecting to reciprocal tooled surfaces.

The conical valve function simulated in the 3D prints on display in the examination accommodates for misalignment of up to 15 millimetres in any direction to guide the Lifecell into position

Further development of this system would be a substantial iterative development project and was not covered in this body of work.

Rain collection

The Lifewall system relies on the municipal water supply pressure to operate. Developing a way to integrate with a downpipe for rain collection would provide another benefit to the system.

Conclusion statement

The thirteen primary product benefits that Lifewall provides meet and exceed the initial desire to design a better emergency water storage.

This has been achieved through case studies, iterative and experimental design processes.

Lifewall can provide water daily by integrating into the plumbing of a building, scale to any size and produce clean water independently if the underground water network is destroyed.

The Lifewall system can be further expanded due to its modular product architecture, increasing the capacity for specific applications like businesses or schools.

In reflecting on my research questions, Lifewall addresses all of the research questions and develops as a design that provides benefits through a range of features and manual handling characteristics.

Lifewall presents a user focused EWS supporting resilience and wellbeing for communities, families and individuals.

Fig. 52. Hydraulic prototype testing in the rain.

Reference list

.id. (2016, July). Population forecasts | Wellington City | forecast.id. Retrieved August 9, 2017, from http://forecast.idnz.co.nz/wellington

Australasian Natural Hazards Management Conference, Stewart, C. A., Finnis, K., & GNS Science (N.Z.) (Eds.). (2011). 1st Australasian Natural Hazards Management Conference: from warnings to response and recovery: Brisbane 2-3 July 2007, workshops 1 and 5 July 2007. Lower Hutt, N.Z.: GNS Science.

Be Ready to Get Through a Quake. (2013, July 30). Retrieved August 9, 2017, from http://wellington.govt.nz/your-council/news/2013/07/be-ready-to-get-through-a-quake

Cameron, L., & Shah, M. (2015). Risk-Taking Behavior in the Wake of Natural Disasters. Journal of Human Resources, 50(2), 484–515.

Centers for Disease Control and Prevention. (2011, October 25). CDC Global Health - Cholera in Haiti: One Year Later. Retrieved May 16, 2016, from http://www.cdc.gov/haiticholera/haiti_cholera.htm

Centre for Research on the Epidemiology of Disasters. (2016, January 12). CRED CRUNCH. 2016 preliminary data: Human impact of natural disasters.

CentrePort confirms demolition of four Wellington wharf buildings. (2017). Retrieved April 10, 2017, from http://www.stuff.co.nz/dominion-post/news/90447975/centreport-confirms-demolition-of-four-wellington-wharf-buildings

Chang-Richards, A., Vargo, J., & Seville, E. (2013). Organisational resilience to natural disasters: New Zealand's experience. China Policy Review, 10, 117-119.

Council's emergency water plans. (2017). Retrieved August 9, 2017, from http://wellington.govt.nz/services/environment-and-waste/water/wellingtons-water-supply/emergency-water-plans

Davis, C. A. (2014). Water System Service Categories, Post-Earthquake Interaction, and Restoration Strategies. Retrieved August 2, 2016, from https://doi.org/http://dx.doi.org/10.1193/022912EQS058M

Emergency Survival Items. (2017). Retrieved March 7, 2017, from http://www.getthru.govt.nz/how-to-get-ready/emergency-survival-items/

The forgotten impact | Kaikoura earthquake: Wellington still paying the price. (2017). Retrieved May 4, 2017, from https://www2.deloitte.com/nz/en/pages/about-deloitte/articles/forgotten-impact.html

Franco, A. A., Fennessy, L., & Glover, J. (2017). The Role of Industrial Design in Effective Post-disaster Management. In Sustainability Through Innovation in Product Life Cycle Design (pp. 651–662). Springer, Singapore https://doi.org/10.1007/978-981-10-0471-1_44

Fraser, C. (2017, January 21). Wellington runs dry of water tanks. Newshub. Retrieved from http://www.newshub.co.nz/home/new-zealand/2017/01/wellington-runs-dry-of-water-tanks.html

Gaillard, J.-C., & Gomez, C. (2014). Researchers' gold rush in the aftermath of major disasters: too much of an opportunity or serious lack of understanding? ResearchGate. Retrieved from https://www.researchgate.net/publication/260980243_Researchers'_gold_rush_in_the_aftermath_of_major_disasters_too_much_of_an_opportunity_or_serious_lack_of_understanding

GeoNet - Quakes. (2017). Retrieved April 5, 2017, from http://www.geonet.org.nz/quakes/region/newzealand/2016p858000

Guidelines for Drinking-water Quality: Recommendations. (2016). Geneva: World Health Organization. Retrieved from https://books-google-co-nz.ezproxy.massey.ac.nz/books/about/Guidelines_for_Drinking_water_Quality_Re.html?id=SJ76COTm-nQC

Jang, L., Wang, J., Paton, D., & Tsai, N. (2016). Cross-cultural comparisons between the earthquake preparedness models of Taiwan and New Zealand.

National Civil Defence Emergency Management Plan Order 2015 (LI 2015/140) (as at 14 July 2017) – New Zealand Legislation. (2015). Retrieved May 11, 2017, from http://www.legislation.govt.nz/regulation/public/2015/0140/latest/

Noubactep, C. (2013). Affordable safe drinking water for victims of natural disasters. In ResearchGate. Retrieved from https://www.researchgate.net/publication/256092975_Affordable_safe_drinking_water_for_victims_of_natural_disasters

News - Protecting Our Water Supply - Wellington City Council. (2011). Retrieved October 1, 2016, from http://wellington.govt.nz/your-council/news/2011/07/protecting-our-water-supply

Pritchard, M. (2009). How to make filthy water drinkable. Retrieved from https://www.ted.com/talks/michael_pritchard_invents_a_water_filter

Rosen, J. (2016). Thinking the unthinkable. Science, 353(6296), 232–237. https://doi.org/10.1126/science.353.6296.232

Queensland Strategy for Disaster Resilience. (2017). Retrieved December 3, 2016, from http://qldreconstruction.org.au/QSDR

Shane, P. (2017). The Southern End of the Pacific Ring of Fire: Quaternary Volcanism in New Zealand. In Landscape and Quaternary Environmental Change in New Zealand (pp. 35–66). Atlantis Press, Paris. https://doi.org/10.2991/978-94-6239-237-3_2

Sendai Framework for Disaster Risk Reduction - UNISDR. (2017). Retrieved September 10, 2017, from http://www.unisdr.org/we/coordinate/sendai-framework

Reference list

Swinnen, L. (2017). Wellington close to running out of water after leak discovered in main supply pipe. Retrieved May 15, 2017, from http://www.stuff.co.nz/national/88652473/wellington-close-to-running-out-of-water-after-leak-discovered-in-main-supply-pipe

Thermal Conductivity of common Materials and Gases. (n.d.). Retrieved August 19, 2017, from http://www.engineeringtoolbox.com/thermal-conductivity-d_429.html

Ulrich, K. T., & Eppinger, S. D. (2016). Product design and development (Sixth edition). New York, NY: McGraw-Hill Education.

UNISDR. (2009). Retrieved August 22, 2017, from http://www.unisdr.org/

Water Kaikoura's most pressing need. (2016, November 15). Retrieved Janruary 16, 2017, from https://www.odt.co.nz/news/national/water-kaikouras-most-pressing-need

Wednesday, February 2017, 1, & Zeal, 10:40 am Press Release: Insurance Council of New. (2017). Kaikoura earthquake business claims reach $900 million | Scoop News. Retrieved August 8, 2017, from http://www.scoop.co.nz/stories/BU1702/S00017/kaikoura-earthquake-business-claims-reach-900-million.htm

Wellington City Council. (2017). Exploratory harbour bores - Wellington Water. Retrieved August 6, 2017, from https://wellingtonwater.co.nz/work-in-your-area/test-bores

Wellingtonians facing three-month wait to get emergency water tanks from council. (2017). Retrieved February 15, 2017, from http://www.stuff.co.nz/national/nz-earthquake/89338770/wellingtonians-facing-threemonth-wait-to-get-emergency-water-tanks-from-council

Wellington City Council, W. C. C. (2017). Wellington Resilience Strategy. Retrieved August 11, 2017, from http://wellington.govt.nz/about-wellington/wellington-resilience-strategy

Figures & Tables

Appendix: A – EWS products & Polar chart comparison.

Products

Michael Pritchard (Icon Lifesaver Ltd), United Kingdom.

1. Lifesaver water purification bottle – $259.85
2. LIFESAVER Cube - $259.85
3. LIFESAVER jerrycan 10000UF – $441.70
4. LIFESAVER C2 - $3500.00 + Extras and installation tools

Vestergaard Frandsen, Switzerland.

5. Lifestraw® Personal - $59.49
6. Lifestraw® STEEL - $130.00
7. Lifestraw® Go - $81.83
8. Lifestraw® Mission 5L - $297.75
9. Lifestraw® Home/Family 2.0 - $268.00

Dean Kamen, United States of America.

10. SlingShot vapour compression distiller
$TBA, Prototype build cost $100,000.00. (Schonfeld, 2006).

The Tank Guy, New Zealand.

11. WREMO 200L. - $105.00

Storage Box, New Zealand.

12. Non-branded 20L rotationally moulded containers - $14.00

Polar chart product comparison

Products previously listed are compared using a series of polar charts to identify product opportunities. Four charts were developed to compare and contrast against a continuum of criteria that included:

1. Usability vs. Performance cost
2. Usability vs. Water storage ability
3. Usability vs. Mobility
4. Long term storage vs. Water supply reliance.

Polar chart summary

- Some products function only within a functional water supply network. When the network fails, the product has no function at all leaving the user with no clean water supply.
- Some products can supply water on-demand, filtered and clean, in limited amounts. Bigger products tend to store larger quantities of non-potable water over extended periods.
- The larger the water storage product, the more likely it is to be immobile. These designs tend to rely on other components that are not part of the original system, i.e. a bucket to move the water around from the larger tank to the point of need.
- As the leading regional product, the 'WREMO 200L' has a capacity that aims at the reccomended emergency water storage volume for households.

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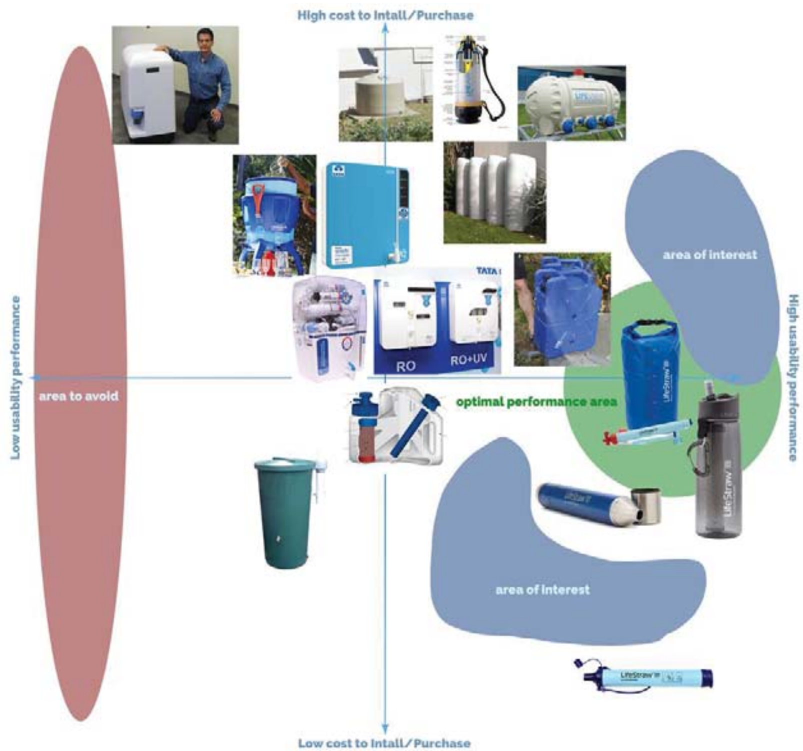
Polar chart 1. Usability vs. Performance cost.

Objective

Compare ease of use and affordability across selected water products.

Results

- Handheld bottle-type products at represented along the entire vertical axis from high cost to low.
- Most products offer a straightforward method of filtering water.
- Ease of use compromises water storage capability.
- The products consider more than just function. Some usability characteristics are addressed.



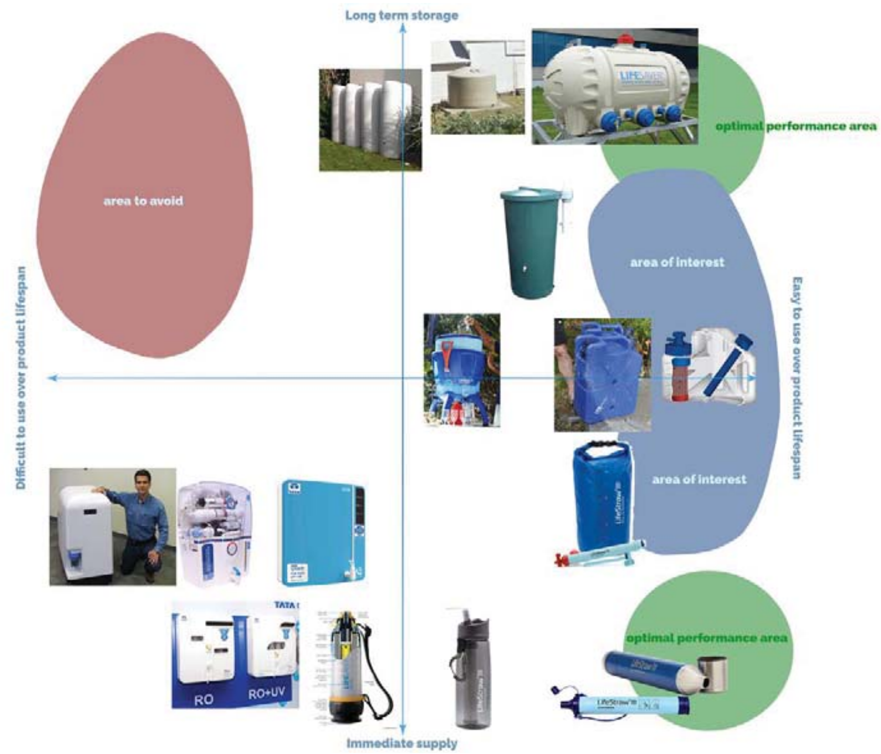
Polar chart 2. Usability vs. Water storage.

Objective

Access if ease of use affects how long these products store water.

Results

- The larger the volume of water that is stored the simpler the operation becomes. These products need smaller containers to distribute the greater volume to become mobile.
- Easily used designs can also filter water on the spot with no option to store potable water using the item.
- This chart shows that there might be two optimal areas to direct a new concept.



Polar chart 3. Usability vs. Mobility

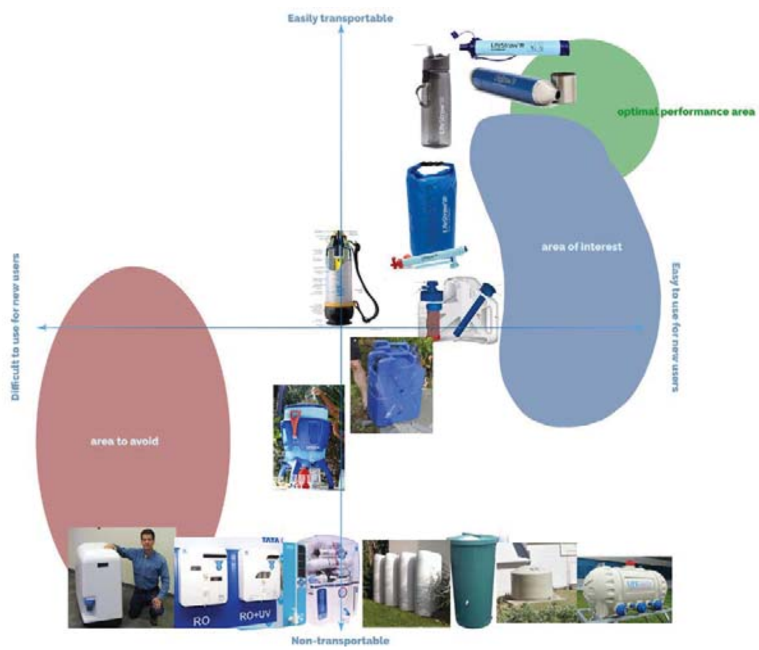
Objective

How transportable products are against the usability of the product.

Results

- The non-transportable fixed position EWS systems completely limit mobility.
- Mobility may assist in collecting water to bring back to a location in an emergency.
- The Lifestraw Personal is the best choice for a mobile simple to use solution.
- The products between these previous points are standalone designs not intended integrated into any other system.

Polar chart 4. Long term storage vs. Municipal water supply reliance.



Objective

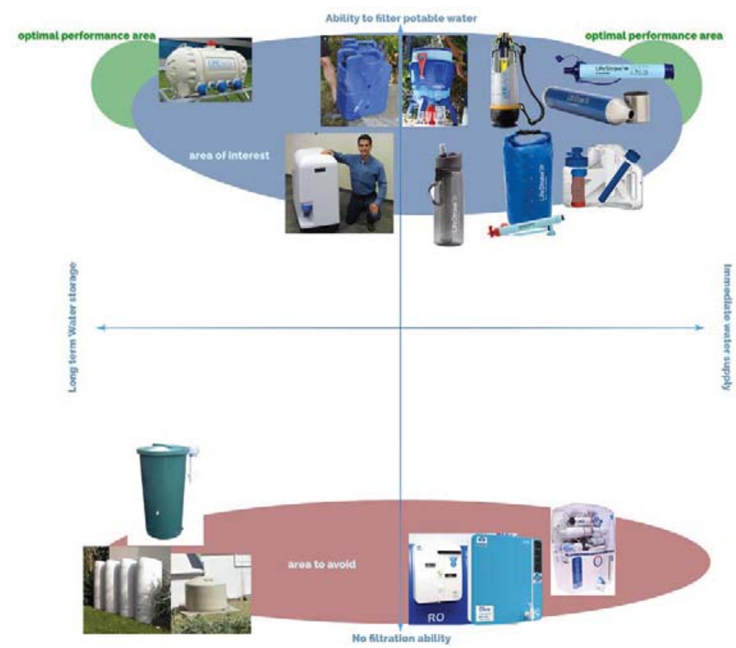
Compare water storage ability against the capacity of the product to filter water when disconnected from a water supply.

Results

- These commodities have a water supply boundary. There are limits on each of these products where the design handles a certain amount of water, beyond this point their functionality becomes limited.
- Depending completely on a municipal water connection can leave the owner without water if that supply is severed. A backup EWS would be a good option with any of these types of system.
- The Lifesaver C2 is the standout product for storing a large volume or water and being able to filter it. However, being fixed in place which will need other vessels to make the C2 useful.

A two-hundred-litre capacity storage system that could filter the water inside it and also be portable could potentially be a very desirable product for domestic, suburban and urban areas.

This process has found a product gap for a design that is not only portable but can be used easily to filter water and store it for a long time.



Appendix: B – Water filtration technology case studies.

This appendix covers contemporary water filtration and sterilization methods for potential use in the Lifewall system. Each have been analysed for their strengths, weaknesses and opportunities.

- Polymer micro-pore tubes (PMP). Seen in LifeStraw.
- Asymmetric Multi-Bore Hollow Fiber Membrane (AMBHF). Seen in LifeSaver C2 Community.
- Nanostructured Titanium Dioxide (TiO2) hollow fibre photocatalytic membrane.
- Vapour compression. Seen in the Slingshot system.
- Reverse osmosis. Seen in large output city water supplies.
- Ceramic cartridge filter. Seen in the LifeSaver water bottle and KATADYN products.
- Composite filters. Seen in under-the-sink water filter products.
- Water softeners. A larger home system for reducing scale build up in plumbing.
- Ultraviolet light (UV). A plug-in addition to numerous other systems.
- Nanoporous Graphene oxide membranes. Experimental.

1. Polymer micro-pore tubes (PMP). Seen in LifeStraw.

Thin flexible tubes, similar in appearance to a small clear electrical wire. Manufactured by a dry-jet wet spinning process with a single spinneret needle.

Technology strengths

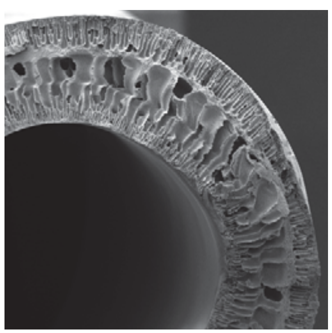
- These have a very low failure rate
- Flexible material quality
- Can be densely packed into products of all forms and sizes
- Easy to manufacture
- Recyclable

Technology weakness

- Sealed at one end and held in place with a resin cap. (Required design consideration).
- Fibre volume to filter capacity (L) is lower than some other systems.

Technology opportunity

- No limitation on product form, can be installed in any sized shape.



2. Asymmetric Multi-Bore Hollow Fiber Membrane (AMBHF). Seen in LifeSaver C2 Community.

AMBHF hollow fibres are a much denser rigid variation of PMP tubes. Manufactured by a dry-jet wet spinning process with specially designed seven-channel spinneret needle.

Technology strengths

- Up to eight bores allowing a higher filtration capacity.
- High flow rate
- More durable
- Rigid fibres (Required design consideration).
- Easy to manufacture
- Recyclable

Technology weakness

- Requires linear product form as the fibres can not be bent or curved. (Required design consideration).
- Sealed at one end and held in place with a resin cap. (Required design consideration).

Technology opportunity

- The volume of water filtered to number of fibres is very high

3. Nanostructured Titanium Dioxide (TiO2) hollow fibre photocatalytic membrane.

Another variation of a filtration fibre but with unusual physical properties. Not commonly used as the technology is in early development.

Technology strengths

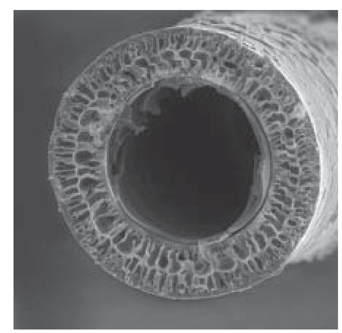
- With temperature applied, the fibres pore close smaller increasing performance.
- With temperature applied, the fibres become more rigid

Technology weakness

- Intended to be used with heat.
- Required expensive Titanium compound to produce.

Technology opportunity

- There is a potential for a hot water system to be developed with this technology.



4. Vapour compression. Seen in the Slingshot system.

The product boils water and then compresses the steam back into clean water

Technology strengths

- Cleans large quantities of water

Technology weakness

- Requires electricity
- Produces much heat
- Produces a concentrated waste stream
- Cumbersome product form factor.
- Heavy system
- Complex engineering
- Unclear where the clean water ends up after leaving the system.

Technology opportunity

- If a stationary water supply is needed this system may be beneficial.

5. Reverse osmosis. Seen in large output city water supplies.

An extensive system of filtration tubes

Requires extensive operation and land to set up. Produces toxic filter tube cartridge once they have expired. Reverse osmosis needs a significant energy to output ratio to generate pressure necessary to filter. Requires significant funding to run.

Technology strengths

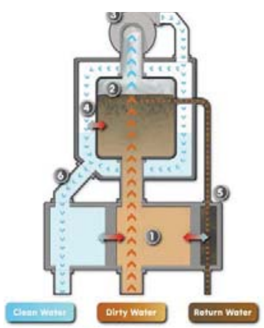
- Large scale filtration with the capacity to produce enough potable water for a major city.

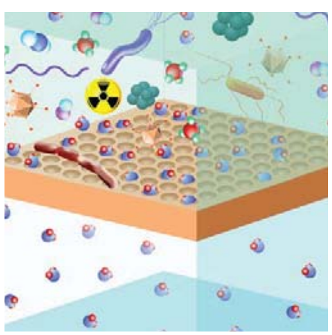
Technology weakness

- Requires electricity
- Large land requirement
- Produces large, concentrated waste filter tubes.
- Complex engineering.
- Requires considerable force to push water through filters

Technology opportunity

- Ideal for a city. In a residential system, the filter would need a pump to generate the force needed to push water through these filters.





6. Ceramic cartridge filter. Seen in the LifeSaver water bottle and KATADYN products.

A thick ceramic shell that traps contaminants but allows water to pass through.

Technology strengths

- Compact
- Simple operation
- Often used in military applications.
- Lightweight
- Durable
- Simple to manufacture
- **Technology weakness**
- Filter clogs quickly.
- Needs regular sanding to clear filter pores.

Technology opportunity

- A very compact filter that can withstand bumps and impacts easily. Often housed in metal handheld devices to further increase durability.

7. Composite filters. Seen in under-the-sink water filter products.

Consists of a cartridge that has multiple layers of filtration material. These are found containing a combination of carbon granules, calcium, polypropylene beads, sand and coconut fibre.

Technology strengths

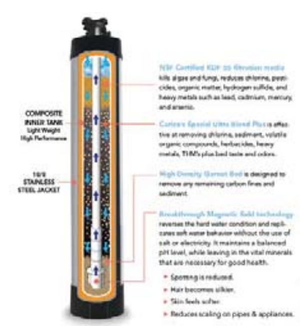
- Compact
- Simple operation
- Filter particles in the order of size.
- Lightweight
- Can be chained together in series to filter the supply even further.
- Simple to manufacture
- Simple to recycle.

Technology weakness

- This system recommends filters be changed yearly.
- These filters can not filter down to the micron level.
- Need to be installed vertically.

Technology opportunity

- This type of filter is possible to build at home using the right materials.



8. Water softeners. A larger home system for reducing scale build up in plumbing.

Filter tanks which have ion-exchange resin beads inside. The beads trap calcium and other heavy metal ions and release 'soft' water.

Technology strengths

Prolongs the lifespan of plumbing

Reduces limescale build up.

Simple operation

Simple to manufacture

Technology weakness

This system recommends filters be changed yearly.

These only filter heavy ions in the water

These filters can not filter down to the micron level.

Need to be installed vertically.

Technology opportunity

This type of filter is installed to improve the lifespan of plumbing.

9. Ultraviolet light (UV). A plug-in addition to numerous other systems.

Water flowing through a metal tube is bombarded with a high concentration of UV electromagnetic radiation. The bulb is in the centre of the tube.

Technology strengths

Compact

Simple operation

Kills organic matter at a cellular level.

Lightweight

Simple to manufacture

Technology weakness

Expensive light UV bulb.

Does not filter anything from the water.

Large wattage use.

Technology opportunity

This type add-on can be beneficial to an existing system.

10. Nanoporous Graphene oxide membranes. Experimental.

Similar to reverse osmosis, however, the final membrane layer has a graphene coating that has the potential for filtering seawater directly to potable water. This method is experimental and is not used outside of the laboratory.

Technology strengths

The smallest pore size of any filtration technology discovered.

Can filter chemicals and compounds.

Can filter sea water.

Simple operation.

Technology weakness

Experimental manufacture.

Technology opportunity

The literature on just how much it costs to produce is hard to find. The science behind this technology was too complex to read completely and discover its full potential use.

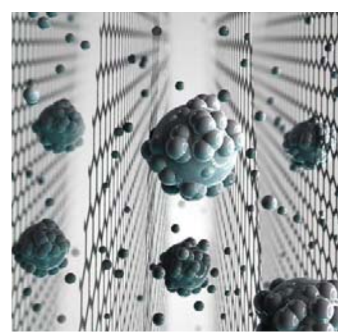
Builds upon existing technology and improves it significantly.

Summary of water filtration technologies.

The most appropriate filter technology for the Lifewall system identified is the Asymmetric Multi-Bore Hollow Fiber Membranes (AMBHF). These fibres offer the most benefits for the Lifewall design criteria and direction.

The performance of these fibres was calculated from published claims of filtration capacity. Working from images online, the volume of the filter membrane was calculated down to a single strand capacity and lifespan.

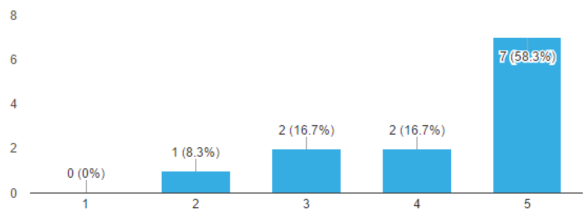
This figure was then multiplied by the volume of the Lifepods filter cartridge to give a value of approximately 2-4 years before expirey.



Appendix: C – User survey results.

Initial thoughts

How interested are you in any product that could manage an emergency water supply for you?
(12 responses)



After reading briefly what LIFEWALL can do, what is your initial reaction towards it. Both positive and negative.
(9 responses)

Solution has to be cost effective, despite our best efforts members of public cannot or will not spend huge amounts of money on emergency preparedness (if it is more than $100 NZ then many people just wont

Not clear if this is an individual (person or household) solution or community/council solution

How does this integrate with other preparedness work (200 l water tanks, community water tanks etc)

Could this solution also work in non emergency situations e.g. purifying drinking water for those on water tanks (such as farms or bachs)

Otherwise I am interested

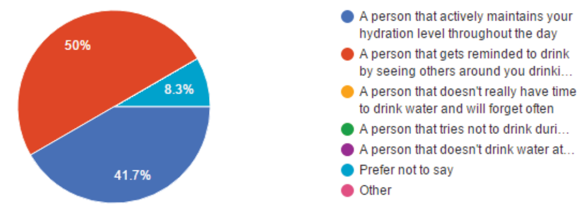
It is still not clear what on earth this product is

Positive towards emergency water, curious of how it would be intergrated into the home environment, for example if it's moving would it be like a waterfall and make me need to go to the bathroom a lot? Also as a female I would be interested on how the transportation works, I reasonably can not carry 12l of water for a distance, I would probably max out at 4 to 8l over a larger distance and in an emergency if I was the only person able to access the wall how would I transport it to my partner who would also be in need of water?

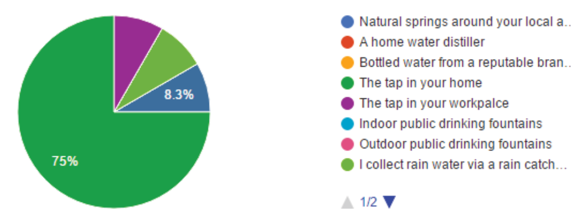
good ides

Just as crucial to the future homested as sewege pumps/storage is today..

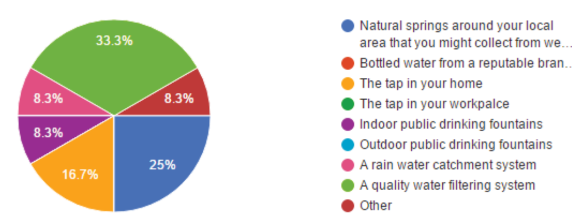
When it comes to drinking water, do you think you are... (12 responses)



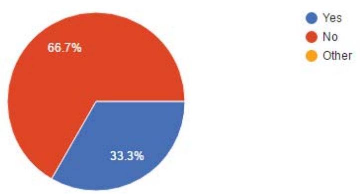
What is your regular water source? (12 responses)



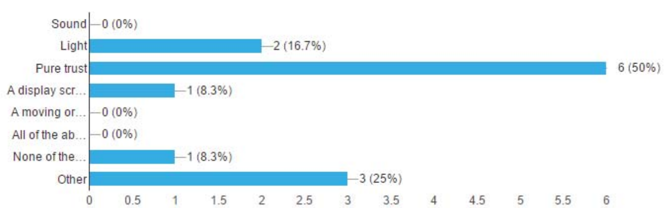
What would your preferred water source be if it was easier to manage or get to than your current one?
(12 responses)



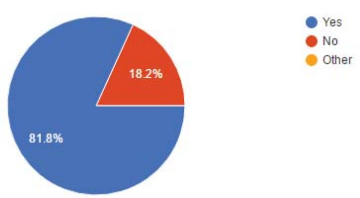
There are many types of water filters around us, under the sink, inside the drinking fountain etc., have you ever checked the expiry date of a filter?
(12 responses)



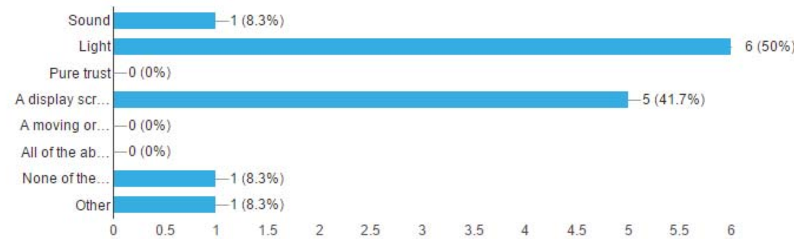
Imagine you are approaching a public drinking fountain, that you know has a filter, to fill up a glass or bottle etc.. How do you know the water is safe to drink?
(12 responses)



Would you like this drinking fountain to tell you how clean the water is?
(11 responses)



How best do you think the drinking fountain could tell you the water is clean and safe?
(12 responses)

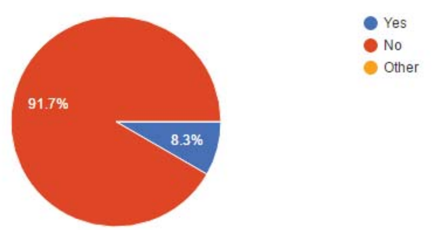


What material do you think is best to store water? Glass, plastic, metal or something else?
(10 responses)

Plastic
Plastic
We did have metal water bottles, but my husband hated not being able to squeeze it when driving - he likes a softer bottle
Glass as a material (infinitely recyclable), however metal and water seem industry standard also..
Glass, it tastes the best
glass
Glass or other inert materials.
Glass
Plastic or glass
Glass as it is easily recylable, but it is heavy. Some form of 100% genuinly recycled plastic would be best - esp one that you know can be recycled again

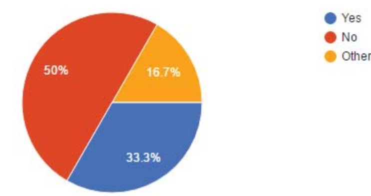
Water and your environment.

Do you know where your own city has placed any emergency water supplies?
(12 responses)

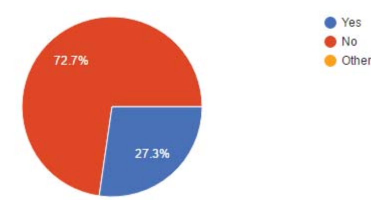


Location.

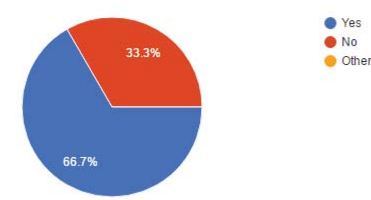
Do you have an emergency water supply at your place of work? (12 responses)



Do you know where your workplace emergency water supply is? (11 responses)



Do you have an emergency water supply at your residence or place where you regularly sleep?
(12 responses)



If you have an emergency water supply at your residence, describe what it is (bottles, twenty liter tanks etc.) and where the supply is stored.
(9 responses)

- 200 litre water tank (http://www.getprepared.org.nz/rainwater-tanks) filled with tap water. Stored in my garage, fastened to wall. Refilled annually
  2 x 10 litre water bottles filled with tap water. Stored in a spare cupboard inside house
- I did have plastic bottles but have been using them and forgot to replace
- twenty liter tanks
- bottle under sink
- 20 liter tank
- Rainwater tanks
- Garage rain water tanks
- Bottles
- 2x 20L bottles

No more water.

What would you do right now if all available water supplies were taken away or disabled? The supermarket ran out of bottled water, taps and drinking fountains are contaminated and you are now completely on your own to find water.
(12 responses)

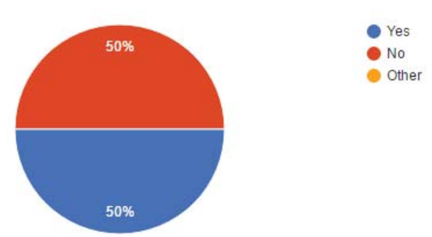
- At work rely on the water supply here
  At home use the 220 litres we have stored
  Connect water tank to downpipe to collect additional water supplies (noting that I will need to boil this water)
- Go to the river nearby
- Good question.. Find a fresh water source
- Go to my Aunty's she has a 200litre water cylinder, get supplies and hike out of Wellington or the damaged area and live somewhere else
- the stream in my garden and i have UV water cleaner
- drive to river
- Dig a hole.. use my lifestraw.. filtrate or distill urin temporarily.. steal
- Catch rainwater. Find a running stream and purify it.
- Would have to use the water from rainwater tanks
- Visit the stream that runs through my property
- Find my nearest wAter spring an fill up bottles be in town or in the country

A new water supply.

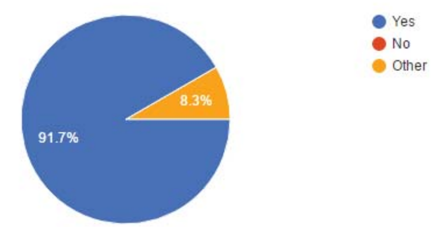
Once you have found a water supply, what do you think you would do with it?
(10 responses)

Use it for other needs (cleaning and toileting) until my stores ran out out then use it (boiled or with a little bit of bleach) for drinking
Bottle in spare plastic bottles
Bottle some for the hike out
bottle
Store as much as possible close to home
Purify it by tablets or boiling
Boil some for drinking
Boil it
Fill up bottles an go home an boil it
store. drink.

Are you confident that you could tell if your newly found water supply was safe to drink?
(12 responses)



Do you know how make water safe to drink? (12 responses)

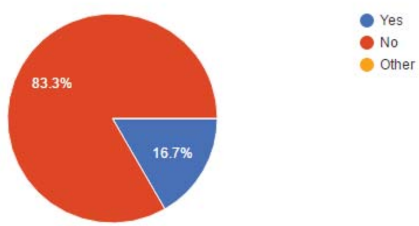


If you know how to produce safe drinking water, how would you go about this? Feel free to provide multiple ways.
(12 responses)

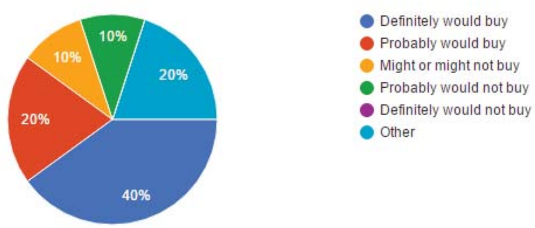
Boiled for 2 minutes Or follow Ministry of Health Guideline: Add five drops of plain (no additives), household bleach per litre of water (or half a teaspoon for 10 litres)
Filter, aerate and boil
Boil
Boiling water, collecting condensation on gladwrap
UV light, bole it and i have pill the you can put in it
boil or bleach
Boiling, then distillation, sterialisation.
Tablets or boiling or filter
Boil water and then cool for drinking
Boil it on gas bbq
Boil it

LIFEWALL - DESIGN

After providing your initial reaction earlier and arriving to this point in the survey, has your reaction to this product concept changed?
(12 responses)



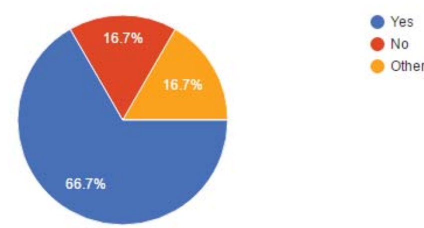
How has your reaction to this product changed? (10 responses)



What would you expect a minimal maintenance emergency water storage product like this to cost?
(11 responses)

150
As little as possible. $10 per person approx.
$1000
1000
300?
Anywhere from 1000-3000 USD
800
$200
$175
No idea
$200

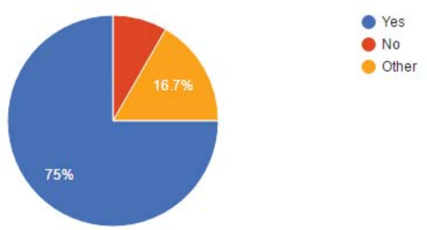
Aside from an emergency, would you see a benefit if LIFEWALL could provide clean water daily?
(12 responses)



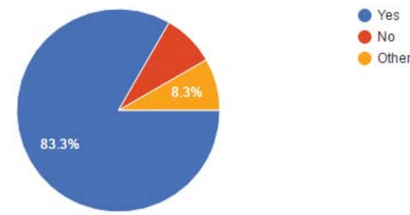
Where would you expect an emergency water supply product like this to be kept?
(11 responses)

Either
on the design board
Garage, wardrobe, under beds etc.
Depends, if I purchased it. In my home somewhere sercure as in a disaster I can imagine if you were prepared people expect you to share but that may not be an option if you only have 12litres for 20 days
laundry
Kitchen/Entrence area
Kitchen make it beutiful to be a feature
Near the household water cylinder
in Laundry cupboard
Somewhere at home
In homes, workplaces, schools, uni's, certain public locations

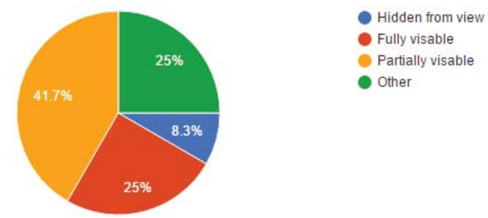
When you think about a container of water, do you think it is important to be able to see inside it to see the water inside?
(12 responses)



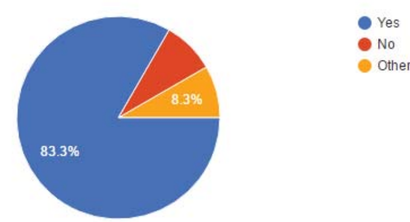
Do you think it would be beneficial for a water container to communicate the purity of the water inside it?
(12 responses)



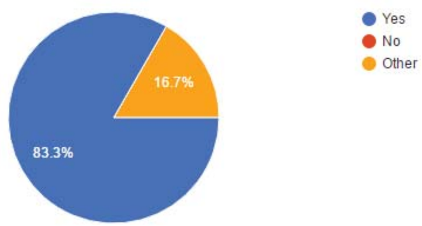
Do you think an emergency water supply should be.. (12 responses)



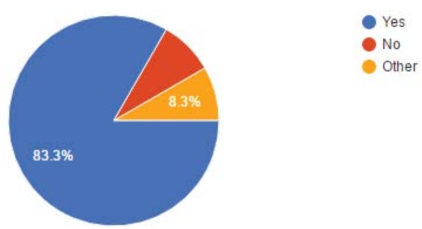
Do you believe an emergency water supply product should also be capable or producing more clean water once its own supply is empty?
(12 responses)



If there was a chance heavily contaminated water could enter the LIFEWALL system, do you think it should automatically isolate its-self? (through some form of water flow stop valve).
(12 responses)



Do you think it would also be a good idea for the LIFEWALL system to have a manual cut-off as a backup?
(12 responses)



Is there anything else you would like to add?

Further comments. (5 responses)

I don't think think this survey provides enough information to be able to make a decision on whether I would buy a Lifewall product

Still don't understand what Lifewall is. You have described what the aim is and a tiny bit about the design, but pretty much nothing else?! I am guessing here that it is a modular wall of storage containers full of water. But where is that explained? or are you hoping that people will design this for you?

Good luck, it could be a complex project given the restraints. I believe the best solution will be low cost, as hassle free as possible and un-obtrusive.

I think this is a great idea and it's the execution of the design and how it will interact with people that will dictate success.

2 sizes, one for homeowners .. smaller for mobile folks .. students n apartments

Further comments. (0 responses)

No responses yet for this question.

Appendix: D – Focus group summaries.

Focus group one

Objective:

Focus group one with Spatial design professionals.

I was curious to present the design as a product concept to people with an architectural background for an in-depth discussion.

This focus group duration was one hour and forty-five minutes.

Focus group one results summary

- A design that was segmented to allow for transporting would benefit everyone. Jen places an EWS container in her car most of the time in case she gets stuck somewhere.
- We could keep one of these segments under a desk in the event of aftershocks.
- The segment could be used to build a shelter or have another purpose such as replacing the 'sandbag' and protecting an owner's house against flooding.
- Integrated into a raised garden bed underneath the soil.
- The segments could connect to for a stretcher for injured people.
- Build a water storage system into a wall or fence.
- The discussion leads to questioning the form factor of the design. The concept presented is positioned on the ground and protruded from a wall surface 350mm at the time. This focus group was the first instance that the design would move towards a minimal depth form.

Focus group two

Objective

Deliver a state of play presentation for Lifewall to product design master's students.

Receive analytical and critical feedback from trained industrial designers.

The focus group was thirty minutes.

Focus group two results summary

- The discussion covered the form factor of the water storage system.
- Discussed valve technology with examples
- Basic hydraulics involved in getting the system to work.
- Conciderations for mounting the vessels into the system.
- Usability of the system
- The fact that users will randomly select a vessel to take out of the system at any time could be a system design issue.
- How water enters and exits the design.
- Material choice
- Concealing the system
- Wear and tear
- Basic ergonomics
- Hand grips and symmetry
- Focus group two summary
- After manually handling a few of the RotopaX water containers.

Focus group two pressured the thinking behind the concept operation. Glenn Catchpoles point of making the system empty all partially full vessels to a chosen one to fill it was a performance concept that would ideal for investigating for version two of the concept but would require substantial hydraulic engineering far outside the scope of this project.

Focus group three

Objective

Present the Lifewall design concept to a group of non-designers to receive perspectives and insights from a consumer angle.

The focus group was fifty minutes.

Focus group three results summary

- The discussion responded to explanation of how the system works.
- There were a few questions about the detail of the system and how it works after the explanation.
- The first response was one of amazement that there is technology like this available. (specifically talking about the filtration fibres.)
- Questions arose in regards to how to use the system in an emergency which I role-played the various functions and actions for them to see.
- How long would it take to go from the idea to production?
- Investment opportunities.
- How would people find out about the design if they wanted to buy one?
- Focus group three summary
- The team was excited to see that so many technologies and ideas could come together and be concealed inside one minimal design like Lifewall. The exact way that Lifewall filters and stores water seemed highly usable to them.
- We discussed what the next steps might be for the design, who would pay for it, how would it be made.
- One of the most interesting notes that came from the presentation was that they could not quite understand why a product like Lifewall does not exist right now since it is so simple. They suggested that a legal document to cover the design would be a good idea.

Appendix: E – Role-play & experience investigation

Role-play within a disaster scenario aided design discovery leading to the identification of latent product needs.

The primary scenario that was used to role-play occurred immediately after the Magnitude 7.8 Culverden earthquake, Mon Nov 14, 2016, 12:02 AM. It was later confirmed that this quake was the third biggest earthquake ever recorded in New Zealand history.

Primary role-play scenario – All municipal water cut-off for three days.

RP Objective 1.0

To discover firsthand the difficulties in not having freely accessible water from a residential tap and the effects on daily life are.

Introduction

Due to the subject matter of my research, the morning of the earthquake I instinctually filled the bathtub with as much water as possible and purchased six Lifestraw's from a local retailer the next day. Due to the severity of the quake, there was a chance that the local water supply would get cut off, become damaged or destroyed via aftershocks. At the time of the earthquake, it became clear that this product would also have a comforting effect on the user who owned it. The family I live with thanked me for getting hold of multiple Lifestraw's just in case thing go bad because none of them had an action plan, including myself.

The first time we filled the bathtub the plug failed to seal correctly, and we lost the entire EWS. One we refilled it there was a noticeable amount of sand like grit coming out of the tap and into the tub.

For the next five days, this was my only drinking water supply. I dank the sandy water through a Lifestraw and quickly realised my daily routine revolve a round this volume of water that sat in a bathtub.

RP results 1.0

The entire daily routine became dedicated to cycles of going to the bathtub throughout the day.

It was easy to take small volumes in a bottle with me but due to the way LifeStraw functions, the container could not fill to the top. If the container were full, the LifeStraw would overflow it while trying to expel air inside its filter.

At the time of the scenario, I was studying full-time with no work commitments which meant that over the three days it was not an issue to stay home and carry on with my time there.

The secondary issue as part of the role-play scenario was that of food. One of the scenario rules was that I was only allowed to eat what was in the cupboard, nothing more. I became fearful of this fact when I saw the supply getting lower. A longer duration extending into months would certainly mean a complete change of routine.

Secondary role-play scenario – Walking 5Km to find water.\

RP Objective 2.0

Test and evaluate the criteria for a primary hand grip to be used for the Lifewall Lifecell.

RP 2.0 Results

The RotoPax provided an opportunity to experience the difficulties in handling 20L(20Kg) of water over a long-distance. This scenario showed my research how important the hand grips are to offer various positions of grip as we do not regularly need to carry heavy items over such distance. The effects of this exercise on my shoulder and arm muscles lasted the following four days.

Culverden (Kaikoura) earthquake psychological effects diary.

After having organised the necessities of water I noticed a change in my behaviour over the next few weeks.

The news and radio broadcasts warned of aftershocks, and I believed them.

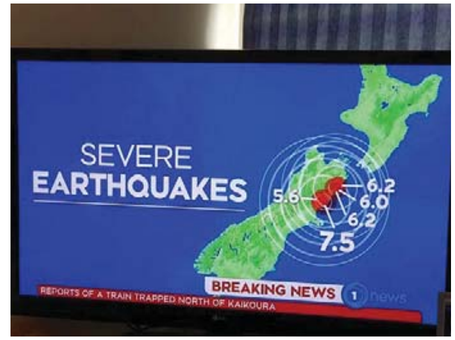
Unexpecedly while researching in a space on the third floor of a timber frame building was that any and all movements and sound would casue an instinctual fear reaction.

Every time the wind blew was followed by release of adrenaline and my body tensing up in preparation for the next big shake because of how scary the first event was.

Wind noise, the wind blowing the house enough to make creaking noises, rain. I was completely on edge for about two weeks in my little office.

The thought that I had secured a clean water supply for a few days reassured me that if there was a significant aftershock, the seven people in my home would be ok for a few days. Beyond this, we had no plans.

Damage to my home after the Culverden earthquake



One news bullitin the morning after the 7.8 earhtquake.

Wall damage to my home studio

Appendix: F – Topographic mapping.

Research method - Mapping of three local residential land areas

Objective

Discover potential placement of the Lifewall system within confined spaces.

The aim of this task was to get an understanding of the distances to boundaries and

Three suburbs analysed with Google Earth mapping and its distance calculator as well as the Wellington City Council interactive property maps. The three areas were chosen based on economic quotable value rating. Very high (Oriental Bay, near the summit facing west. Cresent Street), Moderate (Woburn, Lower Hutt. Nikau Grove) and Low (Wallaceville, Upper Hutt. Rimu Street).

Summary of findings

The current form of the design points to the possibility that there will be issues within some properties. Houses positioned close to fences and boundaries will not cater for the first version of Lifewall form of Lifewall installed as it would block narrow pathways. It could also pose a risk to those in the area walking into it.

This result was the first indication that the system form would need redesigning to a low-profile format which was eventually the final design direction.

Michael S. Jones - M.Des Exegesis 2017.

Appendix: G – Lifewall full-scale hydraulic prototype.

For this experiment a 1:1 scale prototype was built using readily available components from building hardware suppliers and home kitchenware product retailers.

Sistema, 7-litre containers, were used as the water 'cell' and connected with garden irrigation components.

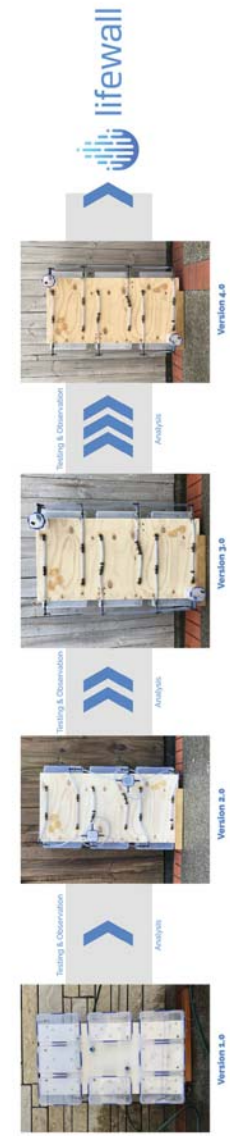
The arrangement consisted of, three containers tall and wide.

The irrigation components were fixed in place with an Epoxy resin to simulate a quick disconnect coupling.

The middle 'cell' was constructed to be functional by using self-sealing garden hose connectors and fittings to test the hydraulic properties of installing and removing the cell while the system was running. The cell can be freely removed and connected back into the system.

The remaining eight cells were permanently fixed into place to minimise the possibility of leaks in this working prototype,

All pipes and cells were chosen in a clear material to observe the water flow unrestricted.



Prototype test 1.0

Prove the design performs as expected with the chosen system architecture.

Test 1.1

Began test with 15% of total mains pressure released into the system and gradually released more pressure in similar steps until a fully open valve was running water into the system under local pressure.

Results 1.1

After three minutes into the test, a technical flaw in the design has been discovered. The water entering the intake manifold was shooting across the manifold chamber and directly into one of the three outlets.

The effect caused two of the three outlets to receive no water at all. Only two of the cells filled at this point.

An object was required to be placed into the manifold to disrupt the beam of water entering the manifold. A small tin can fit perfectly inside the manifold to distribute the water evenly.

Test 1.2

Re-ran test 1.1 with the small can inside the manifold.

Results 1.2

All the cells begin to fill, at an even rate, now that water is evenly pressurising inside the manifold.

The can moves freely around the inside of the manifold, sometimes blocking an outlet and disrupting the system flow.

The cells only filled to 20% each as too much water is escaping through the seals to 'charge' the system.

The lower row of cells is appeared to fill first, and this is where the highest pressure from the system is seen.

The Sistema container lids on this row were bulging outward under the weight of the water.

In phase: two an adhesive sealant will be applied to all the lids to gain 100% seal on every cell.

Test 1.3

In this test, I simply reversed the manifold connections to see any unforeseen changes to the hydraulic system and to justify that the initial cell layout was the most optimal product architecture setup.

Results 1.3

Like we saw in 1.1 and 1.2, the strength of the seals was unable to keep its shape with about six litres of water in the cells. Test 2.0 will hopefully resolve these core issues.

Test 1.4

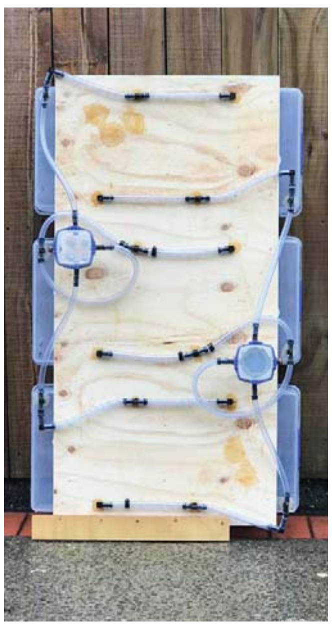
This test is to remove the variable of gravity affecting the system after the observation in the earlier three tests.

The prototype is laid down horizontal to see if gravity is affecting the filling of the cells.

Results 1.4

The rate of water leaking from the prototype was too high to get a much observation during the test.

At one point, I tried to apply pressure to the prototype by standing on top of the prototype and put pressure onto the seals of every lid using my body weight; this did not affect the seal.



Test 1.5

Reversed the manifolds to see if this made a difference to the prototype while laying down.

Results 1.5

Same result as in 1.3, however, the can moved in such a way as to block one of the outlet lines leading to the adjustment in test 2.0 of glueing the can down in a fixed position.

Conclusion notes for 1.0

Interestingly the two manifolds seem to work together by creating some form of equilibrium to fill every cell evenly before water leaves the system.

Prototype test 2.0

Changes since 1.0

- Modified intake manifold. The epoxy resin was used to fix small can centrally inside the manifold equal distances from every inlet and outlet connection. The can stopped freely moving and blocking any of the outlets which is observed happening in 1:2
- All Sistema container lids are fixed into place with an adhesive sealant which proved quite difficult due to the polypropylene's natural resistance to adhesives.
- Applied a second coat of epoxy resin to all hardware connections to reinforce them against the water volume weight when the system is fully charged.

Test 2.1

Repeated steps as in test 1.1.

Results 2.1

Three minutes into the trial the fill rate of the containers is not even.

The hydraulic movement of the water in the system indicates the intake needs to reposition to the top of the products architectural layout. Positioning it at the bottom means that the supply pressure has to push all of the water uphill to fill all nine cells. Tthe system has to push 42Kg upwards first before filling the top row.

Gravity is naturally pulling everything down to the lowest point first, so it is best to rethink the architecture to work with gravity than against it.

Test 3.1 will observe this effect after modification.,

The prototype suffered repairable damage after it fell over during the trial due to the support structure built at the very back of the cells.

In the real design, the cells will be supported from the bottom edge to remove this issue completely. It is only due to the prototypes construction that it fell over. It should have been leaning on the fence at more of an angle.

It continued to fill well although the damage that occurred stopped the prototype reaching 100% volume as too much was leaking through cracks in the cells.

Test 2.2

In this test, the prototype is laid on its side to see if gravity is affecting the filling of the cells because of the overall height. The tap connection was running at 100% from the start of the test without a gradual build up.

Results 2.2

The cells did fill slightly easier which is due to being shorter in the vertical dimension.

The water is not having to be pumped up as high, so it moves upwards more freely. The next stage will see how this prototype works with the new manifold layout.

Test 2.3

The testing steps are the same as in 2.2.

In this observation, the prototype is rotated so that the entire back is visible exposing the clear pipes.

Results 2.3

Test 2.3 makes it clear that the pipe system and manifold locations are not in an optimal layout.

The curved tubes and loops prevent flow and increase resistance in the system making the upper cells fill poorly, and it must loop over or under to get to the cell.

Conclusion notes for 2.0

The water lines for the intake and outlet connectors need to be in line and horizontal with the connection as it keeps the water flow stable without having to move up and down against gravity.

Prototype test 3.0

Changes since phase 2.0

- Removed 1.0 and 2.0 manifolds and replaced with a new vortex creating design that spins the water inside before it exits the manifold..
- Modified both manifold positions to optimise flow pattern observations and water distribution.
- Fixed small can in place with an adhesive sealant in the centre of the chamber as in test 2.0.
- All Sistema container lids are fixed into place with a second adhesive sealant layer.
- Repaired damaged cells and connections with epoxy resin.
- Rotated and moved cell connections to match new product architecture.
- All cell intake 'T' connectors have been rotated to create a completely horizontal filler tube at each cell level.
- Intake and exit manifold is connected to each row Individually.
- Each row of cells still has its own intake tube; these now all run to the new manifold locations.
- New manifolds have no internal mixture device (tin can). A vortex has been created by simply rearranging the valve positions after observing how the water flows into them during 2.4.

Test 3.1

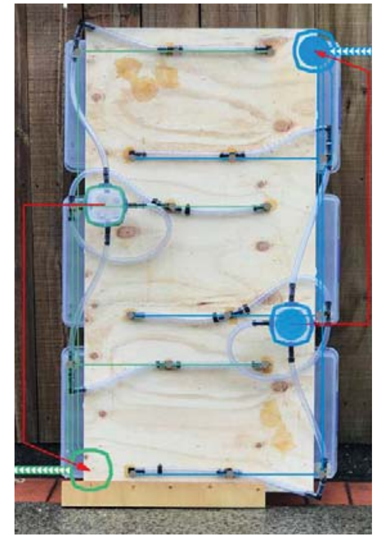
Released the tap connection to 15% letting mains pressure water into the system and gradually opened the tap connection until it was 100% open. With the full mains pressure running into the prototype I simply observed what happened over fifteen minutes.

Results 3.1

Three minutes into the test the flow and fill rate of the containers is now even over all nine cells.

The current product architecture has achieved a consistent fill of all cells after refinement of the observations.

The repaired damage successfully held together and was mostly water tight during the entire test.



Test 3.2

To confirm what is believed to be happening, the prototype was rotated so that we could see the entire back to a slow-motion video capture and introduced blue food colouring with a needle and syringe. The colouring was injected into the hose of the intake manifold so that it would flow through the entire system.

Results 3.2

Immediately the dye is evenly dispersed throughout the system, and no obstructions are seen.

This is an exciting result as the lower level water has to move the most distance than the top rows which is the opposite to what is observed in test 1.0.

Conclusion notes for 3.0

Currently, the prototype is functioning well. However, there is still room to minimise the componentry. Currently, from each manifold, individual water lines are supplying and removing water from each row.

It is worth testing to see if these three water lines per manifold can be reduced down to one for the entire system. This will be the last and final implementation of the system architecture. From here all the concept variables have led to this point, and an optimal outcome chosen

Prototype test 4.0

Changes since phase 3.0

- Simplification of prototype
- Removed all six intake and exit lines and condensed down to one single line.
- All other layout architecture aspects remain the same.

Test 4.1

Began test with 100% mains water pressure released into the system. Observations recorded and evaluated performance for fifteen minutes.

Results 4.1

Thirty seconds into the test it was evident that this configuration was performing significantly less than in 3.0. Observing the flow of water into the system showed that water would put most of the system pressure into the bottom row of vessels. The speed at which the water was flowing through the single intake line means that it bypassed all previous cells, flowing directly to the furthest and lowest point first.

The two upper rows did not fill at all until the bottom row was 100% full.

The configuration in test 3.0 is the most optimal for this product architecture.

Appendix: H – Aeration testing.

Objective one

Prove with a single cell that turbulence through the continual flow design could potentially limit bacteria growth.

Test with single cell.

An important process to implement in the system is to aerate the water before it flows into the home. This motion helps break down volatile substances such as sulphides, trace methane and carbon dioxide that can cause bad tastes in the water. (World Health Organization, 2016).

The central hydraulic prototype removable cell was hooked directly into a hose line.

A flow test conducted with a slow-motion camera to see the mixture effect of having the intake and exit valves found in opposite corners.

The position of the valves provides the most distance for the water to travel. The aim was that the water would 'spin' inside the container before exiting ensuring that there were no idle or still water volumes inside the cell.

Results:

The water 'spins' inside much more than expected before it leaves the cell. This higher spinning rate produced by being directly connected to a hose instead of the system.

Even at 20% of this observed rate the water would mix well.

This test confirmed that there will be no 'still' water in each cell so that when fully active the water will not be sitting motionless.

The test was repeated several times with the food colouring. In all tests, the colour is mixed in violently which could in turn minimally, aerate the water inside Lifewall and provide that benefit.

Objective two

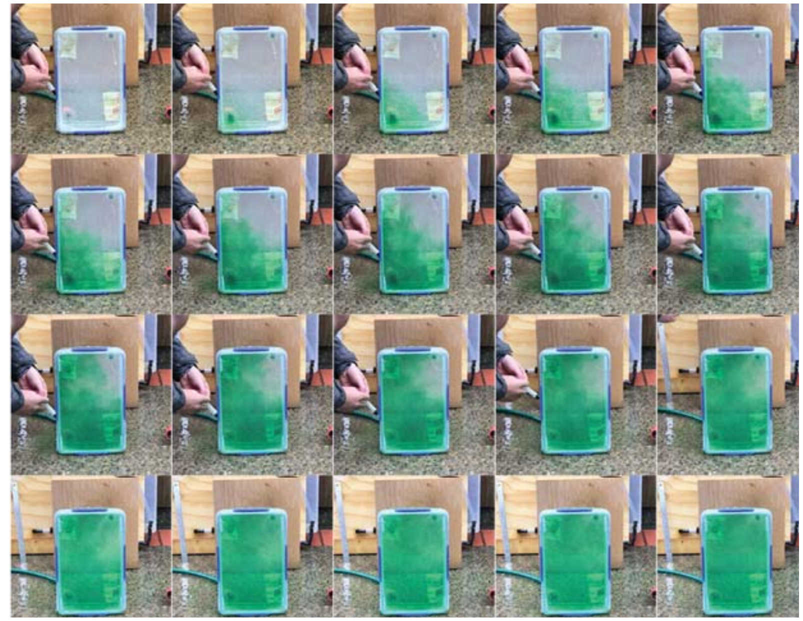
Prove with hydraulic prototype test 3.0 configuration turbulence through the continual flow design could potentially limit bacteria growth in the entire system.

Test with hydraulic prototype test 3.0 configuration and inject dye into the intake manifold and observe what happens.

Results:

The system performed better than expected. From previous tests it was assumed that the lower rows of water cells would receive more dye than the others. Because the manifold churns the water, an even feed is supplied to all inlet water lines.

Because of this effect, every cell filles evenly obtaining the desired performance.



Appendix: I – Special topic research paper.

Objective

Develop in parallel a water product from an early concept idea that arose from early concept screening.

Offer the concept to a team of 400 level industrial design students to develop a design in response. This concept would thenbe entered into various design awards.

Octave

Near the end of 2016, a team of staff hosted a special topic paper focusing on product design relating to natural disaster events, (198.490 ID Special Topic: 28th & 29th Nov 2016). Students were offered a range of scenarios to develop an idea towards a highly plausible outcome which would then enter into the international Red Dot Awards. A concept idea that arose out of this research was that of some form of a desktop water purifier that could be used daily with a drink bottle. This concept was written up and offered to a team of three 400 level students to concept, design and develop the idea. The resultant design named 'Octave' is a wall mounted daily use system that incorporates multiple drink bottles, filters, chills and heats water on the fly.

Outcome

The validity of the concept was reinforced when it was awarded a prestigious Red Dot Award: Design Concept in 2017 for Domestic Aid after entry in the Red Dot Design Award competition.

Appendix: J – Task analysis.

Task analysis

Evaluating the Lifecell component first occurred during the role play exercise and was later extensively tested using multiple looks-like, weighs-like prototype models. This lead to insights and discoveries both positive and negative that were refined to ameliorate further the issues that Lifewall aims to solve.

Appendix: K – Lifewall brand design.

Using the key steps developed by Emmy Award winning graphic designer Chris Do, Lifewall's brand was created and brought to reality using the thirteen step CORE framework.

This framework was then used to develop a definition of the Lifewall brand.

The design brand criteria creation was a necessary step to forming a picture of how the product might be perceived, colour way choice and typography for all visual material going forward.

This also help my own understanding of the semantic qualities to aim for within the various forms of the components.

This step adds a level of professionalism to the product and giving it a quality feel above anything available.

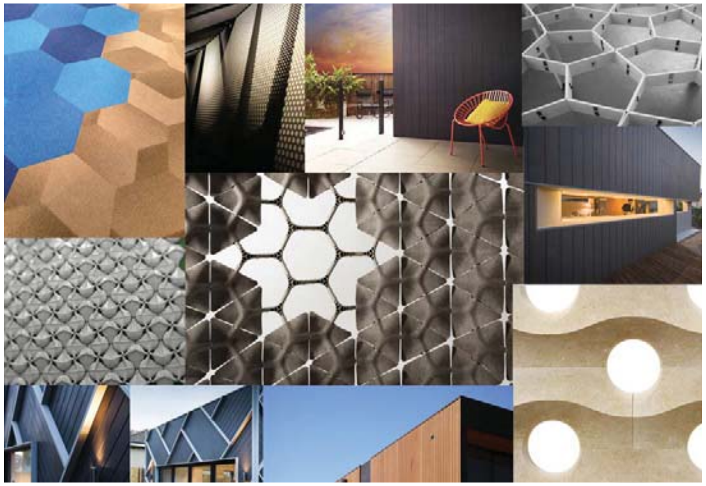
Brand keywords

1.Culture	2.Customer	3.Voice	4.Benefit	5.Value
Caring	Friendly Proactive Contemporary	Professional	Concealed Secure Protection	User - friendly Ground-breaking

Moodboard one: Emergency and safety.

Moodboard two: Water filtration.

Moodboard three: Modularity.



Moodboard four: Water.

Final Lifewall logo.

Colourways.

Appendix: L – Case studies of EWS products.

Locally available products have been investigated further in person. The designs range from large scale to small personal products to cover a range of users. These products will be detailed using the SWOT model by Albert Humphrey. As this is a conceptual product the last point of the SWOT analysis, 'T' won't be used as these products do not pose any threat to my own business. A summary of findings will follow this section.

The Tank Guy – 200l Rainbutt – WCC endorsed emergency water supply. - $105.00-$199.00

The Tank Guy' (TTG) based in Palmerston North. TTG's "tanks represent the very best in water storage technology and are endorsed by WREMO" ("The Tank Guy | Emergency Water Tanks | New Zealand," 2017).

As of June 2017, it has been rebranded again from the "200L rain butt" to the "Wremo 200L" using the same acronym as the company that promotes it.

An effective ad-hoc solution and produced in quantity to provide maximum availability. The rotationally moulded parts are an already existing product that has been remarketed and rebranded as the most affordable way to cheaply store rainwater from the roof of a building for an emergency.

Installation requires the owner/installer to have basic hand tools and DIT skills. The installation components are commonly available from hardware and plumbing suppliers of off-the-shelf parts sourced from other areas of plumbing.

This ad-hoc solution was chosen as a primary case study for this research as it was easily affordable. Being sold locally in the location the research conducted in this master's project was based allowed a contrast and compare for various opinions from those who had encountered the design.

The 200L rain butt does not address usability as evidenced in the company's own how-to-install YouTube video titled "EmergencyRainTank". The owner of the company himself has trouble finding the correct position to lock the lid of the tank in place as well as installing all of the various parts. (The Tank guy, 2013).

The unit purchased for a hands-on analysis came with a lid that did not fit correctly at all even with some aggressive persuasion. The design of the form itself is utilitarian and has no consideration of the environment it might occupy. The components also did not match the ones shown in the video which would likely cause some confusion to users who are not industrial design students.

Product strengths.

- Small enough to fit in a small hatchback allowing easy pickup of a new unit.
- The vessel holds 200L total.
- The durable wall thickness of the main tank.
- Manufactured using simple rotational moulding technique.
- Supported by the WCC and 50% subsidised.
- Suitable for garden watering and as an emergency water supply.
- The plastic used is both food contact and potable water safe.

Product disadvantages.

- Too many unassembled components a user must assemble.
- Not as easy to install for most people as promised by advertisements.
- Although the vessel is safe to store water in, the water draining into it is not potable because it drains off an openly exposed building roof. Any particles that land on the roof of the house will be washed into the gutter and down into the tank.
- All water from this product requires boiling before drinking because of the unknown state of the water held inside coming from an open roof supply.
- The user needs moderate hand tool skills.
- Without a hacksaw, Crescent, Craft knife and drill, the full installation is impossible.
- One chance to cut the properties downpipe correctly. If unsuccessful, the entire downpipe will require replacement or the tank may not function properly.
- To reach a 200-liter capacity, the unit needs installation on a rostrum for the lowest outlet to function. By using the tap outlet midway up the products sidewall, the effective capacity reduces by 40 litres.
- Some units are reported to release obnoxious odours before first use.
- The tapered shape of the form creates a high centre of gravity which is why the tank is supplied with two wall hooks and a strap to secure it to the wall.
- It has minimal aesthetic consideration. The original came in a dark military type green and had recently had a new mid tone grey colour way added to blend in more architecturally.
- Is not designed to blend into the environment it occupies.

Product opportunities

- After discussing the product with multiple product designers who have installed this system, some of the key points raised were:
- The lid should have a seal of some kind.
- The lid should fit correctly and have its mould tolerances adjusted.
- The supplied strap is inadequate to hold onto 200Kg of mass in place.

Vestergaard Lifestraw® Personal - $59.49

Product advantages

- No need for local water storage.
- Can filter 1000L before it expires.
- Ultra-lightweight at only 57 grams.
- Water intake is not near the mouthpiece.
- The filter technology is capable or removing 99.9999% of all waterborne bacteria and 99.9% of protozoa.
- Suitable for anyone able bodied.

Product disadvantages

- Does not filter Virus however other models such as the Family and Mission models do.
- Cannot filter sea water or chemicals. (Chemicals such Chlorine, found in a swimming pool for example).
- Is slow to begin operation.
- Requires decent suction force over time from the user's mouth which strains the user's muscles around the mouth.
- After use, the user must blow all the water out of the straw which can take some time.
- Blowing water from the straw would be difficult for people with lungs that have medical issues.
- Post-natural disaster event, users need to find a water source to use the straw.
- The necklace loop does get in the way of use. However, the mounting clips allow for easy removal and replacement.
- When cleaning after use, it is impossible to see that the straw is empty before placing the cap back on.
- The tested unit had its cap mount snap in two, so care was needed not to lose it during use.

Product opportunities

- Greatest performance in the smallest product available.
- Completely recyclable.
- Product colour choice suggests a healthy water source but using two bright blue pastel tones.

RotopaX 2 Gallon Water Pack. $100.00 + $50.00 for a single pack mount.

The RotopaX brand of adventure motoring liquid storage products. These offer a simple rotationally moulded container that provides more benefits to an end user to create a highly versatile product.

Product advantages

- Very durable with an approximately 5-7mm wall thickness.
- The Kiss-off design is a functional mechanical locking hole.
- Strong locking clamp.
- Multiple options to tie down the vessel with ropes or straps.
- The flat form factor allows stacking.
- Low profile height from the mounting surface.
- Two hand grips and one pinch grip.
- Two containers can join with a twist lock moulding on the bottom of the container. A pair can mount on a tailgate of a vehicle.
- The cap is a standard fuel cap/spout design that can be reversed to store the long spout inside the bottle.
- Can be frozen and has a maximum fill line for freezing moulded into the bottle.

Product disadvantages

- A single unit is rotationally moulded with three layers meaning it is in a mould for a long time before a single unit is complete.
- Because of the large wall thickness, the container alone weighs 1.5Kg empty.
- The advertised product online does not match what is delivered. (Missing a secondary cap/air valve as shown on product website).
- Minimal ergonomic usability considerations. Its asymmetrical handle layout creates and awkward handling situation.
- Can only mount on a flat surface.
- Pack mount screw holes are square and not countersunk so any protruding screws would dig into the plastic body of a RotoPax potentially causing a weak spot or hole.

Product opportunities

- A clever design choice to make the kiss-off functional.
- Highly durable design, suggests this visually through the form.
- Multifunction cap
- A useful selection of hand grips.
- Minimal profile height means it does not interfere with the surrounding area around a vehicle.
- RotopaX uses one mould design for multiple packs. Fuel, water and emergency supplies.

Rotationally moulded 20L water containers - $10.00-$20.00

A simple rotationally moulded water storage container available from multiple plastic item retailers and the most basic choice for storing a generous size of water for an emergency use situation.

Product advantages

- Stackable.
- A Large volume of water per container.
- Durable.
- Tool-free usability.
- The plastic used in its construction is food safe.
- Low cost

Product disadvantages

- They do not interlock; stacking more than two units high is unstable
- Once filled, the total weight is over 20Kg making this size of vessel difficult to transport if the user does not have some physical strength
- No filter
- Transparent container allows light in which promotes bacteria growth hence the need to change the water at regular intervals
- One handle located centrally creating a lack of grip options.
- The square shape is an awkward form to carry while walking as it forces a user to hold the mass away from a person's centre of gravity.
- Unregulated Polypropylene plastics used in construction.

Product opportunities

- Visually able to see the water volume inside through the translucent material (Polypropylene).
- Affordable option means anyone can uptake an EWS.

Appendix: M – Case studies of Hydraulic valves.

California (Koso) seismic shut-off valves.

These valves operate very simply to automatically shut off the gas supply in the event the valve is bumped, rotated or shaken by a natural disaster event.

A large metal bearing sits on a podium and remains stationary during ground movement. The bearing then trips the mechanically activated trigger, closing the valve until a user resets it. The valves are used in natural gas pipelines however the way in which the valve operates can be adapted and utilised to stop the flow of water.

They are rated to handle sixty pounds per square inch (PSI) which is more than sufficient for suburban/urban water connection.

Product advantages

- Automatic operation.
- User resettable.
- Fail proof, mechanical design.
- Plumb-line integrated into the design to aid installation.
- Individually numbered and tested before sold.
- Easily adapted to be used with water.
- The trigger will not activate by people bumping the valve. Small bumps and taps can not move the large ball weight inside.

Product disadvantages

- A specific unit for water would need to be designed and tested.

Product opportunities

- An automatic solution for isolating an EWS.
- No delay in the automatic cut-off action. Dry disconnect quick couplers.
- The ASUS GX800 laptop has a detachable water cooler utilising a quick disconnect coupler.
- The water cooler can be added or removed at any time, and no coolant liquid is spilt during the connection because of these valves.

Hydraulic quick disconnect couplers

This design of hydraulic coupler has no integrated locking mechanism which allows instant connection and release to offer a seamless experience.

Product advantages

- This type of coupler offers the same function as a common design but in a way that does not interfere with the usability of a product connected to it.
- Offers a quick way to remove multiple connections quickly.
- Automatically connects and disconnects a fluid connection with no leakage when establishing or releasing the connection.
- Easiest hydraulic coupler to release

Product disadvantages

- A secondary means of holding the coupler is needed.
- Currently researched models require a motion along one axis only which does not allow for the human factor or alignment error when connecting.
- The coupler is small enough to use anywhere within a product design.

Product opportunities

- A conical design rather than a cylindrical one would cater for misalignments and a more satisfying connection.
- Trouble-free operation.

Michael S. Jones - M.Des Exegesis 2017.