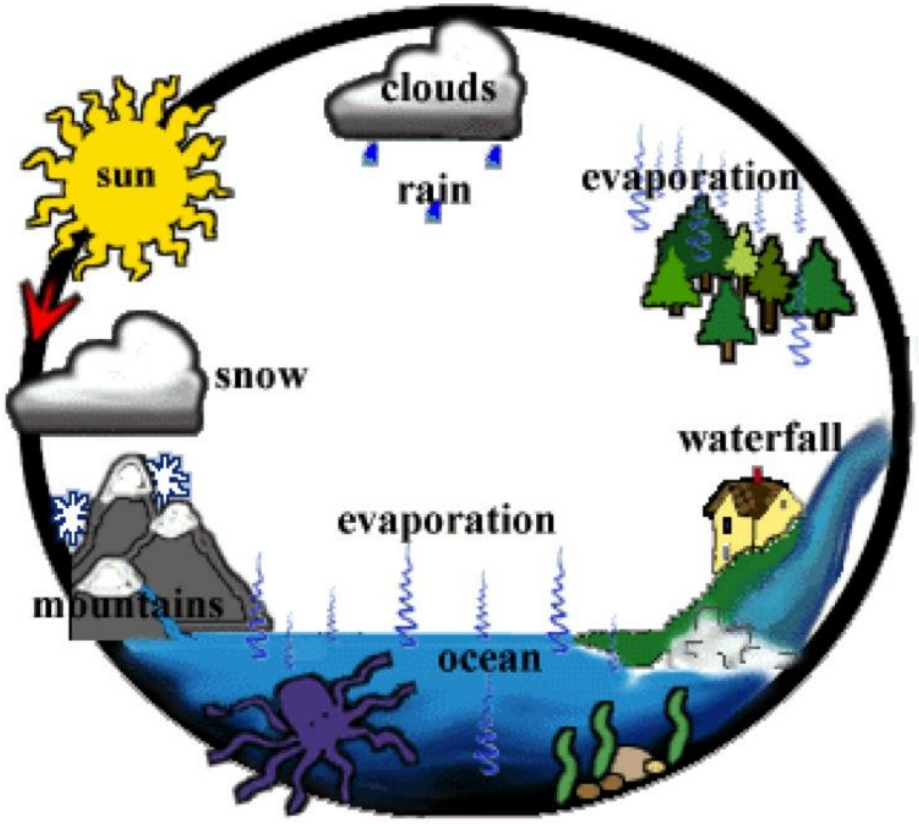
TREADWELL WATER SYSTEM



Permaculture Design by
Michel Thill – 2014/2015

Diploma in Applied Permaculture Design,
Design 9/10
Start date: Aug 2014
End date: Nov 2015

Using GoSAD(I) as a design process
Implementation not yet started.

TREADWELL WATER SYSTEM

OUTLINE

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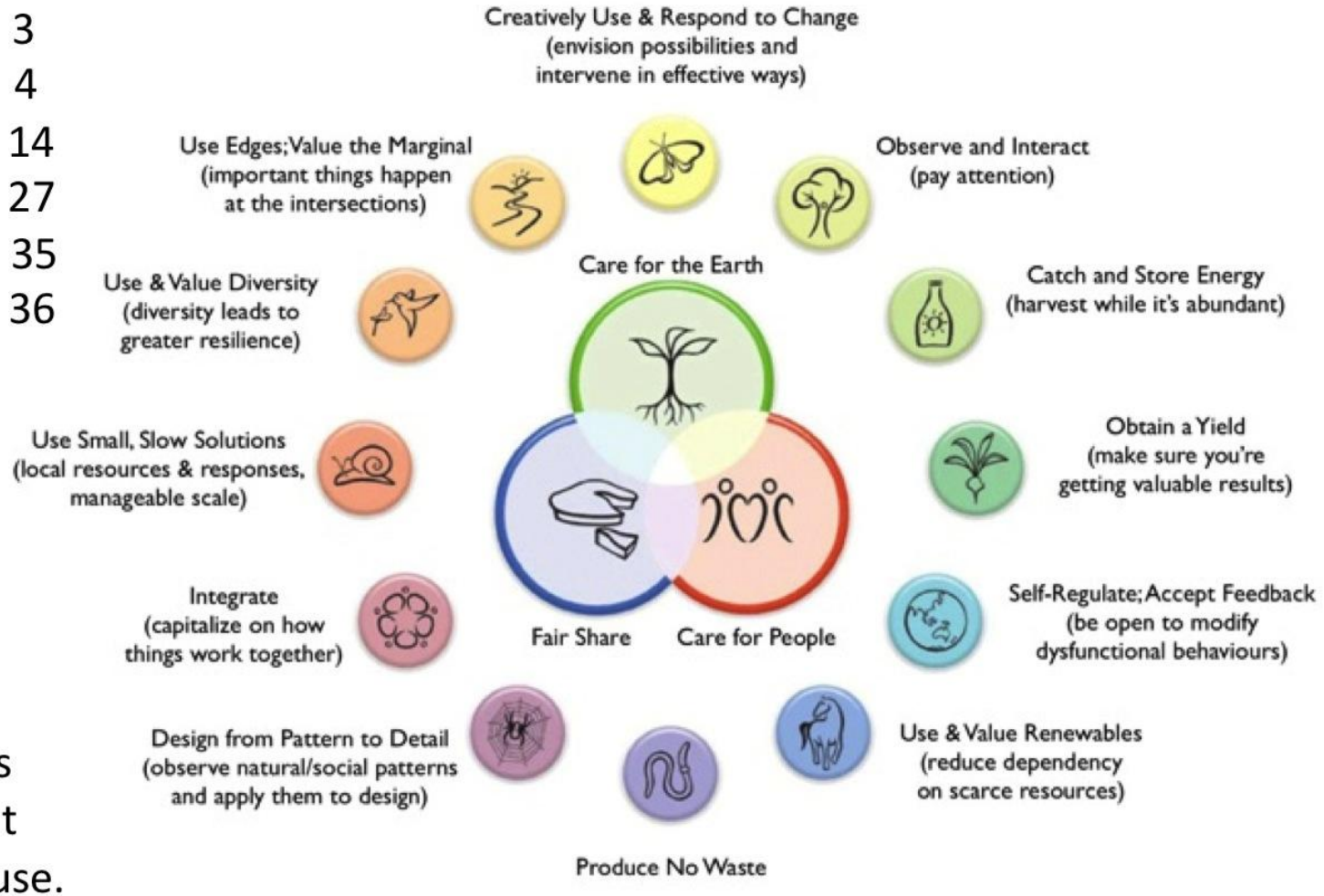


Find the principle symbols throughout this document referring to principles at use.

BACKGROUND & GOAL

As mentioned in the 'Treadwell – Beyond the Sustainable Home' design, it is my ambition to get this home off-grid at least as much as possible and demonstrate urban regenerative and post-capitalist living systems.

Therefore, the goal of this design is to come up with a design that can potentially take our water system out of the grid.

Therefore, the goal formulation is as follows:

- **Creating a sustainable off-grid water system.**
- **Using 99.9% rainwater, re-using it for multiple purposes & finally cleaning it before feeding it back to the Earth.**

These goals were formulated in the 'Treadwell – Beyond the Sustainable Home' design.

SURVEY

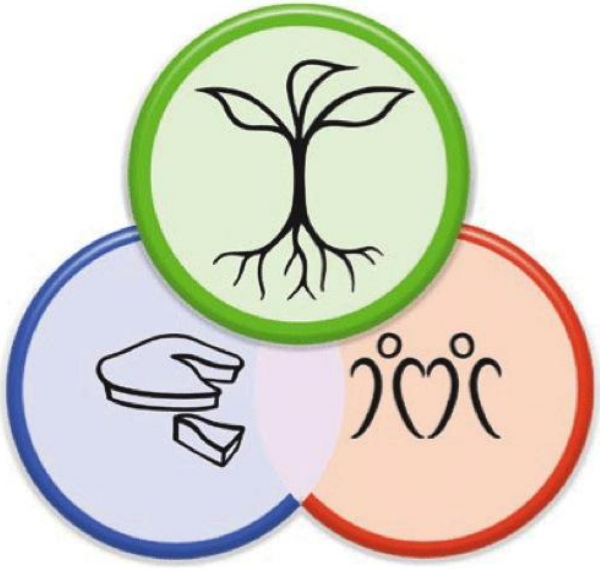
- PERMACULTURE ETHICS

Earthcare

They say wars will be fought for water and who know that might be the root cause of the Syrian crisis. Also the UK is becoming dryer and the current water treatment system is energy intensive and reliant on chemicals. Our drinking water is a liability. This design aims to find local urban solutions to water usage.

Fairshare

The earth gets her fair share from this process just as much as everyone who comes to Treadwell. The design will be shared and hopefully an inspiration for others.

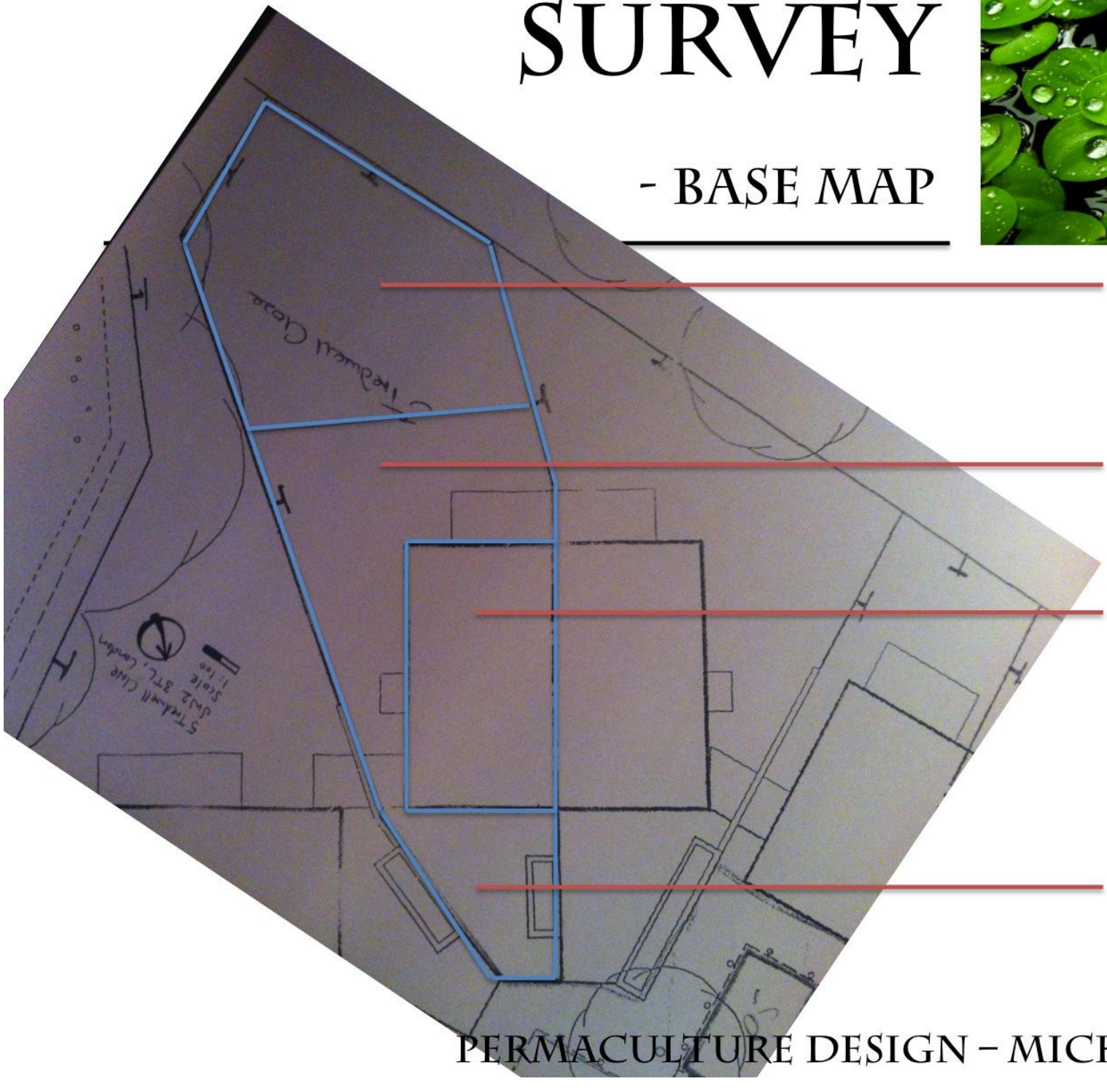


Peoplecare

The water we drink and clean ourselves with is full of chemicals. Harvesting, filtering and cleaning our own water will benefit everyone who uses it. There is bound to be great learning involved as well.

SURVEY

- BASE MAP



Back garden on slope

Terrace

House

Front garden

SURVEY

- BASE MAP WITH CURRENT HARD-TO-REMOVE ELEMENTS

Pond

Planter

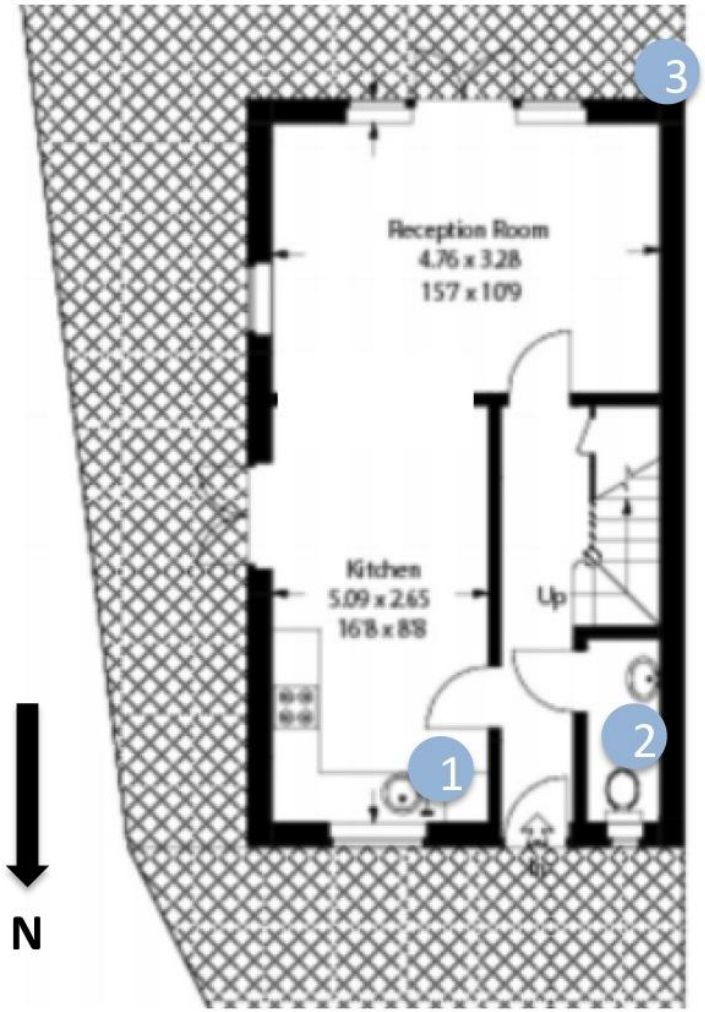
Terrace

Planter

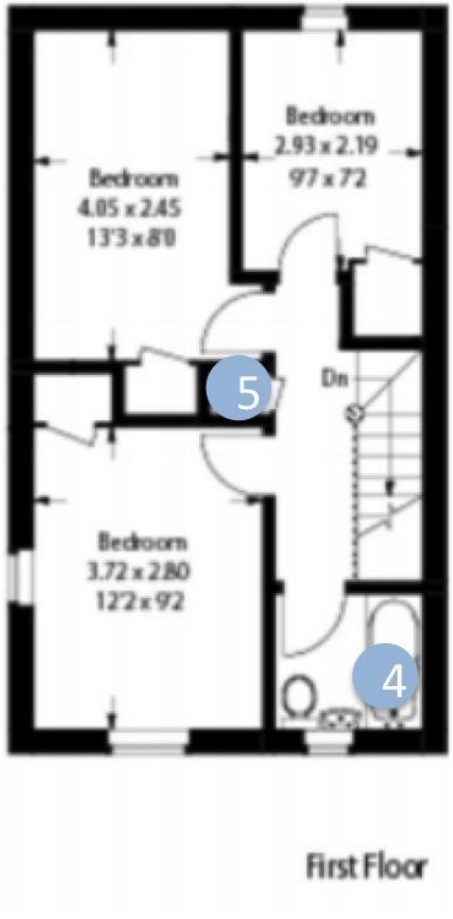
House

SURVEY

- CURRENT EXISTING SYSTEM



Ground and first floor of the house.



1. ***Kitchen*** – water for washing the dishes as well as washing machine; water stop; boiler (Potterton Suprima)
2. ***Toilet*** – sink and toilet
3. ***Roofwater drain*** – drain for S roof of ours and neighbour's roof + small water butt
4. ***Bathroom*** – Sink, toilet, bath and shower + pump to get pressure on hot water supply
5. ***Airing cupboard*** – Hot water cylinder

SURVEY

- CURRENT EXISTING SYSTEM

Other important elements of the current system are:

- **Water meter and outside stop tap**

Located on the pavement outside the actual property

- **Cold water storage tanks**

(Titan 70/50 Gallon Rectangular Tank
+ Titan 10/4 Gallon Rectangular Tank)
In the loft with:

- Valve to cold water tank
- Valve to cold water taps
- Cold valve to hot cylinder
- Valve to heating

SURVEY

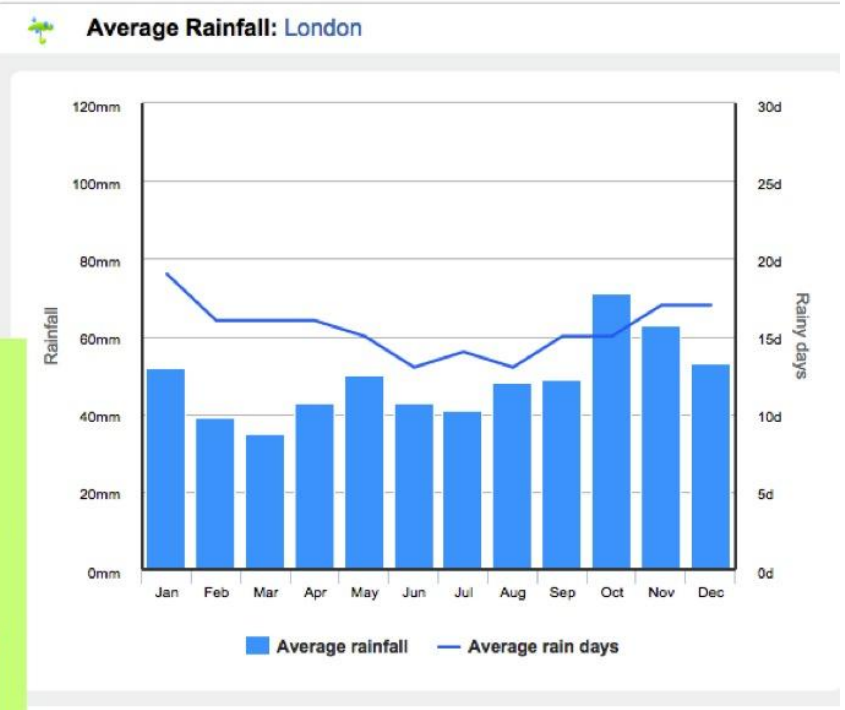
- UK RAINFALL PATTERN

Mixed information on different webpages…

- London, England arrogates on average 594 mm (23.4 in) of rainfall per year, or 49.5 mm (2 in) per month.
- On average there are 164 days per year with more than 0.1 mm (0.004 in) of rainfall (precipitation) or 13.7 days with a quantity of rain, sleet, snow etc. per month.
- The driest weather is in March when an average of 37 mm (1.5 in) of rainfall (precipitation) occurs.
- The wettest weather is in November when an average of 64 mm (2.5 in) of rainfall (precipitation) occurs.

Precipitation Table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Precipitation mm (in)	53 (2.09)	40 (1.6)	37 (1.5)	38 (1.5)	46 (1.8)	46 (1.8)	56 (2.2)	59 (2.3)	50 (2)	57 (2.2)	64 (2.5)	48 (1.9)	594 (23.4)
Precipitation Litres/m² (Gallons/ft²)	53 (1.3)	40 (0.98)	37 (0.91)	38 (0.93)	46 (1.13)	46 (1.13)	56 (1.37)	59 (1.45)	50 (1.23)	57 (1.4)	64 (1.57)	48 (1.18)	594 (14.57)
Number of Wet Days (probability of rain on a day)	17 (55%)	13 (46%)	11 (35%)	14 (47%)	13 (42%)	11 (37%)	13 (42%)	13 (42%)	13 (43%)	14 (45%)	16 (53%)	16 (52%)	164 (45%)
Percentage of Sunny (Cloudy) Daylight Hours	17 (83)	20 (80)	31 (69)	35 (65)	40 (60)	41 (59)	40 (60)	41 (59)	36 (64)	30 (70)	19 (81)	16 (84)	33 (67)



SURVEY

- UK RAINFALL PATTERN

www.independent.co.uk/news/uk/home-news/uk-weather-britain-must-be-ready-for-worst-droughts-in-modern-times-9746455.html

EPENDENT News Voices Culture Lifestyle Tech Sport

News › UK › Home News

UK weather: Britain must be prepared for 'worst droughts in modern times'

Desalination, long-distance pipelines, imported supplies, and more efficient appliances in the home are among measures being considered to stop the country running dry. Kitty Knowles reports

Kitty Knowles | Monday 22 September 2014 | 80 comments

667 shares

How dry does England, and in particular London, get?

- In July/August 1999 Southern England experienced **31 days** without rain.
- This year's (2015) longest dry period in London was **14 days** in July/August.
- The longest record dry period in London was in July 2013 and lasted for **18 days**. Is it getting any better with a changing climate??

http://weather.casa.ucl.ac.uk/record.htm

SURVEY

- WATER USAGE

I put up recording sheets in the house for people to tick boxes. This doesn't include the garden which gets quite a lot of water in the summer months. The avg. in the UK is 150 l per person per day. We seem to be below that using about 114.75 l per day, which is still a lot. I avg. the usage rather high – better to have too much than not enough.

	Avg. daily usage	Avg. litres per usage	Total litres per day
Shower	2.5	50 l	125 l
Bath	0.14	80 l	11.2 l
Flush	11.7	13 l	152.1 l
Tap (hands/teeth)	16.4	4.5 l	73.8 l
Washing machine	0.46	70 l	32.2 l
Washing up running water (short)	7.4	8 l	59.2 l
Washing up w/ sink filled	1.1	5 l	5.5 l

Avg. daily water usage at Treadwell: 459 l

SURVEY

- HARVEST CAPACITY

Surface area is 10.50m by 4.50m = 47.25sqm
Annual rainfall for London is 594mm

Calculating **annual rainwater yield**:
Annual rainfall (mm) x roof footprint (sqm) x 0.8 (for tiled roof): 594mm x 47.25sqm x 0.8 = 22,453.2m3

Average **monthly rainwater yield**:
22,453.2m3 / 12 = 1,871.1m3

Rainwater yield for lowest month (March – avg of 37mm)
37mm x 47.25sqm x 0.8 = 1,398.6m3

I won't need to aim to catch most of the water that falls, but enough to get through dry periods of about 2 – 3 weeks.

SURVEY

- CLIENT INTERVIEW

Wants – Needs – Vision – Values

Importance of clean drinking water
Don't want to contribute to an energy intensive sewage and cleaning system
Ideally reuse water many times
Off-grid would be ideal although for legality and security reasons the grid option should stay available
We mostly use non-chemical, biodegradable cleaning and washing products

Resources – Limiting Factors

Money is being saved for this project – would be good to keep it under £2000/2500
Engineer is in the house to help with feasibility
Don't have any plumbing skills but would love to learn
Garden bed on the terrace might be a limiting factor when it comes to water tank position
Ideally done before the PDC 2016 starting in April

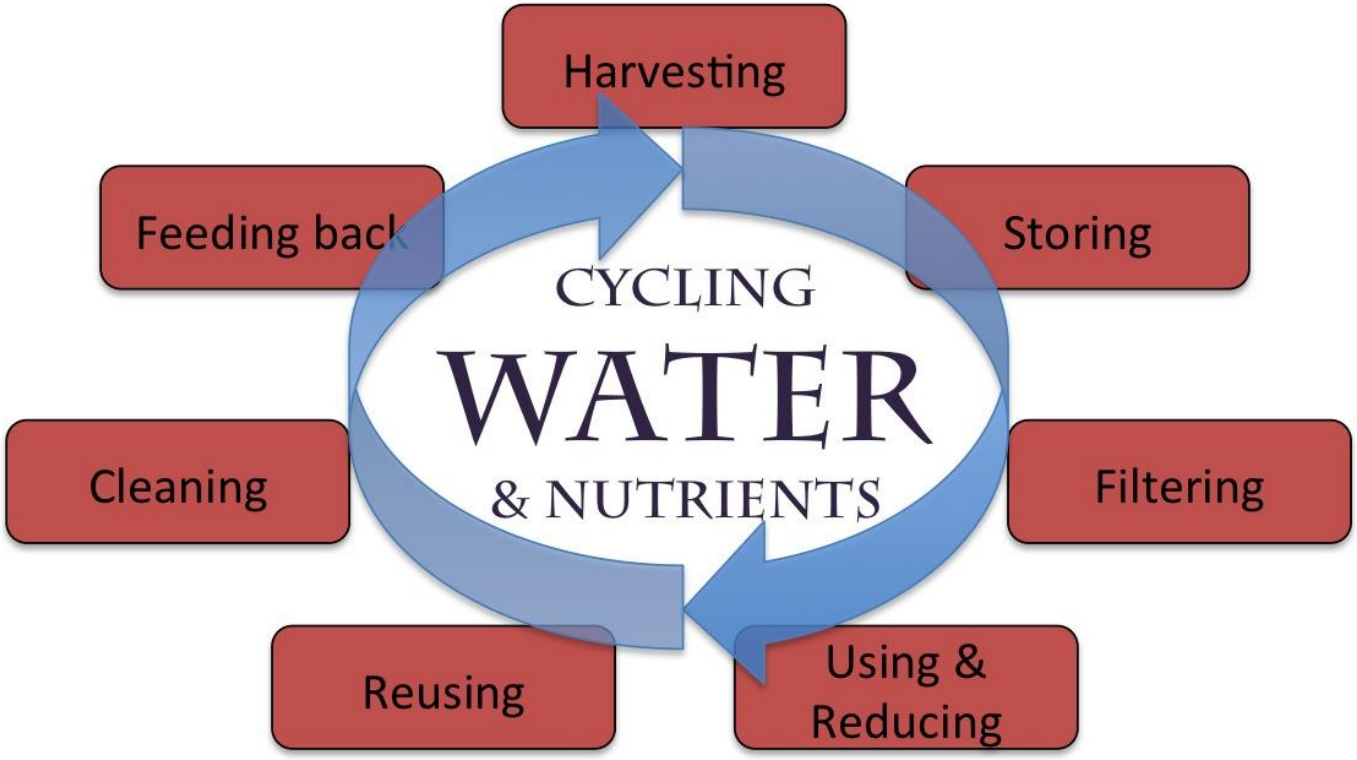
Other Useful Information

All people in the house are happy to use compost toilets to reduce water use
Keep a normal toilet option for the many guests that come on events and courses?
Washing machine is important for all of us – comfort
Garden will need water in dry summers
Our neighbour Roger wants to get off grid as well

ANALYSIS

- FUNCTIONS

What should the design achieve? I was playing around with what we would need to cycle nutrients and came up with the following. I am curious whether I can find multiple elements for each of these functions and also whether each element can directly support multiple functions. Anyway, each element should support the overall function of **cycling water and nutrients**.



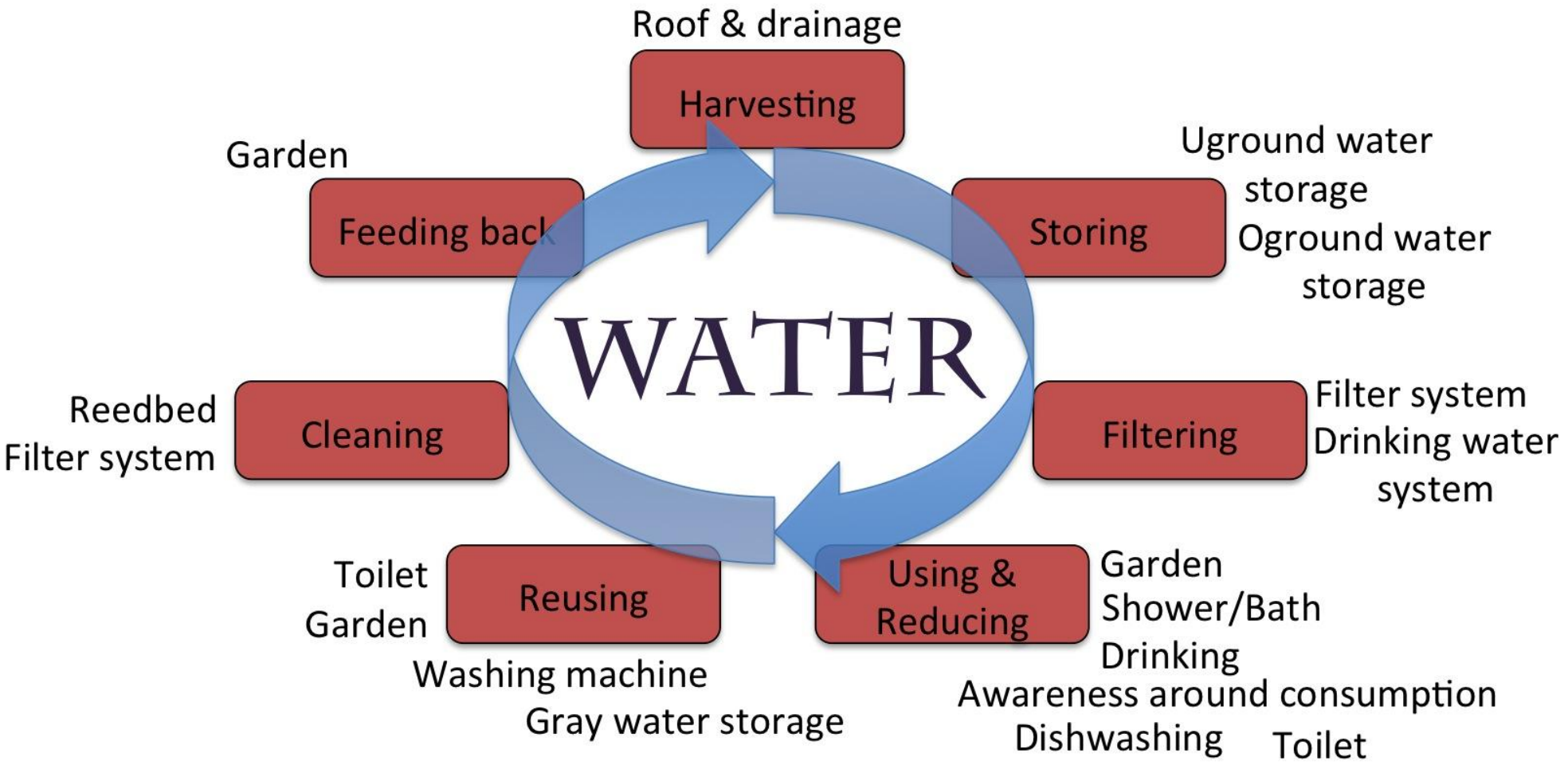
SMART Goals

When the system is installed, fully finishedmid by 2016, I want to use mains water only in extreme circumstances such as long droughts. That means going years without using mains at all!

With dry periods expanding, say a long one being 14 days, and us using 500 l per day we need to store 7000 l or, even better, reduce water usage considerably.

ANALYSIS

- SYSTEMS/ELEMENTS



ANALYSIS

- STORAGE SYSTEMS PMI

1000 l overground water storage – cube

+ Easy to install
+ cheap, reclaimed versions available (£40 incl. delivery)
- Overground & size (where would it fit on our terrace?)
- Ugly
? Use for the garden along with underground storage
? Grow climbers around

1000 l overground water tank – narrow

+ Easy to install
+ Would fit on the terrace
- Overground, looking ugly
? Use for the garden along with underground storage
? Grow climbers around

ANALYSIS

- STORAGE SYSTEMS PMI

Hgt: 1250mm
(Body)
Hgt:Plus 475mm
(Turret)
Dia: 1260mm
Lgt: 3680mm

3400 l underground water storage

+ Comes with fitted drainage connector, filter, calmed inlet
+ New and good quality
+ Underground, so not visible
+ size fits on terrace without taking up garden beds
- Underground & need to dig on terrace (a lot of work)
- Filling will be away from main drain because of size
? Pump can be put inside

Lgt: 3200mm
Wdt: 1350mm
Hgt: 2220mm

3090 l underground water tank

+ light weight considering the size
+ New and good quality
+ Underground, so not visible
+ size fits on terrace close to drain without taking up the beds
- Underground & need to dig on terrace (a lot of work)
? Pump can be put inside

I've considered larger tanks although I am hoping to avoid these as installation would become very labour intensive.

ANALYSIS

- CAPACITY VS. CONSUMPTION

Storage Capacity

If we had a 1000 l tank + 3000l tank, Treadwell could store 4000 l. Using 459 l per day means we would run out of water after 8.7 days – this is without reducing our consumption.

New equation

A compost toilet and new washing up system would bring our daily consumption down to 256.9 l. In that case, we could store water enough for 15.5 days.

Reducing water usage

An important question is: How can we reduce the water usage? Nearly a 3rd of our water is used for flushing the loo (problem) – a solution would be a *compost toilet* which would save us 152.1 l per day and save us from needing to treat blackwater. Using a bowl in the sink and having a better washing up system would save us potentially another 50 l per day.

ANALYSIS
- 1ST STAGE FILTER SYSTEMS PMI

First filtering before water goes into the tank

Rainus downpipe filter
+ On the downpipe, easily accessible for maintenance
+ Double filter for large and fine particles
- Expensive (£100)

Filter basket
+ On the downpipe, easily accessible for maintenance
+ Easy to install
+ Cheap (£20)

Garden filter
+ Easy to clean as collecting basket removable
- Fit underground or even in tank
- Even more expensive (£130)

Rainwater filter collector
+ On the downpipe, easily accessible for maintenance
+ Easy to install
+ No need to remove pipe for maintenance
? Middle price

ANALYSIS
- 2ND STAGE FILTER SYSTEMS PMI

Filtering before home-use and drinking

6 stage ultra violet reverse osmosis water filter
+ Easy to install
+ Filters most of heavy metals, toxins aso.
+ Water flows through it before reaching a drinking water tap
- Expensive £300
? 5 stage also available and cheaper

Berkley water filter
+ Easy to install
+ Filters most toxins, heavy metals aso.
- Water manually refilled, only for drinking and no direct connection to all pipes
? We are using it already at home

I have explored other options and learned a lot about water filters – these are the more relevant ones…

ANALYSIS

- REUSING WATER

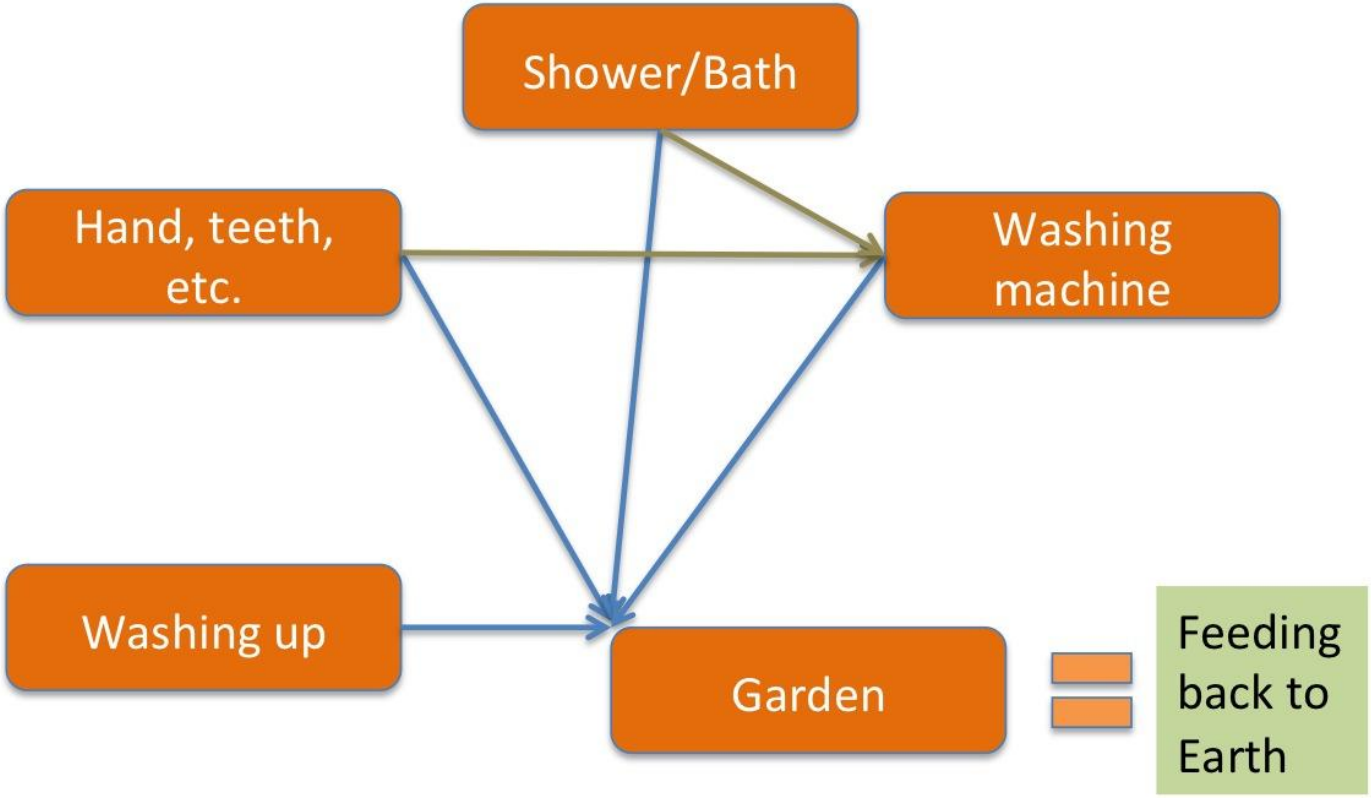
What water could find a second use for in the house?
This would save water again and diminish the storage capacity required.

All of the water could be used in the **toilet,** although I have taken that out already..

All water can be fed to the **garden** and used for gardening.

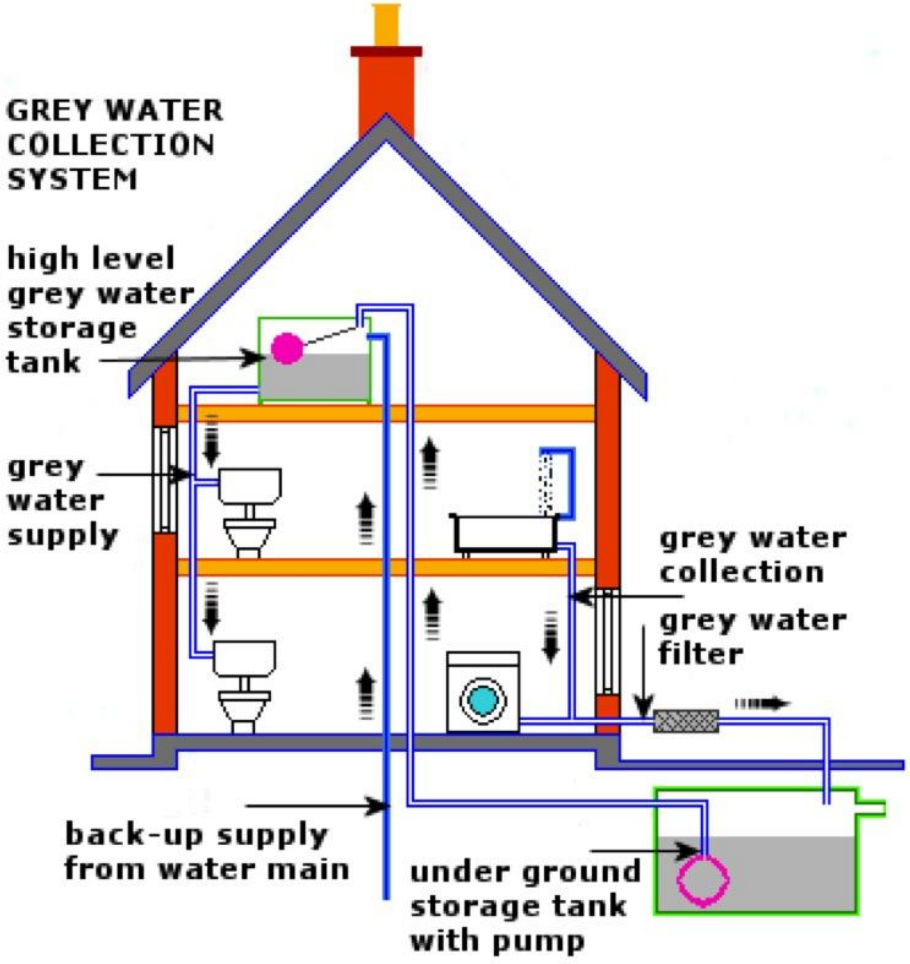
Potentially the water from **body cleaning** such as **hands, teeth, shower, bath** can be saved and reused in the **washing machine**. There are actually new showers that do exactly that.

To do that water will need to be stored…



ANALYSIS

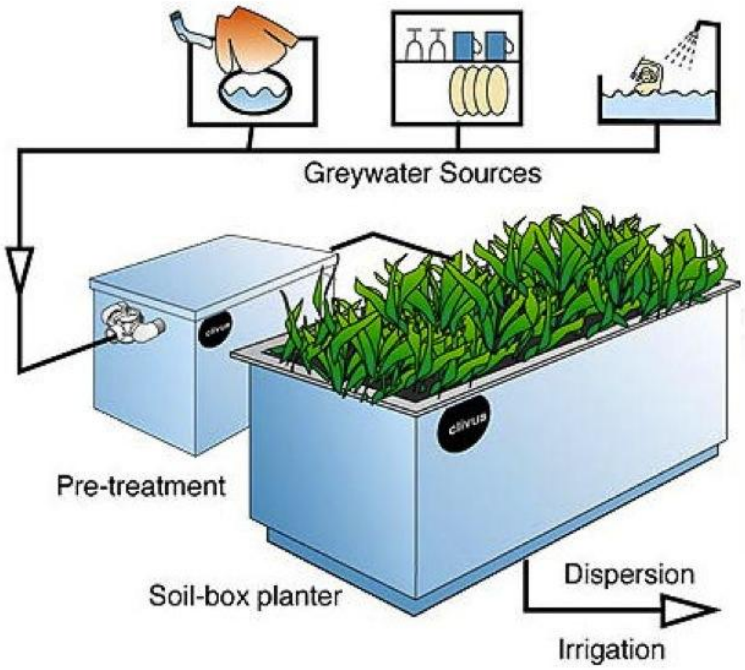
- GRAYWATER STORAGE SYSTEM

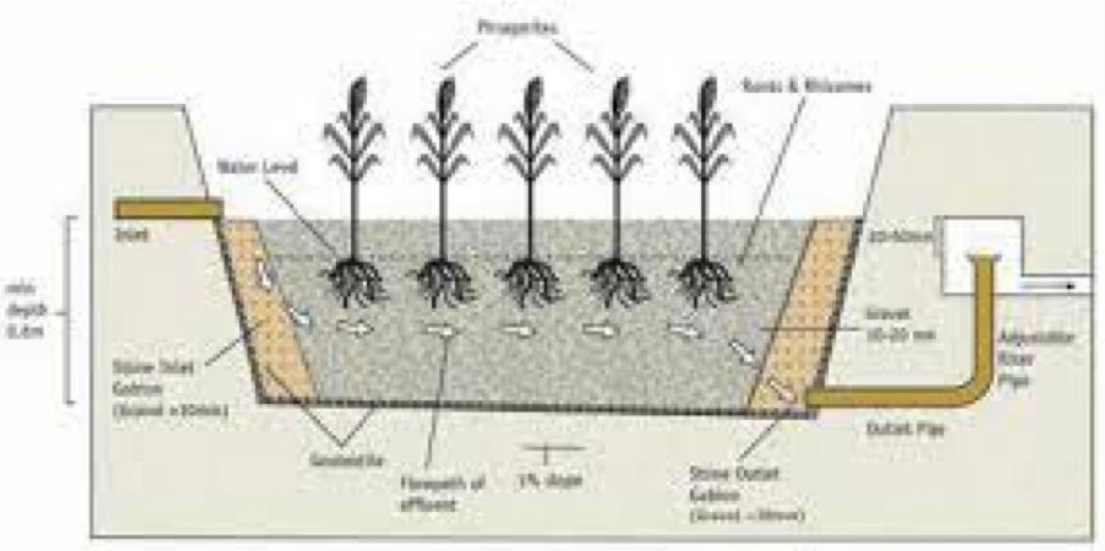


Storing gray water involves another tank and also another pump system to bring it to the washing machine. Could I store water to use in the garden without pump? I could collect an avg. of about 250 l of gray water each day – way more than I would need.

A treatment system could simply treat all the gray water and feed if back to the earth or keep some in a treatment/pond, which in extreme situations could be pumped to the garden beds.

ANALYSIS
- GRAY WATER TREATMENT SYSTEM





A great paper on reed beds can be found here and a gray water system here, info from CAT centre here.

The gray water treatment system can be a simple reed bed. Research shows that, using non-toxic cleaning and washing products in the house and feeding in no blackwater, only the filtering of larger particles and the reed bed is enough. What size will it need to be for a 4 people household? The CAT centre in Wales recommends 1sqm per 100 l of gray water.

We will need a reedbed sized 2.5 to 3 sq m.

ANALYSIS

- ZOOM IN ON CONSUMPTION

PRODUCT INGREDIENTS TO AVOID
IN ORDER TO SUPPORT THE GRAYWATER SYSTEM & NOT POLLUTE THE GROUND

boron/borax (toxic to plants)
sodium and ingredients with the word "sodium" in them
chlorine bleach (acceptable alternative: hydrogen peroxide)
sodium perborate
sodium hypochlorite
peroxygen
petroleum distillate
Alkylbenzene
water softeners (contain sodium chloride or potassium chloride)

anti-bacterial soaps & cleaners
"whiteners", "softeners"
enzymes (enzymes in biological washing powders break down protein or fat stains on clothes)
titanium oxide
chromium oxide
artificial colors; FD&C colors
synthetic fragrance
artificial preservatives
no toxic waste down the drain!!

Source: ecology centre

ANALYSIS

- GIVING BACK TO EARTH

The process of giving water back to the earth can happen in various ways

Raingarden

This would allow water to percolate into the ground and fed the ground water level in one specific area. Not sure whether there will be enough sun for a proper raingarden.

Contour on slope

This would regularly feed the back garden with nutrient-rich water. This part of the garden is to become a highly productive, low maintenance forest garden (see Edible Sanctuary Design and coming Treadwell Forest Garden Design).
The trenches could be filled with woodchip to soak up water and replaced yearly (feeding nutrient-rich woodchip to plants).

Storing in pond systems

Combining the treatment system with a pond system that stores the water could be an option where the water can be pumped up to the terrace for veg growing in time of need (hopefully only rarely).

→ **Is a combination of 2 or all 3 maybe the best option?**

ANALYSIS

- ECOLOGICAL PRINCIPLES

Cycling energy & nutrients
Water is a form of energy and it carries valuable nutrients. This is the ecological principle that defines this design.

Stacking functions & succession
One function supports the next function and turns the combination of elements into a system. This is a succession of elements and mimics natures natural process.

A function met by multiple elements
The function of harvesting and storing can be supported by underground and overground water tanks as well as by storing the treated gray water. Various filter stages clean the water for house use and also before it goes back in the ground, with the ground being the final treatment.

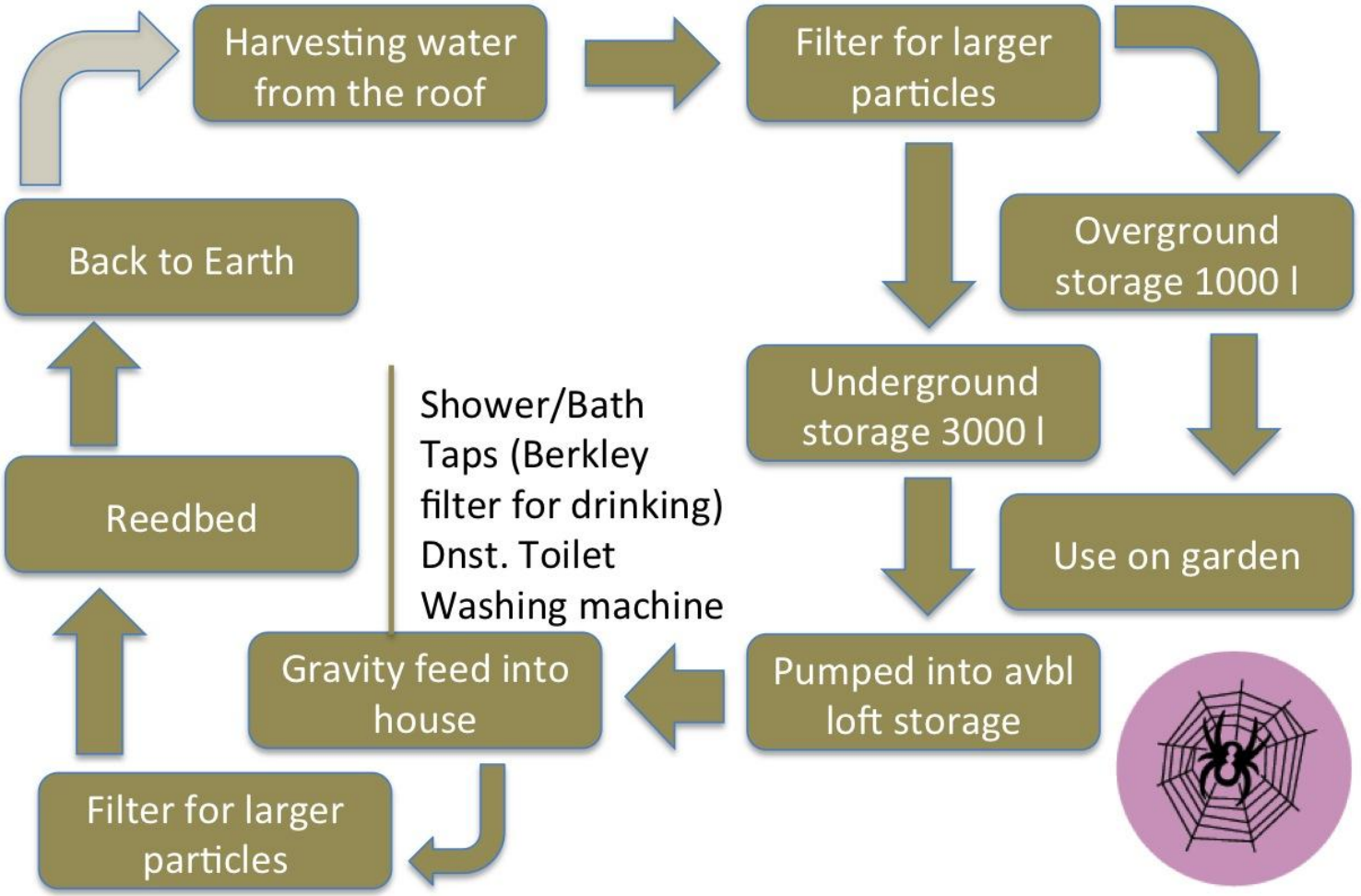
An element meets multiple functions
This a more difficult one. Each element supports the overall function of the system, which is to cycle water and nutrients and within that has its specific role. Many elements meets other support-worthy functions as well, for example the pond in the end could clean water, store water for use and support a wildlife function, which isn't specifically mentioned in this design. Therefore this design will support the functions of other Treadwell designs and integrate into the larder system.

DECIDE

- 'SCHEMATICS' OF THE SYSTEM

Explanation of 'schematics'

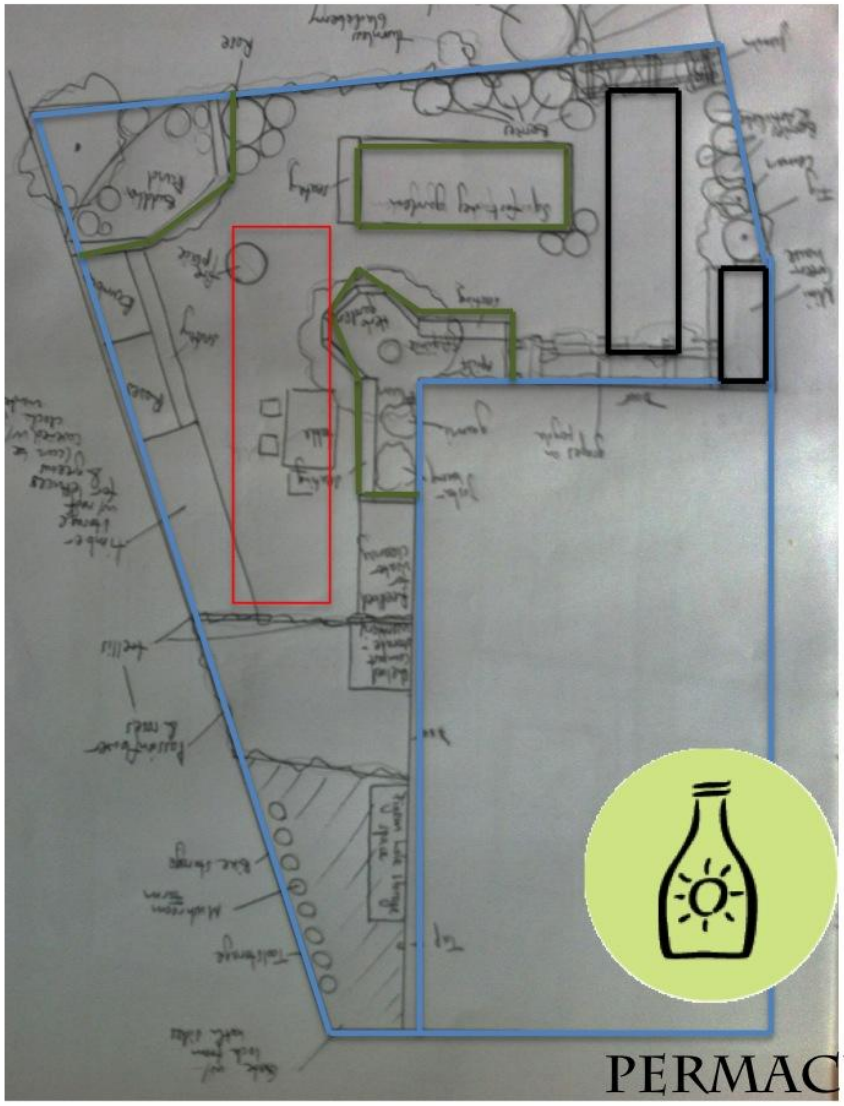
The survey and analysis lead me to the illustrated cycle.
We will have a 3000 l tank connected to the house (or potentially bigger depending on space and 1000 l for the garden.
We might want to use two reedbeds to get to 3 sqm size and could potentially have one on the terrace.



PERMACULTURE DESIGN – MICHEL THILL – 2014/15

DECIDE

- CHOOSING & PLACING SYSTEMS & ELEMENTS

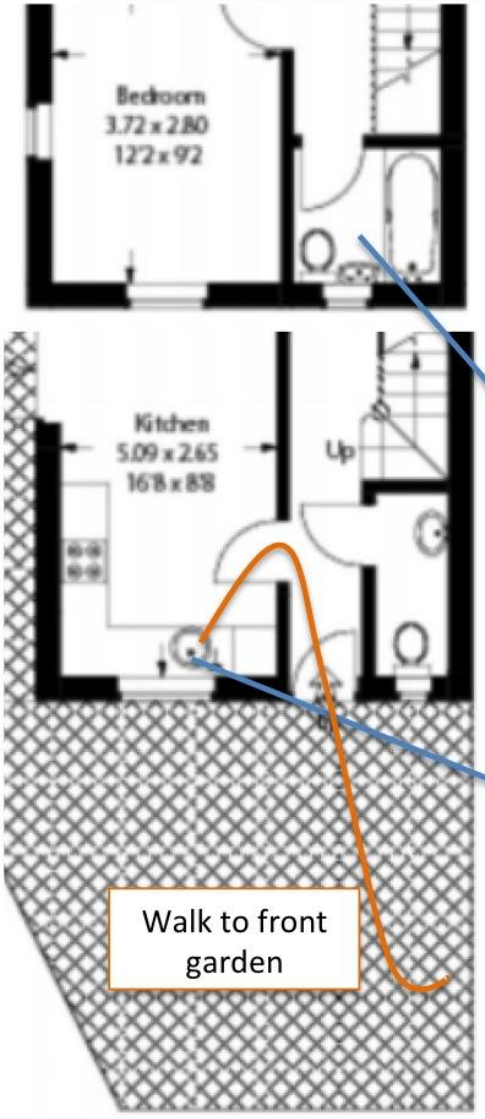


Following on from the analysis, the elements I choose are:

- The water comes off the roof through the downpipe where if is filtered by the **Rainus downpipe filter**, easy to maintain, filtering large and small particles.
- **1000 l narrow overground water tank** for space reasons.
- **3090 l underground water tank**, again for space reasons – the larger one would have fitted on the terrace but further away from the gutter (see red box), which would have led to larger piping system, probably more maintenance in coming years. With us using about 250 l per day, 3090 l will allow us to go 12 days without water – and if we are extra careful around the drier periods, then even longer.

Harvesting | Filtering | Storing

DECIDE
- CHOOSING & PLACING SYSTEMS & ELEMENTS



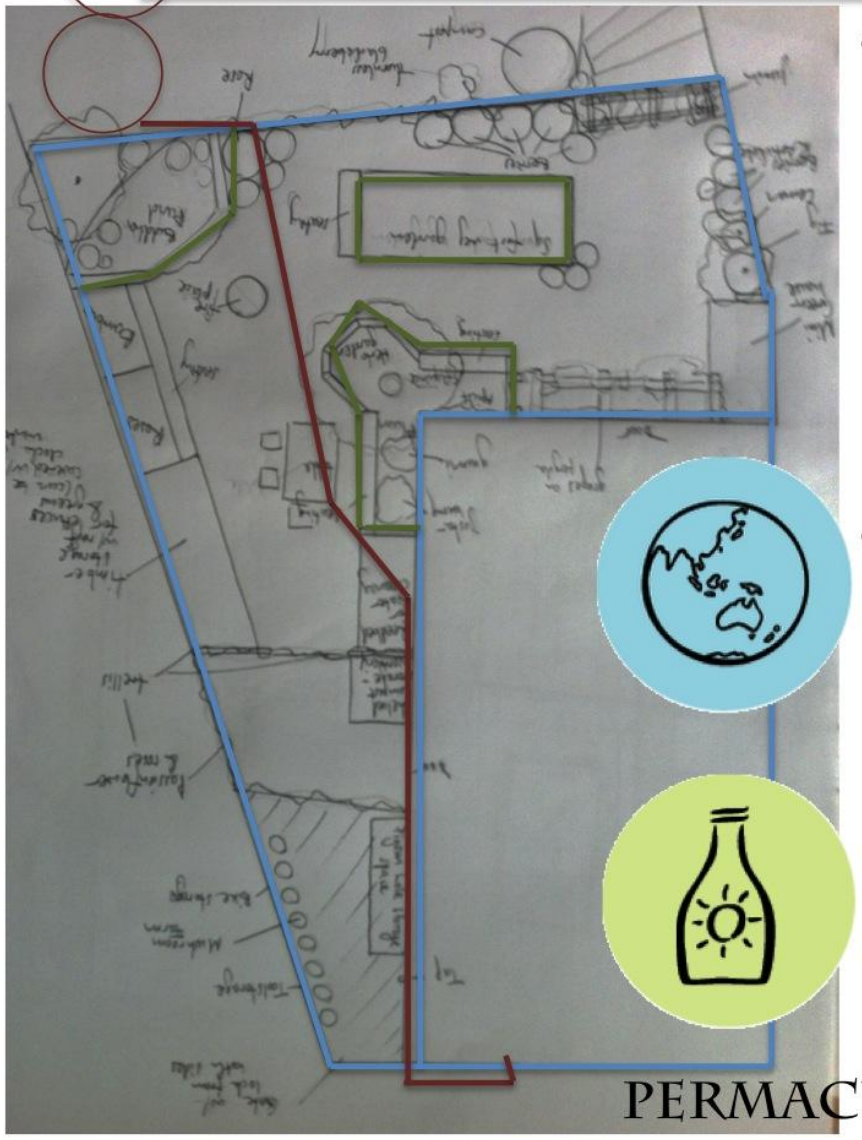
- **Rainwater** will be used for all household purposes (incl. washing machine, shower/bath, taps). It will be, as usual, filtered with the **Berkley's filter** that we own, which will need less maintenance as the fluoride filter doesn't need to be replaced yearly, not having fluoride in the water.

- Upstairs toilet is replaced by a **compost toilet**, where once a week we need to empty the waste into a compost bin in the garden (which we get an extra yield from). The downstairs toilet will stay on the grid – using rainwater to flush but going with the conventional sewage – and will be a guest-only option. This is a compromise, but considering that a bucket & chuck-it compost toilet is probably not legal, it is a worthy compromise.

- The **washing up system** will be properly re-organised in a separate design for the kitchen. For now, we will use a bowl in the sink where we keep the water and feed it to the mostly neglected front garden (see orange line on the plan).

Filtering | Using & Reducing | Reusing

DECIDE
- CHOOSING & PLACING SYSTEMS & ELEMENTS

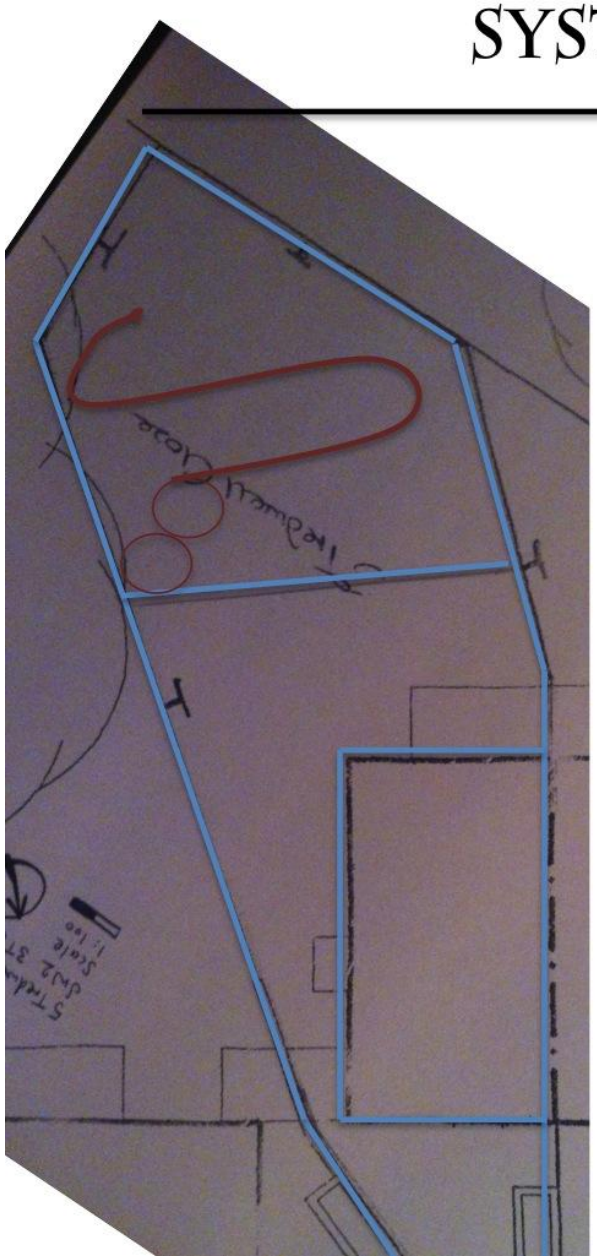


- Only water that is reused is water from **washing up** in the kitchen. This is because it will require another storage and another pump and I am quite happy with the systems storage capacity. It is however possible to integrate at a later stage. In the current system, water will be collected in the **reedbed/pond system** at the bottom of the garden.

- All water leaves the building outside the kitchen (see the red line ———) through a **pipe** that goes underground all along the house on a slight slope to the back garden where it enters a **reedbed** (first circle - ⌀ 2m) and a **pond** after that (second circle), which can be used as an emergency **storage**.

Reusing | Cleaning | Storing

DECIDE
- CHOOSING & PLACING SYSTEMS & ELEMENTS



- The first of the two ponds is a **reedbed** with a diameter of 2. Great details on construction can be found here.

- From the **reedbed** the cleaned water flows into a **pond** with more pond plants that will contribute to further cleaning. This water can be used for watering the garden through pumping it up to the terrace.

- When the second pond overflows, the water is channeled into a couple of **swales** down the bottom of the garden. These swales can be filled with woodchips yearly, which will soak up some of the water and start composting. The wood-chip can be harvested and used as a fertile mulch.

- If need be a **raingarden** can be constructed below the swales.

Cleaning | Storing | Reusing | Feeding back

DECIDE

- APPROXIMATE BUDGET

Rainus downpipe filter	£100
Narrow overground tank	£320
3090 l underground tank	£1200
Concrete for tank	£50
Pump	£200
Piping + bits	£60
Reclaimed large tires for pond system	£0
Reclaimed gravel	£0
Total	**£1930**
+ 10% contingency	**£2130**

+ a lot of work digging the whole for the tank

DECIDE

- IMPLEMENTATION PLAN

Dates and actions
(some details will need to be figured out while doing that)

Dec 2015	– Get the compost toilet in
Jan 2016	– Start with the hole on the terrace
Feb 2016	– Fit the tanks and connect to downpipe
Mar 2016	– Fit the pump to get it in the tank in the loft
Apr 2016	– Pause
May & Jun 2016	– Build the pond system in the back garden
Jul 2016	– Lay the pipes to the pond system
Aug 2016	– Connect the system and monitor
Sep 2016	– **Celebrate**

CONCLUSIONS

- REFLECTIONS & PERSPECTIVES

Process Review

GoSADI suits me best I believe, although I realise it is not the best for every occasion as well. I thoroughly enjoyed this process and learned a lot from it and I know I will learn a lot doing the details and the implementation. This process again involved a lot of research and many phone calls with companies providing the material.

Tools Review

Great to reuse a map from a previous design and also the drawing in it digitally has worked I believe. The analysis and the PMI was an interesting process with those more technical elements and systems. The functions confused me to some extend as they describe the way the water will flow and also kind of give an idea of what this design needs - I guess the fulfill multiple functions.

CONCLUSIONS

- REFLECTIONS & PERSPECTIVES

Project & Personal Review

So far the project has been a great learning experience, while I am aware that the real deeper learning will come with the implementation. It is stretching my edges quite a bit with all the technicalities of the system and also the scale of intervention – therefore the implementation will be of great importance.

Professional Review

Finishing the design with an implementation could actually lead me to offering much more holistic design services, not only for garden but for the sustainable retrofitted home. Not there yet – but it could go in that direction and as this water system design is quite technical and also quite prescriptive, this design can very much serve as a blueprint as well as a portfolio design for further work for clients.