AQUA HOUSE

A house design that explores the possibility of integrating architecture and water, technically and aesthetically.

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If water operates in architecture at either a technical or an aesthetic level, can architecture integrate the technical and aesthetic aspects of water?
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**Abbreviations Legend**

FN = Footnote, PP = Diagram, A = Appendix
1 Introduction

This project has resulted from current concerns about global water usage and the increasing pollution of water environments (FN1.1). The research focuses on the relationship of water and architecture. The preliminary research re-examines the place that water occupies in architecture in order to determine how current practices in architecture contribute to the pollution of water environments and to what is believed to be an unsustainable usage of water. The project then seeks to investigate how some of these practices in architecture could be modified in the future in order to mitigate the water problem.

Water is vital to survival and on another level, it is mysteriously beautiful. Similarly, architecture celebrates water at one level and at another level, water damages architecture and architecture contaminates water. Architecture celebrates water at the aesthetic level and yet it pays little respect to the role that water plays in sustaining life. Architecture presents water to us as an object of beauty, while at another level it operates like a machine for the contamination of this water. (PP1.1)

While water and architecture have a long history, today’s buildings do not give sufficient attention to integrating water, a relationship between architecture and water that needs to change. I argue that buildings have rarely given sufficient attention to integrating the two levels that water operates at within a building. Throughout history, there is evidence of architecture celebrating the beauty of water. There is today a new ‘sustainable’ architecture being created that restores and seeks to reduce the destructive effects of architecture on water and the proposed design contributes to this movement. This ‘sustainable’ architecture does not, however, simultaneously acknowledge the way water can contribute to architecture
The purpose of this design project is to identify and explore the areas where it might be possible in a single building to use some of the techniques developed by the water-sustainability movement, in an aesthetic way. The project is the design of a house that integrates water and architecture. The design seeks to identify a series of key areas where integration is possible and to show how the impetus towards integration will cause a number of other assumptions within the design process to change.

In the process of designing the building, contextual information consisting of: data about the project site; its buildings and features; the surrounding sites, buildings and features are used. The manner in which information from the site was gathered; the use of levels, the way the plan was arranged around collected sources of water, the role of structure, the building envelope, and the way a building is thermally insulated were all re-examined. Another set of values were used in addition to those conventional values of liveability, buildability and affordability, to evaluate the options that were being considered. The result is a project that is both familiar and unfamiliar.

The research has shown that there are aesthetic and technical functions of water in buildings but that they are seldom integrated, and if they were, water could be used in buildings in other ways than at present. How can the design of a house integrate the technical and aesthetic functions of water? I have attempted to answer this by designing a building that works with both the aesthetic and technical functions of water. In addition, the design integrates water and architecture in a way that could contribute to reducing contamination of the water environment. While this is a small project, focused on the problem of residential architecture it can perhaps help raise awareness of wider water issues.
The lessons learned can perhaps be extrapolated to a re-examination of other types of buildings, where a wider set of water issues could be examined.

My research into water and architecture has led me on an amazing journey in which I have found fascinating information about how water can generate architectural ideas. Water can make architecture come alive, water and buildings can work together in unique and unusual ways.

(FN1.1) "Water is wasted all over the world, in countries with rapidly growing cities that are in the early stages of industrialization, in industrialized countries growing at a moderate rate, in regions that have little water and regions that have a lot of water", (Geiger, 2005, p78).
(PP1.1) Water, a precious commodity that covers more of the earth’s area than land, is wasted all over the world.
Project has resulted from current concerns about global water usage and the increasing pollution of water environments being caused by architecture's management of water.

Research re-examines the place that water occupies in architecture to determine how current architecture contributes to an unsustainable usage of water.

Design seeks to investigate how the use of water in architecture, both technically and aesthetically could be modified in the future to mitigate the water pollution problem.
Civilization from its beginnings has sought protection from the elements, one of the four elements being water (FN2.1). Before the 20th century water was not integrated in the home. Loos (1997) maintains that through Latin times, “no one washed because no one ever got dirty. Only the common people washed; the genteel were enamelled” and “Englishmen had no fear of getting dirty” (p16).

Architecture has in some ways always been organised in relation to water, there are the examples of baths and spas but even the organization of the house has been influenced by water; its collection, storage, accessibility and use. Molesworth and Giedion (1997) point out that at the beginning of the 20th century a shift occurred in the degree to which domestic architecture was governed by its mechanization of water and that together with other mechanizations these have continued to occur at an extraordinary pace (FN2.2). In the 20th century, Loos (1997) argues that houses without water are impossible as they are plumbed with cylinders, toilets, sinks, basins, showers, baths, spas, swimming pools, lap pools, water walls, reflection ponds etc, etc (FN2.3). The water flushes the toilet, the basin, the bath, the shower; cleans the body, the house, the car; irrigates the garden; is drunk; used for pleasure and once used gets sent to waste.

Lowes (1998) and Strang (2004) report that recent global water usage is increasing and is creating problems for the environment (FN2.4, FN2.5). For example, in Auckland’s 1990s water shortage, crises were averted by laying a new pipeline from the Waikato River and more recently, pollution of the harbour has caused beach closures (PP2.1). The water crisis is not only local, but occurring worldwide (FN2.6) and existing
architectural practices play a significant part in the problem. Architecture’s historical relationship with water has changed, (FN2.7) and more importantly, water management has become the domain of the engineer (FN2.8).

The house is the most appropriate form of architecture to investigate if one is to affect the degree to which architecture is instrumental in escalating the water crisis. There are two levels at which humans have a relationship to water and although there may be evidence that some research is being done to reduce the water crisis through architecture, this form of architecture is not acknowledging the second level of the relationship.

(FN2.1) “Adam, driven from the Garden of Eden, protected himself from the rain by joining hands above his head – a gesture that subsequently led him to construct the first roof”, (Burgin, 1997, p105).

(FN2.2) “the home was re-structured around water availability in order to incorporate standardized plumbing…at an extraordinary pace” (Molesworth, Giedion, 1997, p76-77).

(FN2.3) “A home without a bathroom! Impossible in America. The idea that at the end of the nineteenth century there is a country with a population of millions, all of whose inhabitants cannot bathe daily, would be outrageous in America” (Loos, 1997, p17).

(FN2.4) “The major cities in which most of us live have huge ecological ‘footprints’ – they draw water and resources from enormous areas of land, they produce mountains of solid waste and mighty rivers of liquid waste, ……. their energy needs are changing the global climate” (Lowes, 1998, p5).

(FN2.5) “In the UK domestic water use per captia has almost doubled in the last forty years, and similar increases can be seen in every industrialised nation” (Strang, 2004, p2).

(FN2.6) “Senseless use of water in precisely those cities where there is a drought. In recent times, despite all the insights and knowledge about it, water has become a utility whose origins we do not think about, that we simply use and throw away”, (Geiger, 2005, p78).

(FN2.7) “We have to accept that urban water concepts cannot be based on prefabricated models, whether they are local or imported. Water problems must be solved specifically and within the immediate vicinity for every town, every district and even every neighbourhood”, (Geiger, 2005, p79).

(FN2.8) “Water management in the town, like for example rainwater removal, drinking water provision and sewage disposal, is dealt with functionally, scarcely visibly and without any aesthetic sense as part of the engineer’s domain”, (Dreiseitl, 2005, p9).
(PP2.1) Auckland Beach Closure
Water is critical to survival. For humans there is a **Hierarchy of Water** (PP3.1) use ranging from survival water needs (drinking and cooking), to maintenance water needs, (personal washing, washing clothes, cleaning buildings, growing food and waste disposal) and lasting water needs (business and recreation). Water usage for survival purposes requires high water quality but usage is low in quantity and as the quantity of usage increases for maintenance and lasting water requirements, the quality of water decreases. This inverse ratio has been used constructively in the design of the house by incorporating technical states of water eg flowing water, water temperature, water storage, with aesthetic qualities of water, eg reflection in water, playing in water, water's visibility.

Water exists in three three forms: liquid (in oceans, rivers, lakes...), as a solid (as ice, snow, hail...) and as a gas (as water vapour). The **Hydrologic Cycle** (PP3.2) diagram shows water’s states and transformations. The water, which is constantly moving and changing over time, flows from the ocean to the atmosphere to the land and back to the oceans creating a natural filtration process (FN3.1). Water is relentless and continually transforms providing for both life and death. This cycle has been used constructively in the design of the house by incorporating the aesthetic qualities of water eg gas, ice, liquid with technical functions of water eg heating, cooling, cleansing. Critical to survival yet with the force to be destructive (flooding, tsunamis) water is beautiful in many ways and can be integrated into everyday life (FN3.2).

The great minds, **Thales of Miletus**, **Plato** and **Palissy** have all taken an interest in water (FN3.3). Water’s beauty and power are acknowledged and respected by writers such as
Saint-Exupery (FN3.4) and Masefield:

***Sea-Fever***
by John Masefield

I must down to the seas again, to the lonely sea and the sky,
And all I ask is a tall ship and a star to steer her by,
And the wheel's kick and the wind's song and the white sail's shaking,
And a grey mist on the sea's face and a grey dawn breaking.

I must down to the seas again, for the call of the running tide
Is a wild call and a clear call that may not be denied;
And all I ask is a windy day with the white clouds flying,
And the flung spray and the blown spume, and the sea-gulls crying.

I must down to the seas again to the vagrant gypsy life.
To the gull's way and the whale's way where the wind's like a whetted knife;
And all I ask is a merry yarn from a laughing fellow-rover,
And quiet sleep and a sweet dream when the long trick's over.

(PP3.3)

The various water states and transformations have distinctive tastes, sounds and smells. Water’s beauty is in its fluidity, transparency and reflexiveness. Water has symbolic meanings: to Chinese Feng Shui it represents good chi and in Christianity, it means cleansing. People are naturally drawn towards water for its aesthetic qualities and musicians frequently celebrate it in their work. Schubert’s Water Songs, Deep Purple’s Smoke on the Water, Simon and Garfunkel's Bridge over Troubled Water, Lady in the Water, are some examples of songs and movies inspired by water. Paintings by artists like Hockney, Dali, Picasso, Monet, Escher, English all depict the beauty of water (PP3.4).

In architecture, water is referred to metaphorically in the expression “spaces flow together”. Water is used physically as suggested by Moore and Lidz, that “through the careful arrangement of water and architecture, we can create for ourselves a place in the nature surrounding us – a place like Fallingwater, the Hearst pool, the Salk Institute, the Kyoto basins, or the Trevi – connected to the cycle, and all of the
world’s water” (1994, p204).

Connections between the two separate aspects of water, water as essential and water as entertainment, exist and can be extrapolated, overlayed and integrated into architecture.

(FN3.1) “In the cycle, water evaporates from oceans and the vapour is carried in air currents. As the vapour cools, it condenses and forms clouds or fog, which, with further cooling, may fall on land as precipitation (either rain or snow). This precipitation can then follow a number of pathways. It may be evaporated immediately, be absorbed by plants which then release the water back to the atmosphere through transpiration, or drain into surface water and groundwater systems which eventually drain into the sea”, (20 Apr 2007, http://www.stats.govt.nz/).

(FN3.2) “Water is not just a vital element in our lives, it can, also be experienced in a whole variety of ways. It creates different kinds of atmosphere and moods that appeal to our feelings”, (Woodward, 2005, p10).

(FN3.3) “Thales of Miletus (624-545 BC) reflected on the water cycle, Plato (427-347 BC) later philosophized about it and Palissy (1510-1590) provided scientific justifications” (Geiger, 2005, p78).

(FN3.4) “Water thou hast no taste, no colour, no odour; canst not be defined, art relished while ever mysterious. Not necessary to life but rather life itself, thou fillest us with a gratification that exceeds the delight of the senses”, (Tripp, 1976, pg687).
PP3.1 Hierarchy of Water

Drinking and cooking water
high quality, low quantity

Washing and cleaning water
medium quality, medium quantity

Sanitary and garden water
low quality, high quantity
Water constantly moving and changing over time, flows from ocean to atmosphere, to land and back to the oceans, a natural filtration process.
I must down to the seas again, to the lonely sea and the sky,
And a grey mist on the sea's face and a grey dawn breaking.
I must down to the seas again, for the call of the running tide
And all I ask is a windy day with the white clouds flying,
I must down to the seas again to the vagrant gypsy life,” Masefield.
Hockney – reveals water’s transparency & complexity
Dali – reflective qualities

Escher – shows effect of disturbing water
English – reflective qualities

Picasso – depicts the blue-ness of water
Monet – reflective qualities

PP3.4 Artists Paintings of Water
In 20th & 21st century architecture there is also a long history of the use of water in and around buildings. These (PP4.1) are examples of water at an aesthetic level that the design in this research project attempts to acknowledge.

Le Corbusier celebrated the triumph of running water by placing a sink in the foyer of Villa Savoye, 1928-30 and the roof solarium feels like the deck of a ship (Rowe, Friedman & Lahiji, 1997, p35 & 37; Weston, 2004, p62). Wright’s sense of water resulted in the extraordinary exposition of water and building: Fallingwater 1935-7. In the Kaufmann Desert House, 1946, Neutra placed the swimming pool to mediate the foreground with the desert beyond (Wylson, 1986, p212). Van der Rohe’s response to a flood prone site was to elevate the single-storey Farnsworth House, 1951 (Weston, 2004, p92). The free and sensual curves of Niemeyer’s Niemeyer House, 1953, are metaphorical expressions of sinuous courses of rivers (Weston, 2004, p112).

A stream runs through Noel Lane’s Westmere House. The use of water in Villa Savoye, Fallingwater, Kaufmann Desert House, Farnsworth House, Niemeyer House and other similar 20th & 21st century houses focus on the aesthetic aspects of water eg flowing water, sensuous curves, mediation.

In Canada and Sweden, there are Ice Hotels that are built of solid water (FN4.1). The freezing temperature is treated as one of the hotel’s experiences and the reason why most people staying there wear thick layers of insulated clothing. Most human activities are possible in these hotels, however, they have to be rebuilt every year because over the summer they melt.
While Reichardt (2006) thinks that “liquid architecture is ... an irrational architecture that only exists in cyberspace”, and Friedman (2006) thinks, that liquid architecture can only be a metaphor, Diller & Scofidio’s, Blur Building, can be considered a gaseous architecture that contradicts Reichardt and Friedman’s notions. Built in 2002 for the Swiss Expo the Blur Building emits water gas. Designboom (2006) describes it as an inhabitable cloud consisting of a metal structure that spray tiny drops of lake water from thousands of jets (FN4.2). Water’s wetness is one of the building’s main experiences and the reason why most people visiting it wear a watertight rain jacket.

Although the architectural profession celebrates these examples, they do not acknowledge the affect that they are having on the water crisis. Typically, the plumbing systems in modern houses (PP6.24) rely on external water and waste systems. Each year worldwide, each house on average (based on a household of 2.5 people) consumes about 230,000 litres of potable water from water reservoirs and the house roof catches (based on a house area of 200 square metres and rainfall of 95 millimetres per month) about 230,000 litres of rainwater. The house produces 230,000 litres of wastewater and 230,000 litres of storm water that is discharged into the rivers and oceans, (al Mobbs, Wrigley) causing widespread contamination of water (PP4.2). Architecture on one hand celebrates water but at the same time, architecture contaminates water.

(FN4.1) “10 000 tons of crystal clear ice....and 30 000 tons of pure snow...are needed to build the Ice Hotel... The hotel sleeps over 100 guests, and every bedroom is unique. Covering more than 30,000 square feet, the Ice Hotel includes an Ice Chapel, the hotel itself, an ice art exhibition hall, a cinema and last but not least, the world famous ‘Absolut Ice Bar’,” (Scantours, 2006)

(FN4.2) “an inhabitable cloud whirling above Lake Neuchatel” consisting “of a 60 x 100 x 20 - metre metal construction that sprays innumerable tiny drops of lake water from 31400 jets”, (Designboom, 2006).
Fallingwater, 1937, Wright celebrates flowing water

Kaufmann Desert House, 1946, Neutra pool mediates foreground of desert

Vancouver House, 2003, Patkau captures water’s reflected light

Taj Mahal pool famous for ability to reflect architecture

Ice Hotels, Canada & Sweden built completely of ice

Blur Building, 2006, Diller & Scofidio's emits water vapour
On average each year worldwide each house consumes 230,000 litres of potable water from water reservoirs and the house roof catches 230,000 litres of rainwater. Consequently the house produces 230,000 litres of wastewater and 230,000 litres of stormwater that is discharged into the rivers and oceans, causing widespread contamination of water.
Since the end of the 20th century, there has been considerable work on harvesting, recycling and treating water for use in buildings (FN5.1). The project design acknowledges these examples of water integrated at a technical level (PP5.1).


In the commercial building world, there are significant developments in sustainable technologies and aesthetic approaches using water. While commercial architecture is embracing the integration of water technically and aesthetically, it could be argued that this is not happening in the same way or at the same speed in domestic architecture. The methods of integrating water in commercial architecture are relevant to domestic architecture and are applied to the design.
The **Sustainable House**, located in Sydney, autonomously harvests and recycles water, and sends its wastewater to a wetland that consists of a landscaped catchment (Mobbs 1998). Typically, the plumbing systems for sustainable houses (PP6.25) rely on internal water and waste systems. Each year the house saves 100,000 litres of potable water, which is left in water reservoirs, and the house roof catches 100,000 litres of rainwater. The house keeps 100,000 litres of wastewater and 100,000 litres of stormwater out of the rivers and oceans, (Mobbs, 2004, p17) reducing contamination of water. However, water in the **Sustainable House** is not used metaphorically or symbolically and it is extraordinary that the sustainable house fails to celebrate water.

Although addressing the water crisis most green houses do not consider adequately the second level of relationship between humans and water – the positive aesthetic experience that is possible if one is able to find points of overlap between aesthetics and sustainability.

(FN5.1) “Sewage treatment plant at the Worme Hofgemeinschaft in Handeloh” “O'er seven stones the water flows, 'tis pure again, the farmer knows.' This piece of agricultural wisdom may well no longer apply to the present day and the highly complex ways in which water is now polluted, but there is a grain of truth in it: water is able to purify itself. But cities have long since had to say goodbye to giving sewage the time and space to purify itself. They have ultimately arrived at narrow-mesh sewerage networks and treatment plants, via the intermediate stage of sewage farms. This is a hygienic but very expensive method of getting rid of the daily quota of faeces. Since the early 1990’s country people have increasingly started to remember decentralized sewage treatment. An increasing number of farmers, but also private householders who have enough land, are letting their sewage flow not over seven stones, but through settling tanks and purification beds, so that it can then pass into an effluent tank having been cleaned”, (Dreiseitl, 2005, p94).
Sustainable House, 1996, Cantrill collects rainwater, recycles waste

Taylor House, 2001, Harmon rain collection system

Kangaroo Valley House, 2003, Murcutt rainwater stored in cisterns

Civil Lines, 1999, Lall water cooling

Water tank ubiquitous for its rainwater storage capacity

The Solaire, 2002, Pelli numerous green water features
Fortunately, there are overlaps in the aesthetic and technical uses of water in buildings (PP6.1). The potential overlaps include: pools storing water that can mediate between foreground and background through reflection; waterfalls that cleanse with the aesthetic of flowing water; water which when cooled or heated creates mist; and gardens grown from the discharge of water. Pools in the Kaufmann Desert House and Fallingwater have a technical function. They collect precipitation but the water is not used to operate the house. The wetland, where the effluent is sent, in the Sustainable House and Mawson House, has an aesthetic compound comprising of dense planting, although the smell of the water is repugnant. In commercial and community architecture there are some projects that utilize overlapping to integrate water technically and aesthetically. However, limited overlaying techniques have been found at the residential scale. Therefore, the project design focuses on an individual house and the potential overlaps to integrate the aesthetic and technical uses of water.

The project site (PP6.2), located in Auckland, is in a glen that has a history of connection with water. The land because of its steep sloping contour is a problematic undeveloped area of land. The height difference from the road to bottom of the site is approx 15 metres. At the western side of the site is the road access; to the northern and southern sides are neighbouring houses. Along the eastern side, an underground pipe contains a stream and the land area above the pipe is an overland flood path. Almost half of the site is covered by the overland flood path, which is there to accommodate a flood occurring once every fifty years (PP6.3).
The initial title for this research was *From Fallingwater to Waterfalling* and the first design called *Waterfalling* (PP6.4) occurred prior to any site mapping or studies of water. The house design incorporated a stepping series of ponds that formed the roof and terminated with a waterfall that connected to the stream. However, the water in ponds was above its occupants and could only be appreciated when it reached the waterfall. There were also issues with insulating the home. Nevertheless, the concept of creating ponds and waterfalls that supplied the water became the central theme. In later designs, the ponds moved to areas of the house that would not need insulating and to where the water would be more visible to its occupants. This exercise in the integration of form and technology provide clues for the collection of precipitation and levels of storage ponding.

The design process employed the normative architectural design process used in professional practice but prioritized water systems over other criteria in developing the design. There are numerous books outlining this design process and it is a methodology in which I have many years professional experience. One of the techniques employed in this design process is digital. This technique provides accurate overlaying of the maps prepared in the program Computer Assisted Design (CAD). The importing of site and mapping information into the architectural program CAD was the most efficient system for analysing the proposed design and its environmental impact thereby allowing the overlapping of technology and aesthetics to be easily seen.

Silver and Balmori (2003) state that “in recent years, new digital-mapping technologies have begun profoundly to alter the ways we measure and represent space” (pg11) and that “like the telescope or microscope, it allows us to see at scales impossible for the naked eye and without moving the physical body over space” (pg137). At the start of the mapping process, I had some
difficulty establishing a three-dimensional digital representation of my project site and surroundings. Equipment that could produce an instantaneous three-dimensional digital image downloadable into a CAD drawing would have been very valuable, much quicker and provided greater accuracy as the information would be from a single source. Instead, a manual process of topographically surveying, sourcing existing house drawings and drawing the information into a CAD drawing was used to provide an electronic model that represents the site and surroundings.

Water-features, air-space, trees, windows, decks, paths, drives, fences and neighbouring houses have been two-dimensionally mapped and undergone analyses that exposed aspects about the site that have helped inform the design. These were prior to the focus on water and to a degree shaped the design in its early stages. As the focus shifted to water, the design became influenced by the water focus.

Mapping the houses that neighbour the site provided information about the vistas between the houses that the design could orientate toward and be visible to (PP6.5). Two types of vistas are portrayed, vistas between adjacent houses, shown by dense hatching and vistas between buildings beyond the adjacent houses shown by subtle hatching. This map provided the design with positions for windows to view the open spaces between the surrounding houses and for neighbouring houses to see the house. This helped locate the house and its water features to be visible to the neighbouring houses and create opportunities for the awareness of water crisis solutions in an iconic way.

Mapped are two types of windows, windows in living areas, indicated by dense hatching and windows in bathrooms indicated by subtle hatching (PP6.6). The view through the windows is projected from the horizontal and vertical planes of the window frames. The window map has provided the design with wall locations that block direct views from surrounding
houses, where water could be placed and again create opportunities for the awareness of water crisis solutions.

Mapped are the heights and gradients above the site (PP6.7). This is a two dimensional drawing that allows a three dimensional reading of the space available for the design. This mapping helped determine the various height changes that water could be positioned to facilitate the various levels the water needed as part of its plumbing cycle and how the topography could be used to control the flow of water.

Mapped are the original stream, original flood area, overland flow path, storm-water drains, sewer drains and water pipes (PP6.8). This map shows there are many opportunities for the design to connect to the water cycle. Through the process of mapping water occurred the idea that the site and house are machines for processing water giving clues to potential water sources, flows and waste outlet.

Through the mapping process, the constraints of the site, in both the technical and aesthetic dimensions, were established and have determined the locations for the house and access to it (PP6.9). In conjunction with the mapping process a number of studies of water were undertaken. The water studies generated ideas that shaped the design by water. This process explored the three natural forms of water; liquid, solid and gas, and applied them to the design.

The flow study focused on the topography as vital to water and its flow (PP6.10). Architects when describing how architectural spaces relate to one another frequently use the term flow. Flow is of course a characteristic of water; it always flows downhill and collects in lakes or ponds or flows into rivers. **Fallingwater** is an extraordinary architecture that celebrates moving water. It has living spaces on terraces above a stream, the terraces are metaphorical diving boards, and water is sensed through sight, sound, smell, touch, feel and it is symbolically connected to the
water cycle (al Weston, Moore & Lidz), but when inside the house one is not aware of the water (FN6.1). One of the aims of the design is that water is an integrated experience within the house. Flowing water with the use of micro-generators could produce power to operate the house, an area that is not covered in this research but is an area of potential investigation.

One of the challenges of the site is to provide vehicle access. Linking flow in a functional and aesthetic way helped in solving this particular issue. Vehicle movements can resemble a sinuous river and the analogy of a river can be used to explore ways that a vehicle might navigate the descent. Friedman in 2006 proposed that, “behavioral systems form a kind of liquid architecture” “Traffic flow is a perfect example of liquid architecture”, he says. Here water meandering in rivers generates an option for vehicular movement within the site. Ponding water has often been used for its ability to reflect architecture and the most famous example of this is the Taj Mahal (PP6.11). When an object is reflected in water, symmetry occurs. The preciseness of the reflection is dependent upon the condition of the water's surface. Reflections cast by water that has a still surface, create near identical reflected images, but if the water’s surface is disturbed, a distorted reflected image occurs. In the Taj Mahal studies, the building is separated from its reflection to show how different conditions of water produce radically different reflected images. Although the reflections differ in relation to the surface water condition, the reflections are still a symmetrical image of the object being reflected. Another characteristic of the reflection is that the water’s surface is in the horizontal plane and the object is in the vertical plane, but the reflection, which is in the horizontal plane, appears in the vertical plane. Based on the Taj Mahal studies a grid is reflected in different surface conditions. In this study, the
reflective quality of water has given the design geometrical rules about changing direction by using a line of reflection.

The wave drawings were an exploration undertaken that became manifested in the design of the access, elevations and roofs (PP6.12). In the search for a roof form for the design a wave shape was explored and experimented with in a three-dimensional model (PP6.13). However, the downward concaved shape of the roof was not going to be suitable for creating pools in which to store rainwater.

In this study (PP6.14), dropping water onto different surfaces was used to observe the shape of water. When water falls on a surface, globules form. The shape of the globules depends on the viscosity of the surface and while no two globules are ever the same shape, they are always characteristically rounded. The globule water study generated a way for the second design to be shaped. Here a house shaped as a globule was explored and developed (PP6.15). However the more the design was developed the less globule like it became, to the point where it was considered that this attempt to design a building to be metaphorically water should be abandoned.

Water as an integral feature of domestic architecture is the theme of Stephen Crafti’s H2O Architecture. The fifty homes featured in full colour in this book are diverse, and include apartments and townhouses, small terraces and large houses. While the styles of these houses may vary, they are all enhanced by the magic of water, and demonstrate some ways that water can be integrated within architecture. Water is not seen as an afterthought but has been thoughtfully considered from the outset to achieve a certain goal. This book doesn't simply suggest using water for the sake of creating a "splash" or as a means of impressing visitors; its purpose is to show how, with imagination and skill, water can strengthen architectural forms, complementing the experience of living in these houses.
but nowhere are the technical and conservation aspects considered. In a review of 20th & 21st century houses that I undertook, I found that 30% of the houses I reviewed have some kind of water feature but that none of those water features form part of the water systems operating within the houses. (A1)

In the next design, water studies helped re-shape the site constraints that were established through the mapping process. The site plan shows how the mapping and water studies are brought together. The layout was simultaneously affected by the pragmatics and poetics of water. Reflecting water’s three-dimensional qualities and incorporating the existing stream the main plan was derived by laying a wave and globule form over the site (PP6.16). The various qualities relate to the functions of the site. For example, the kinetic energy of a wave is expressed in the movement to and from the site. The static nature of a globule is the area of stillness in which to locate spaces to live. Water is integrated over the entire site. The plan being affected by the location of ponds as water sources are integrated into the fabric of the house and managed in a controlled way.

The architecture for the house again integrates the technical and aesthetic by adopting the cartesian grid, which is placed inside the globule, and the various levels ripple out to express the splash that occurs similar to an object hitting a water surface. (PP6.17). The alignment of the house (PP6.18) is orientated to align with the vistas between the adjacent buildings and this in turn sets up oblique views away rather than direct views from the neighbouring houses allowing water integrated into the fabric of the house to be visible to its neighbours. The geometrical shifts to enable the chosen orientation are achieved by the placement of reflection lines where the changes of direction occurred.

As the house will consume and discharge about 230,000 litres of water and wastewater per year, (based on rainfall of 95
millimetres per month) the house, reservoir pools and wetland
are sized to be of sufficient catchment area for the rainwater
harvesting and wastewater processing needed to operate the
house.

While staying dry inside the cloud of the Blur Building or, warm
inside the Ice Hotel is problematic, there are also many
problems keeping water potable, especially if the water is
stored, not inside a cistern but displayed as a water feature, as
proposed for the Aqua House. In examining potential overlays
between attempting to keep water potable and the aesthetic
qualities of water, solutions became apparent for the design.
Robinson specifies that for pool water management, “you will
need a depth 60cm (2ft). A depth less than this is an invitation to
algae to spread” (p70). Lessons learnt at The Grey Water
System at Linacre College, Oxford “found that rainwater can
collect material from roofs and down pipes and, when allowed to
remain undisturbed for long periods, can become septic” (Roaf,
Fuentes, Thomas, 2003, p271). Mobb found that during the
design of the Sustainable House “mosquitoes breed best in
stagnant water” (p66). The design has had to overcome the
issues of still water becoming non-potable. Mobb’s also
discovered during the design of the Sustainable House that an
“option for killing mosquito larvae is to fill the pond so that it
overflows and washes out the larvae” (p65). “Submerged
oxygenates” (Robinson, 2005, p121), planted in the bed of a
pool will aerate the water stored in a pool. The Hutt City
Council advises, “collect rain water and use for washing or
cooking - boil before drinking”, (http://www.huttcity.govt.nzcoun councilservicesesemowerwater.html). The
research has shown that there are many ways to keep water clean.

Some of the ways the design maintains good quality water are
by: keeping the water moving to stop it stagnating; utilising
waterfalls to assist oxygenation; raising or lowering its
temperature to kill containments; installing treatment tanks for dropping off heavy sediments, filtering water to remove excess nutrients; oxygenating planting to aerate the water; and using an ultra-violet clarifier to destroy viruses and pathogens.

The various qualities of water are celebrated in the design of the house. The floor plans (PP6.19-21) show the locations where water operates and is exposed throughout the house in various ways so that is can be appreciated and the places in the house where different methods of ensuring potability are located. They consist of refection ponds, waterfalls, water storage columns, fountains and a swimming pool, which all provide a function for the plumbing of the house. The corner where the main deck is trimmed off gives a feeling of being at the bow of a ship, in a similar way to Villa Savoye where the roof solarium feels like the deck of a ship. There is not a space within the house that one is not aware of water. The cross section (PP6.22) shows how the water is integrated by continually circulating through the house to maintain its cleanliness. Allocated at different levels within the houses are pools that store the three different water qualities and between them are waterfalls. The water is collected from outside the house and then is fed into the house, making its way through the house before returning outside. The high quality water pools are located at the upper levels and overflow onto medium quality storage pools that overflow into low quality storage ponds.

Water occurs in the architecture of the house at physical, metaphorical and symbolic levels because the design process has required every aspect about it to have a watery relationship. The elevations (PP6.23) express flow and artistic watery expression similar to the paintings by well known artist, Monet, Dali and Hockney. The composition of the elevations has been derived from a series of water features representing pools and streams, similar to the Niemeyer House and its metaphorical expressions of sinuous courses of rivers. The mapping of
colours refers to the numerous colours water has the ability to reflect. In response to the site's flood plane, part of the house cantilevers over it; this was Van der Rohe's response to elevate the Farnsworth House over a flood prone site.

There are numerous ways that water effects building and usually the concern is with the control of and protection from water. Generally, buildings are designed to keep the structure of the building and its occupants dry; the function of the building's fabric is resisting and repelling water. Water is however required in buildings to provide for its occupant's needs and is normally fed through the building in a managed and controlled way. When the occupant's water needs are fulfilled and the buildings fabric has performed its task, the wastewater is dismissed and discharged. In Modern Plumbing (PP6.24), water companies supply and discharge water and wastewater to and from buildings, through an infrastructure of underground pipes. All the water supplied is high quality and over time quantity has increased and they are generally wasteful of this precious commodity. In the alternative ‘Sustainable’ Plumbing method (PP6.25), water and wastewater are harvested and recycled to and from a house through an arrangement of cisterns. While alternatively plumbed houses are more environmentally friendly, they are a minority. The two plumbing diagrams are different, one focuses on sources of water and, the second has an additional focus on storage and alternative forms of discharge. In the appendices (A1) is a review of 20th & 21st century houses that I undertook. I found that 5% of houses I reviewed have incorporated rainwater harvesting and water recycling techniques. However, once again no aesthetic use of water is present in those houses. The design's early plumbing diagram (PP6.26) show a single source, supply and circulation of rainwater, re-cycled and wastewater and this is evident in the earlier designs. However, it became apparent that processing high, medium and low quality water together was inefficient and unhealthy. As established by the Hierarchy of Water there are
three different personal water needs, which in a house represent a need for three separate water-processing systems and so the design of Aqua House revolved around the plumbing of the three water qualities. The three different systems are also visible in the plans, sections and elevation drawings.

Aqua House is independent of the city’s water supply and waste systems, in a technical and aesthetic way that aims to eliminate its dependence on the city’s water supply and wastewater network. The technical operation is to supply water to the house by harvesting precipitation, recycling greywater (FN6.2) and purifying effluent. The aesthetic component is to incorporate the technical component in a way that the water can be used pleasurably. Aqua House is designed to integrate rainwater harvesting and wastewater recycling techniques to provide aesthetic functions for the house. In the design, water and wastewater is harvested and recycled to and from the house, through a series of water features and is plumbed to make the movement of water an aesthetic experience. Water is circulated by both gravity and mechanical means eg water pumps, heating and cooling pumps, however achieving a total gravity feed system is not fully explored in this research and is an area of research that warrants further exploration.

Water, which is collected, recycled and cleansed, is celebrated and organises the house. The Aqua House plumbing diagram (PP6.27) shows how the house autonomously collects and treats water within the site using the Hierarchy of Water as it organiser. Rain falling onto the roof is collected and sent to the water storage pools. The pools are located at different levels and the water continually circulates between them. Water for drinking is syphoned from the storage pools and sent to a steam pond where the water is heated to boiling point to purify it, then it is sent to water storage columns. In winter, distributing warm water through the house by way of underfloor pipes is used to heat the house. By using reverse heat pumps this process is
reversed in summer and the water frozen as ice, and then thawed to purify it and cool the house. Before being used for drinking and body washing, it passes through a water filter. Water for cleaning purposes eg bath, dishwasher, showering and house cleaning is syphoned directly from the medium quality water storage pools to those functions. The greywater from the drinking, washing, showering and cleaning is recycled for toilet, clothes washing and plant watering functions. The recycled water first enters a treatment tank for removal of soaps and dirt, then is sent to an upper level and circulates continuously down streams on each side of the driveway to a recycled water pool. The recycled water is syphoned off for toilet flushing, clothes washing and plant watering. The effluent resulting from toilet flushing and clothes washing, better known as ‘black water’ (FN6.3) is sent first to a treatment tank where the solids are dropped off and the liquid is discharged to a landscaped wetland. In the wetland, the black waste is purified through a filtration process, absorbed by the landscaping and evaporates into the atmosphere. In the way that water is processed by the Hydrologic Cycle, the house is organised around the integration of storage, movement and appreciation of water.

In the foyer of the L'Aubier Hotel and Restaurant, Switzerland, rainwater used for the hotel's washing, cleaning and toilet flushing, is stored in a water feature that consists of a sculptural arrangement of rods, chains and cups that harmonically vibrate as the water flows over it (FN6.4). In the entry hall of the house is a reflection pool that stores high quality water (PP6.28). It celebrates the triumph of harvested water in the way that the sink in the foyer of Villa Savoye does, and invites cleansing of a guest’s journey. Visible from most of the living spaces within the house is the central swimming pool (PP6.29). The pool stores the medium quality water used for bath, shower, dishwasher and house cleaning. Water in the pool is kept warm by being fed through photovoltaic panels on the roof of the house and can be
used to warm the house during winter. Water is continually circulating in and out of the pool, which avoids the need to chlorinate the water. The bedroom at the upper level has views out over a reflection pond that stores harvested rainwater (PP6.30) and as in the Kaufmann Desert House mediates the foreground with the neighbouring houses beyond.

The Ice Hotel’s structure is completely of water in a solid state, but is an inappropriate and unsustainable structure for the Aqua House, for climatic reasons. However, the aesthetic quality of the Ice Hotel’s structure is captured by, a structure that consists of a series of water columns (PP6.31). The water columns replace the underground water cistern used in the Sustainable House allowing visual appreciation and awareness of quantity of the stored water, while also being used to supply the water needs. Periodic maintenance will be necessary to clean the water column glass.

In the natural environment as water flows from mountain to sea, clean water is produced. Similarly, by artificial methods at smaller scales, clean water can be produced (FN6.5). This principle is used in the design and the principal of cooling the spaces of the house is used. Nicholas Grimshaw used the principal of water for cooling in 1992 for the British Expo Pavilion in Seville (FN6.6). There are waterfalls (PP6.32) between the various reflection, storage and swimming pools in the Aqua House. The main purpose of the waterfalls is to keep the water free from accumulating leaves and preventing the growth of mosquito lava. There are two types of waterfalls in the house; freefalling and running over glass. These also serve to cool the house in summer. The plans, sections and elevation show the flow locations of the water. The sound of moving water can be disconcerting, and when Philip Johnson visited Fallingwater, he said that the waterfall excited his bladder. The waterfalls have three modes of operation. Firstly, full on which occurs during rainfall when the sound of the waterfall is
mitigated by the sound of rain. The second is normal mode where the water gently trickles and the sound is faint. The third mode is off; although the off mode will disrupt the cycling, water-purging process so cannot be maintained for long periods.

“Sustainable Home Guidelines (Waitakere City Council, 1999) which is based on the experience of their own eco-house development” (Turner, 2000, p127) is appropriate to Auckland’s conditions and has guiding principals to formulate a vocabulary of sustainability for community developments. **On-site wastewater systems** as sourced from the WCC “Sustainable Home Guideline” include; Long drop, Ventilated privy, Septic Tank, Dual Chamber Septic Tank, Aerobic Treatment Plant, Electric Toilet, Incinerator Toilet, Aerated Composting Toilet, Solar Compost Toilet, Biological Toilet, Solid/fluid Separation, Chemical Toilet, Chemical Flush Toilet. **Effluent and grey-water disposal systems:** as sourced from the WCC “Sustainable Home Guidelines” include Sand Filtration, Evapotranspiration, Aerobic Soakage Bed, Compensated Dripper-lines, Wetland Flow and Oxidation Pond. However “the national Building Code states: ‘Where a sewer connection is available, the (home) drainage system shall be connected to the sewer....’ On-site systems are therefore, not generally an option if you can connect to a sewer, (WCC, 1999). However “if you are connected to the main sewer, there are still things you can do to help ... you may be able to re-use your grey water”, (WCC, 1999). Changes to the way wastewater is managed in New Zealand are coming as evidenced by North Shore City’s proposed new stormwater management measures, which will require property owners to manage stormwater within their property by installing mitigation devices such as rain tanks or bio-retention gardens.

Although the site has a sewer connection, a wetland flow and oxidation pond is incorporated into the design. This system has been successfully employed in the Sustainable House, which is
also located in the city. The wetland (PP6.33) (FN6.7) is a landscaped area where the effluent is sent to be purified and is located away from the main house to distance its occupants from the unpleasant smell that is associated with the treatment process. Treated water from the wetland overflows into the old stream as purified water and connects the site to its historical water cycle.

The **Living Water Park** in Chengdu, China consists of a housing development for 100,000 people that overlooks an accessible recreational waterfront park where contaminated water is aerated by flowing it through fountains, streams, ponds, and vegetation (FN6.8). The body of water around the house is the storage pool for low quality water, the wetland is located around the groups of trees and either side of the driveway is rock lined stream were recycled water flows. The exterior view (PP6.34) lists the various ways that water is integrated into the architecture of the house. Viewed from the various sides of the house, the recycled water pool and low water quality water pools are visible at the base of the house. The steam rising around the house is from the water heating processes again permitting a connection with the water cycle. Constructability of the ideas developed in this research has not been fully explored and there are opportunities for investigating construction solutions.

The project site (PP6.35) is steeply contoured therefore well suited to forming artificial streams and waterfalls and in a manner similar to the **Living Water Park** and the **Hydrologic Cycle**, cleanse the harvested and recycled water. However to provide the building’s water needs the falling water will eventually be contained and stored in pools. In the design, water is heated to boiling point so that it is drinking water used within the house and in the process create the effect achieved by the **Blur Building**, through steam.

The **Aqua House**, like the **Sustainable House** has the
possibility of each year sending 0.0 litres of effluent and 0.0 litres of stormwater to the rivers and oceans, but manages in the process to celebrate water. (A2)

(FN6.1) “cantilevered above the waterfall....you actually could not see the falls from the house. You could only hear the sound.... you had to go outside and look down... to see the falls” (Green).

(FN6.2) “Grey water – ‘waste’ water from a house which does not contain faecal matter – usually accepted as used water from showers, baths, basins, sinks, tubs” (Wrigley, 2006, p16-2).

(FN6.3) “Black water – Used water (effluent) from toilets (water closets, WCs) containing urine and faeces” (Wrigley, 2006, p16-2).

(FN6.4) “Musical fountain...power plant for storing rainwater that is used for the hotels toilets and washing and cleaning facilities”, (Dreiseitl, 2005, p22).

(FN6.5) “Rainwater for the bears in Zurich zoo” “The water is pumped up to a rocky plateau, and then runs down an impressive waterfall 6 metres high and 3 metres wide into a stream to two little lakes. It is a considerable challenge to use a comparatively simple technique to process surface and circulating water in a way that is aesthetically appealing and drinkable for the animals. Part of the cycle of 2,000 litres per minute trickles alternately through one of a total of three filter beds in a vertical direction, before being returned to the water cycle”, (Dreiseitl, 2005, p66).

(FN6.6) “The east elevation is the focal point of the building, animated by a water wall, 65 metres long and 18 metres high. The building’s structure is internal, and on the outside water adheres to the glass, forming rhythmic patterns as it runs down the surface. The environmental purpose is to create an intermediate zone of coolness. The water cools the immediate environment by reducing the surface temperature of the glass, thus reducing the radiant heat into the building; whilst, the water spray cools the surrounding air by evaporation”, (Architectural Design, 1994, pg37).

(FN6.7) Diagram from Mobbs, 1998, pg123

(FN6.8) “Contaminated water from rivers...flows through....gardens via gravity. The contaminated water” is “cleansed with modern technology (through mechanical systems), biologically (through vegetation), and chemically (through oxygenation): using principles of landscape technology, sculpture and architecture”, (Architecture Asia, 2005-06, p65).
Swimming pools collect rainwater which can be used to supply water to the house.


Drinking water for bears that is cleansed by waterfall.

Gardens could be wetlands that clean wastewater.


Swimming pools collect rainwater which can be used to supply water to the house.

Living Water Park, 2005, China. Water features aerate polluted water.


Zoo Zurich, 1997, Dreiseitl. Drinking water for bears that is cleansed by waterfall.

Living Water Park, 2005, China. Water features aerate polluted water.


Zoo Zurich, 1997, Dreiseitl. Drinking water for bears that is cleansed by waterfall.

Living Water Park, 2005, China. Water features aerate polluted water.
Project Site – is in Auckland, is in a valley and is surrounded by houses and trees

Stream – flows in an underground pipe along the edge of the project site
Piped Stream – physical presents of water not able to be appreciated, above pipe is an overland flood path

Project Site – steeply contoured land, has a 15 metre height difference from road to lowest ground level of site
Rain is collected by a series of roof pools

Site Plan

Water falls from roof pool to ground level pool which is visible from within house

Cross-section

Storing water on roofs has structural and insulation issues and water is not visible from within house

Aerial View

PP6.4 First Design
Vistas between neighbouring houses that present opportunities for more distant houses to see how the project design integrates water.

Shaded area indicates the vistas between neighbouring houses.
Views from windows of neighbouring houses present opportunities for the neighbouring houses to see how the project design integrates water.
Overlaying the topographical contours provided clues about
the various heights at which water could be located to suit the
different quality levels of water.
Although not physically visible a large area of the site is covered by water, there are many opportunities to connect to the water, for the water to be visible and for processing water.
Area for house and water collection

Area for vehicular turning and water collection

Area for vehicular/pedestrian access and water collection

Area for water storage and waste water treatment
Water flowing in rivers Path of turning vehicle Path of moving vehicle resemble water flowing in rivers

Analogy of water flowing in river explores vehicle’s path to access site

Vehicular path requires removal of trees and reduces potential wetland area

Vehicular path uses large area of site and reduces potential water collection area
Reflections of the Taj Mahal are removed from the artifact to distinguish the various conditions of the water's surface. An interface exists between the object and its reflection – a line of reflection. Reflections are always symmetrical.

Reflections of the Taj Mahal are identical. Broken water's surface is distorted. Reflections and objects are symmetrical in the vertical plane. Reflection is in the horizontal plane.
Wind’s energy is transferred to water

Friction from wind blowing over water creates ripples, then chop which develops into swells.

As swell approaches the land, water’s shape is determined and is dynamic.

PP6.12 Wave Study

Drawing study to create architectural form shaped by water, but form created is static.
Search for architectural form a wave shape roof tested on model of design. Shape of the roof suited water shedding but not water storage pools.
Water dropped onto different surfaces to observe shape of water created.

Shape of the globules depends on viscosity of the surface.

Globules are always the same shape, but always characteristically round.
Globule placed on site in location for house

Series of glass columns form walls for house

Interior view of columns that could store water

Recreational pool around house collects and stores water

Water falling between pools visible from deck

Pool located above garage improves house insulation
PP6.16 Concept Plan

Concept plan derived by adding wave and globule

Static nature of globule area of stillness suits spaces for living

Kinetic energy of wave for movement to and from the site

Globule and wave connect with historical water
Object dropped into water ripples created

Ripples created are always concentric

Rectangular would create concentric rectangles

Plan of house manifested out this notion

PP6.17 Ripple Study
House levels ripple expressing splash landing into globule

Globule becomes reservoir for collecting and recycling water

Windows with water views from neighbouring houses

Wave becomes drive with water recycling streams either side

Areas of trees suit wetland location

Vistas of water visible from neighbouring houses

Reflection line controlling changes in geometry

PP6.18 Site Plan
Water Column – high quality water storage that supplies drinking and washing needs

Water Column – medium quality water storage for dish washing

Swimming pool (lower level) – reservoir for medium quality water

Symbolic pool – reservoir for quality water for supplying basin water needs

Water Column – low quality water storage for wc flushing and clothes washing

Mediation pool – high quality water storage

Water Column – high quality water storage

Glass floor – allows views of water reservoir below

PP6.19 Mid Level Plan
Reflection Pool – rainwater collection reservoir where high quality water is siphoned from

Water Column – high quality water storage that supplies drinking and washing needs

Rainwater falling on roofs cascades over roof edge to reservoirs below

Water Column – high quality water storage for basins and shower

Water Column – low quality water storage for wc flushing

Roof skylight that mimics a river, permits view of rain and clouds from living areas

Reflection Pool – rainwater collection reservoir where high quality water is siphoned from

Rainwater falling on roofs cascades over roof edge to reservoirs below
Swimming pool – reservoir for medium quality water, also for swimming

Chi pool – high quality water storage for bath, shower, basin

Water Views – bedroom Windows have views to external ponds

Water Views – studio windows have views to external ponds

Water Column – low quality water storage for wc flushing
Swimming pool – capacity sized to supply medium quality water demand for house

Stream – collects recycle water from streams on each side of drive

Reflection Pool – rainwater collection reservoir, garage provides insulation from internal spaces

Collection Roof – collects rainwater for reservoirs, photovoltaic panels for water heating mounted on roof

Waterfall – circulates water between pools, separated from interior by glass screen

Water Column – capacity sized to store high quality water demand for house

Collection Roof – collects rainwater for reservoirs, photovoltaic panels for water heating mounted on roof

Plant – location for filters, pumps and treatment equipment

Pond – capacity sized to store low quality water demand for house
Elevations - artistic metaphorical watery expressions

Composition derived from pools, streams, waterfalls, waves

Cantilever responses to site's flood plane

Cutback permits water storage pool

Water has ability to reflect numerous colours

PP2.23 Elevations
Effluent from the building is discharged in underground pipes to locations beyond its site.

Water stored and circulated through the building in concealed pipes and cisterns, is only visible at its final destination.

Rain falling on the building's roof is discharged in underground pipes to locations beyond its site.

High quality water, from water companies beyond the site, is supplied to the building in underground pipes.

Effluent from the building is discharged in underground pipes to locations beyond its site.
Rain falling on the building’s roof is stored in cisterns located within the building’s site.

Potable water, from water cisterns supply the building’s occupants water needs.

Water stored and circulated through the building in concealed pipes and cisterns, is only visible at its final destination.

Effluent from the building is treated within the building’s site.

17% of houses reviewed incorporate green methods of plumbing.
Early plumbing designs for houses focused on the appreciation of water and did not distinguish the three different water qualities or demands that operate in a house.

- **Water feature:** Collects and stores rain to feed the water demands of the house.
- **Harvested water:** Supplied to the plumbing fixtures is discharged as waste water.
- **Waste water:** Is sent to a wetland for purification.
Plumbing for Aqua House integrates the 3 quality levels of water with the 3 water demands for the occupants.

1 = High quality water storage pool
2 = Medium quality water storage pool
3 = Low quality water storage pool
4 = Water circulating by waterfall, fountain or stream
5 = Water circulating in pipework
6 = Water heating (winter) and cooling (summer)
7 = Water storage column
8 = Plumbing fixtures supplied with water
9 = Water filtering equipment
10 = Waste water treatment equipment
11 = Water heating equipment

Condensation / moist air
Precipitation
Steam / mist

Evaporation
Ground water and runoff
Water heating equipment
Waste water treatment equipment
Water filtering equipment
Plumbing fixtures supplied with water
Water storage column
Water circulating in pipework
Water circulating by waterfall, fountain or stream
High quality water storage pool
Medium quality water storage pool
Low quality water storage pool
Water heating (winter) and cooling (summer)
Entry lobby - reflection pool stores high quality water, triumph of harvested water is celebrated.

Entry lobby pool reflects night sky and moonlight.

Entry lobby window captures moon and night sky.

PP5.28 Entry Reflection Pool
Lower Level - recreation pool stores medium quality water, visible throughout the house, is suitable for swimming.
Upper Level - reflection pool collects rainwater and mediates the foreground.

Bedroom window captures view of reflection pool located on roof of garage.
Water Columns – stores harvest water, allows visual appreciation and awareness of quantity.

Glass wall construction to permit vision of water.
Waterfalls – water flows through house and site, is cleansed by the cycle, is seen and heard.

Waterfalls keep water free from accumulating leaves and prevents the growth of mosquito lava.
Landscape absorbs effluent, converts wastewater into purified water

Effluent treatment system successfully used in the city

Purified water overflows into stream and evaporates into air, completing the water cycle
Integration of water and AQUA HOUSE visible to neighbouring community could raise awareness of solutions to water issues.
Project site transformed by design that integrates architecture and water.

Steam – visible from surrounding neighbour flows into atmosphere.
7 Conclusion

On reflection, the early site investigations could have focused more on the possibilities of the use of water, but at that stage, it was not apparent how all-pervasive water is in the domestic environment. This project has used recent developments in architectural practice that attempt to reduce usage and reduce discharge as its starting point, and sought to integrate aesthetic aspects of the human/water relationship with these practices. This research has found the visibility of water and water systems is important as icon of sustainable water practice merged with watery aesthetics. During the process there were changes in priorities in planning relating to the storage and discharge of water. It is possible to extrapolate the noted applications to other building types beyond residential.

Since the end of the 19th century, when homes were reorganized around the availability of water, the use of potable water and the discharge of non-potable water has increased at an extraordinary pace. This is contributing to the water crisis (FN7.1). In the city, houses are predominantly connected to the city's water supply and waste systems. The study indicates there are more houses with aesthetic water features than houses with conventional rainwater harvesting and wastewater recycling systems. Generally, where a house has water used for aesthetic pleasure, the water is not used in the mundane operation of the house. The popular aesthetic use of water is harming the environment while there is talk of other measures to protect the environment.

Water, which is an important commodity, is sent to waste yet it can be recycled and provide significant benefits for ecosystems within the city. Through the process of designing a house for the project site, valuable ideas that propose ways architecture might
incorporate water to support sustainable ecosystems have been revealed. These could contribute to making the city more sustainable (FN7.2).

The design process explored water and applied the findings to the design. The *Aqua House* is designed to integrate water in a technical and aesthetic way autonomous from the city’s water supply and waste systems, and if similar ways of managing water became popular, the damage being caused to the natural water environment could be reduced. The *Aqua House* with its environmentally friendly and pleasurable plumbing solutions could appeal to the mainstream and be an example for other 21st century houses (FN7.3). There is potential for further ongoing research in the areas of water/power generation, constructability, and gravity only/mechanical free solutions.

The use of water to drive the design process turned out to be revealing of possibilities that could be further developed. This study shows there are numerous opportunities and possibilities for incorporation of water in the home. Water is not just aesthetic or technical and the ways water has been integrated could also be applied to larger commercial buildings. The aesthetic and technical dimensions of water could be combined citywide. Plumbing has aesthetic possibilities and the process of cleaning water can be beautiful.

(FN7.1) “If we do not want to have to dig our own water in the future, we must think co-operatively, decentralize, and establish autonomous systems for water use at a local level”, (Geiger, 2005, p78).

(FN7.2) “The all important question ...what form and structure would make the city more sustainable”, (Frey, 1999, p23)

(FN7.3) “In the future we should be increasingly concerned with being able to experience water and gain insights into how to handle it sustainably”, (Dreiseitl, 2005, p9).
Design integrates water and architecture technically and aesthetically, in a managed way that could reduce damaging effects of architecture on the water environment.

Research has potential for further exploration in the areas of constructability, water/power generation, and gravity only/mechanical free solutions.

Project shows the presence of water need not just be aesthetic or technical, water can be integrated into architecture at a residential scale and results of research could also be applied to designs for architecture at larger scales.
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Aim of search – to find houses, which has all of the five categories of water: protection, operation, aesthetic, harvesting and recycling, integrated.

## Category Chart

<table>
<thead>
<tr>
<th>SEARCH CATEGORIES</th>
<th>CATEGORY DESCRIPTION</th>
<th>CATEGORY EXAMPLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repelled</td>
<td>Water that is resisted from entering a building</td>
<td>By floors, walls, roofs, gutters etc</td>
</tr>
<tr>
<td>Operational</td>
<td>Water that is used to supply a building’s plumbing</td>
<td>To kitchens, bathrooms, toilets etc</td>
</tr>
<tr>
<td>Aesthetic</td>
<td>Water that has a symbolically, metaphorically or leisurely function</td>
<td>Symbol for cleanliness, metaphor of water, swimming pools etc</td>
</tr>
<tr>
<td>Harvested</td>
<td>Water that is collected by a building to operate a building’s plumbing</td>
<td>For drinking, washing etc</td>
</tr>
<tr>
<td>Recyclable</td>
<td>Water that a building sends to waste that is recycled to operate the building’s plumbing</td>
<td>For toilet flushing, garden watering etc</td>
</tr>
</tbody>
</table>
Rating method - each house is rated, the totals are added together and then the percentage of each category calculated. The search included 20th and 21st century contemporary houses, eco-system houses, houses personally involved in and houses surrounding the project site.

Rating defined by the following numbers:
1 = water relationship is physical
1 = water relationship is symbolic or metaphorical
1 = water harvesting and recycling integrated aesthetical

### Rating Chart

<table>
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## 20th and 21st Century Contemporary Houses

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## Eco-system Houses

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# Houses Personally Involved

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TOTAL: 16 16 3 0 0

PERCENTAGE: 100% 100% 19% 0% 0%
A2 Aim of Project Design

Aim of project design – to design a house, which has all of the five categories of water: protection, operation, aesthetic, harvesting and recycling, integrated.

### Project Design Chart

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A3 Exhibition
AQUA HOUSE

"Water management in the town, like for example rainwater removal, drinking water provision and sewage disposal, is dealt with functionally, scarcely visibly and without any aesthetic sense as part of the engineer’s domain" (Dreiseitl, 2005, p9).

If water operates in architecture at either a technical or an aesthetic level, can architecture integrate the technical and aesthetic aspects of water?

Lammert Leslie Dykstra
Unitec New Zealand, Masters of Architecture, Masters by Project Level 9, Exhibition, 2007
Architecture that focuses on incorporating water aesthetically, that AQUA HOUSE acknowledges.
Architecture that focuses on incorporating water technically, that AQUA HOUSE acknowledges
Artist's work inspired by water, that AQUA HOUSE acknowledges
In modern plumbing (left) water, only visible at its final destination, invisibly enters and invisibly leaves the site.

In green plumbing (right) water, only visible at its final destination, visibly enters and invisibly stays within the site.
In AQUA HOUSE plumbing water, visible at its final destination, visibly enters and visibly stays within the site.
Opportunities to raise awareness of water’s integration in the AQUA HOUSE resulted from studies of the site.
Research studies inspired by water, which manifested in the design of AQUA HOUSE
Water that supplies the plumbing fixtures is experienced throughout the site and spaces in the AQUA HOUSE.
AQUA HOUSE is architecture that focuses on integrating water technically and aesthetically.
"If we do not want to have to dig our own water in the future, we must think co-operatively, decentralize, and establish autonomous systems for water use at a local level"; (Gelger, 2005, p78)

**AQUA HOUSE explores the possibility of architecture which integrates the technical and aesthetic aspects of water in the design of a house.**

The technical and aesthetic integration of water and architecture proposed by this project design, could be applied to architecture at all scales. The potential for this research project is to raise awareness of new ways to manage water in the city and to generate further research into the integration of water and architecture.

Acknowledged for their support and contribution: Principal Supervisor: Professor Michael Austin; Associate Supervisor: Dr Amanda Hyde de Kretser; Masters Critics & Cohort: 2005-2007; Love of my Life: Tracey Dykstra.