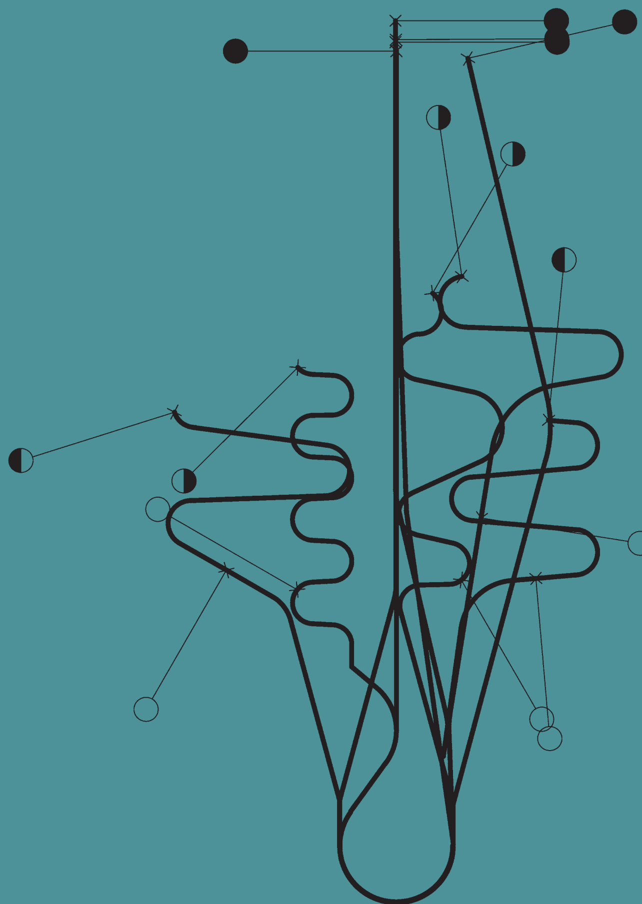
Bartlett Design Research Folios

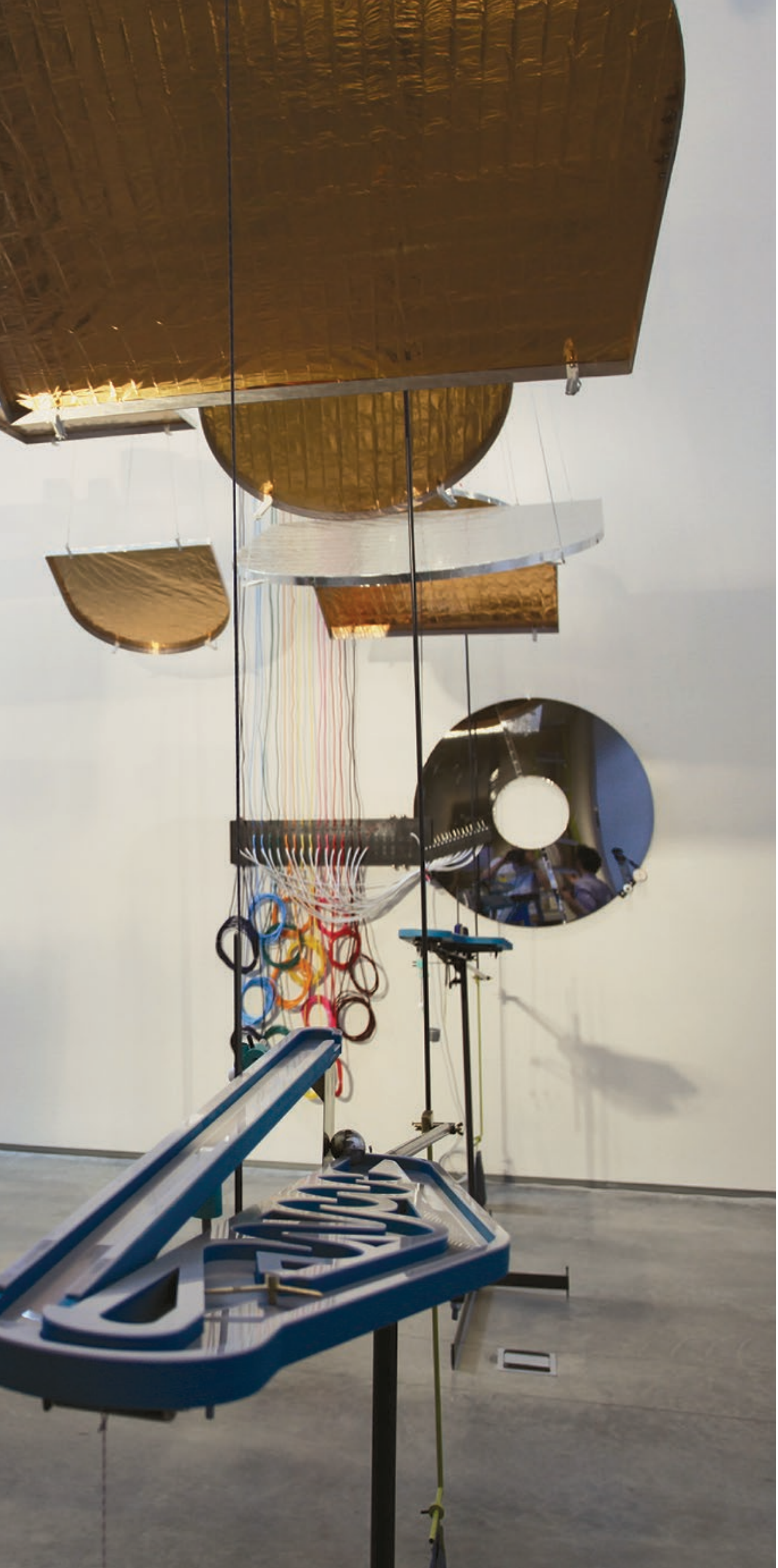
Hydrological Infrastructures



by Smout Allen

Project Details

Practice:	Smout Allen
Designers:	Mark Smout and Laura Allen Mark Smout and Laura Allen contributed equally to this project through their joint practice, Smout Allen.
Title:	Hydrological Infrastructures
Output type:	Exhibition
Exhibition:	*Landscape Futures: Instruments, Devices and Architectural Inventions*
Venue:	Center for Art and Environment, Nevada Museum of Art, Reno, USA
Curator:	Geoff Manaugh (BLDGBLOG)
Dates:	13 August 2011 – 19 February 2012
Size:	The Surface Tension installation is approx. 9m (high) × 7m × 9m.
Funding:	Nevada Museum of Art; Graham Foundation for Advanced Study in the Fine Arts; National Endowment for the Arts; Andy Warhol Foundation for the Visual Arts; Bartlett School of Architecture Research Fund
Fabrication team:	Laura Allen, Mark Smout, Johan Hybschmann, Kyle Buchanan, Jon Kaminsky, Sandra Youkhana, Amy Hiley, Rae Whittow-Williams and Janinder Bhatti, with assistance from the Bartlett School of Architecture Workshop
Other exhibitors:	David Benjamin and Soo-in Yang (The Living); David Gissen; Mason White and Lola Sheppard (Lateral Office); Chris Woebken and Kenichi Okada; Liam Young



1
Surface Tension installation at the Nevada Museum of Art, Reno, USA

Statement about the Research Content and Process

Description

This design research examines hydrological infrastructures from the planetary to the city/landscape scale. Two projects, commissioned by the Nevada Art Museum, utilise interactive design methods, large-scale exhibition installation and time-based drawings to visualise the changing architectural scales of the planet's hydrological resources: 'Surface Tension' examines peak water, and the 'Wet Lands' housing scheme addresses water stress.

Questions

1. **How can responsive environmental design demonstrate different scales of hydrological infrastructures and relationships that compose the planet's water resources?**
2. **How can two scales of critical water impact be represented: a. 'peak water' (i.e. geological and climatic water resources), and b. 'water stress' (i.e. London-based water supply issues)?**
3. **How do analogue and computational architectural design techniques enable this design process?**
4. **How can dynamic architectural design aid public understanding of limited environmental resources?**

Methods

1. **Examining the effects of increased climate variability on hydrological resources.**
2. **Identifying and integrating architecture with hydrological infrastructures and technical design strategies that respond to these conditions.**
3. **Developing fabrication techniques, systems and drawings that dynamically represent these changing conditions.**

Dissemination

Exhibited in Reno and Winnipeg; published in *Landscape Futures, Architectural Design, P.E.A.R.* and *Architectural Review;* presented in five lectures and an online film (with over 5,900 views). The exhibition was reviewed, including in *BD Online, Domus, Surface Magazine, BLDBLOG, Socks, Fast Company, Pruned, Cool Hunting, Metropolis* and *Art Ltd.*

Statement of Significance

Commissioned and funded by the Center for Art and Environment at the Nevada Museum of Art for *Landscape Futures: Instruments, Devices and Architectural Inventions,* curated by Geoff Manaugh. Elements of the work are held in the Nevada Museum of Art's permanent collection.

Statement of Co-authorship

The authors are jointly responsible for all conceptual and design authorship. Additionally, Allen led on project development through drawing, and Smout led on technology, fabrication and manufacturing.

2

Introduction

This environmental architectural design research into anthropogenic climate change and hydrological water resources was commissioned by Nevada Museum of Art's Center for Art and Environment (CA+E) for the exhibition *Landscape Futures: Instruments, Devices, and Archives,* curated by Geoff Manaugh of BLDGBLOG. The design was supported by the CA+E's internationally recognised research resource which supports the practice, study and awareness of creative interactions between people and their natural, built and virtual environments through its exhibitions at the Museum, its research library, archive and public programmes. Two scales of research were undertaken:

Surface Tension

Surface Tension is a large interactive installation for the Nevada Museum of Art that simulates the undulations, waves, droughts and surges of the planet's hydrological cycle. The design is envisaged as a technological landscape that animates and annotates these complex environmental systems and our connectivity with them. It is comprised of an 8m-high, vertically organised kinetic network of analogue and computational devices that animate suspended balancing structures occupying the double-height space of the Museum's Contemporary Gallery. [fig. 1]

Wet Lands: Architectural Waterscapes and Soft Infrastructures for the Thames Gateway

Incorporated into the installation are models and drawings that propose a soft hydrological infrastructure fused with housing. The project, sited in the Thames Gateway Regeneration Zone, repurposes an extended metropolitan area which runs along the north bank of the Thames through the marshes at Rainham and beyond to Tilbury. The project was developed through a speculative drawing and modelling technique and scaled up to be suspended among the installation mechanism for the Gallery show. [fig. 2]

2
Surface Tension installation showing Wet Lands models

Aims and Objectives

Hydrological Infrastructures is an exploration of the global hydrological cycle and local hydrological variability prompted by climate change and anthropogenic progress. It focuses on the design of a technological landscape in the form of an installation and architectural design. It aims to visualise the sequences and relationships of environmental processes and fuse architecture and infrastructure with landscape in a responsive and sustainable fashion.

Questions

1. How can responsive environmental design demonstrate different scales of hydrological infrastructures and relationships that compose the planet's water resources?
2. How can two scales of critical water impact be represented: a. 'peak water' (i.e. geological and climatic water resources), and b. 'water stress' (i.e. London-based water supply issues)?
3. How do analogue and computational architectural design techniques enable this design process?
4. How can dynamic architectural design aid public understanding of limited environmental resources?

Context

Hydrological resource issues

a. Peak water

The recent concept and logistical model of 'peak water' – when the demand for water exceeds the natural limits of supply – underlines water's increasing significance as a capital resource. In the context of global population growth, the 'water grab' for energy and food production, alongside the industrialisation of agriculture that relies on non-sustainable methods of irrigation, puts an inconceivable strain on insufficient supplies of both renewable and fossil ground water resources (Müller et al. 2006). The increasing entanglement of natural and technological systems with which to manufacture, extract and supply water resources will inevitably lead to a global 'infrastructural landscape' of mass production and distribution networks and resource territory conflicts, and further emphasise the disparity between the haves and the have-nots (Postel 1997).

Examples of extensive environmental and humanitarian impacts of hydrological variability can be seen in the catastrophic floods and infrastructural collapse of New Orleans after Hurricane Katrina in 2005, and in Bangladesh in 2004 where 60 per cent of the nation was inundated with flood water. The fate of the Salton Sea, an endorheic lake in southern California that was formed when a canal from the Colorado River broke its bank in 1905, is an interesting illustration of the impact of climatic and anthropogenic change on landscape. The Sea's increasingly salty and contaminated water is now rapidly drying out into a lethal soup of agricultural runoff polluted with fertilisers. This wildlife and public health crisis may soon be exacerbated by toxic dust storms as the exposed dry lakebed is whipped up by gale force winds that regularly buffet the region.

An example of the damaging scale of water extraction and supply is Gadhafi's unfinished project, the 'Great Man-Made River' (GMR) in Libya, which was intended to make Libya food sufficient by supplying water to cities and farming areas in Libya's north. The 3,000km pipeline to the coast extracts fossil water from the Nubian Sandstone Aquifer System, the world's largest freshwater supply which lies 2,000m under the Libyan desert. The fossil aquifer (covering over two million km^2) will not be replenished; estimates differ greatly about the extent of its supply, ranging from thousands of years, to only until the end of this century.

b. London water stress

Problems of water scarcity and abundance are apparent even in the seemingly well-tempered environment of London, where the city is preparing for a future of water scarcity and stress (RIBA Building Futures 2007 and 2009). London is a recognised area of serious water stress due to its limited water resources and its vulnerability to drought. Surprisingly, it is one of the driest capital cities in Europe, with

LONDON'S HYDRO-INFRASTRUCTURES
BUFFERING SCARCITY AND ABUNDANCE

WATER STRESS

London is a recognized area of serious water stress, as it not only has limited water resources but is also very vulnerable to drought. It is one of the driest capital cities in Europe, with available water resources per head of population similar to Israel. Generally speaking, the amount of water in the Thames, River Lea and the aquifer is enough to meet London's current demands, but after sustained periods of low rainfall, water has to be drawn from reservoirs to meet the demands. Londoners currently use more water than the national UK average—161 liters per person per day—as opposed to 150 liters per person per day. The present balance of supply and demand in London is in deficit by approximately 180 million liters per day.

Climate change will affect the availability of water by reducing river flows, reducing groundwater recharge, increasing surface evaporation, and increasing the risk of broken water mains due to subsidence. In addition to the decrease of water availability, climate change will also affect water resource planning by changing the patterns of water demand. Domestic water use is expected to increase due to hotter summers, leading to an increase in garden watering and personal washing. According to estimates, outdoor water use will increase demand in the Thames region by approximately 50 million liters per day by 2025. Careful management is required to ensure that current water resources are sufficient to meet the present demand.

WATER SUPPLY

The majority of London's water supply comes from two sources: from rivers such as the Thames and Lea, and from boreholes that are driven deep into the chalk aquifers. The city is situated at the eastern edge of the London Basin Syncline, which is Britain's most extensive chalk aquifer. Groundwater is an essential source of high quality water and accounts for approximately 40% of public water supply in the Thames region. However, although borehole water is of a better quality than the water from rivers and requires less treatment, the supply is limited; river water is stored in reservoirs that surround London to the North and West, before being transported into the Water Treatment Works, where it is turned into domestic supply.

London's reservoirs store on average 30 million cubic meters of water and are found to the North in the Lea Valley, and to the West of London. The reservoirs to the west of London are supplied by the tributaries of the Thames while the reservoirs in the Lea Valley are supplied by the River Lea and the New River, a 400-year old aqueduct. Although used primarily for water storage, reservoirs are also utilized in the first phases of the water treatment process.

THAMES WATER RING MAIN

After passing from the reservoirs and through the Water Treatment Works, the water enters the Thames Water Ring Main. This is an 80km loop of pipe, buried 40m below the surface of London's streets, which connects water treatment works and pumping stations, and forms the primary loop of domestic supply for the city. The project was originally completed in 1994 and is constantly being updated with new connections to improve the water supply for London's future.

Access Shaft
Pumping Station
Water Treatment Works
New Pipe Connections

VICTORIAN PIPES

A high proportion of water is lost in London, each year, through leakage. Leakage occurs from the old Victorian pipes which still make up a large proportion of the supply network in London. More than half the mains below London are reckoned to be over 100 years old. One third are over 150 years old. Over 20% of pipes in the capital are over 150 years old. Currently, Thames Water loses approximately 685 million liters per day to leaking pipes. Investment by Thames Water in detecting leaks and replacing the Victorian pipes is slowly reducing the rate of leakage, but there is still more work to do.

LONDON'S LOST RIVERS

The expansion of London over the last 200 years has resulted in the loss of several open rivers which have been culverted underground or turned into canals. This has a large effect on the potential flood risk of the city, as these underground rivers cannot aid with the drainage of high rates and volumes of runoff following excessive precipitation or snow melt.

1 The River Neckinger
2 The River Walbrook
3 The River Fleet
4 The River Tyburn
5 The River Effra
6 The River Westbourne

FLOOD RISK

Current statistics indicate that the River Thames is rising on average approximately 3mm per year. Due to the fact that a significant proportion of the city lies in the flood plain of the river and its tributaries, London is exposed to a higher potential of flooding than any other urban area in the UK. 15% of London is in the floodplain, which includes 49 railway stations, 75 underground stations and 10 hospitals. London's flood risk comes from five different sources—tidal, fluvial, surface, sewer and groundwater—and the city is prevented from flooding by a complex system of flood defences. It should also be noted that South East England is sinking due to 'isostatic rebound' from the last ice-age.

MAJOR FLOOD DEFENSE SYSTEMS

1 The Barking Barrier

2 Royal Docks Impounding Flap and the Gallions Reach Flood Gate

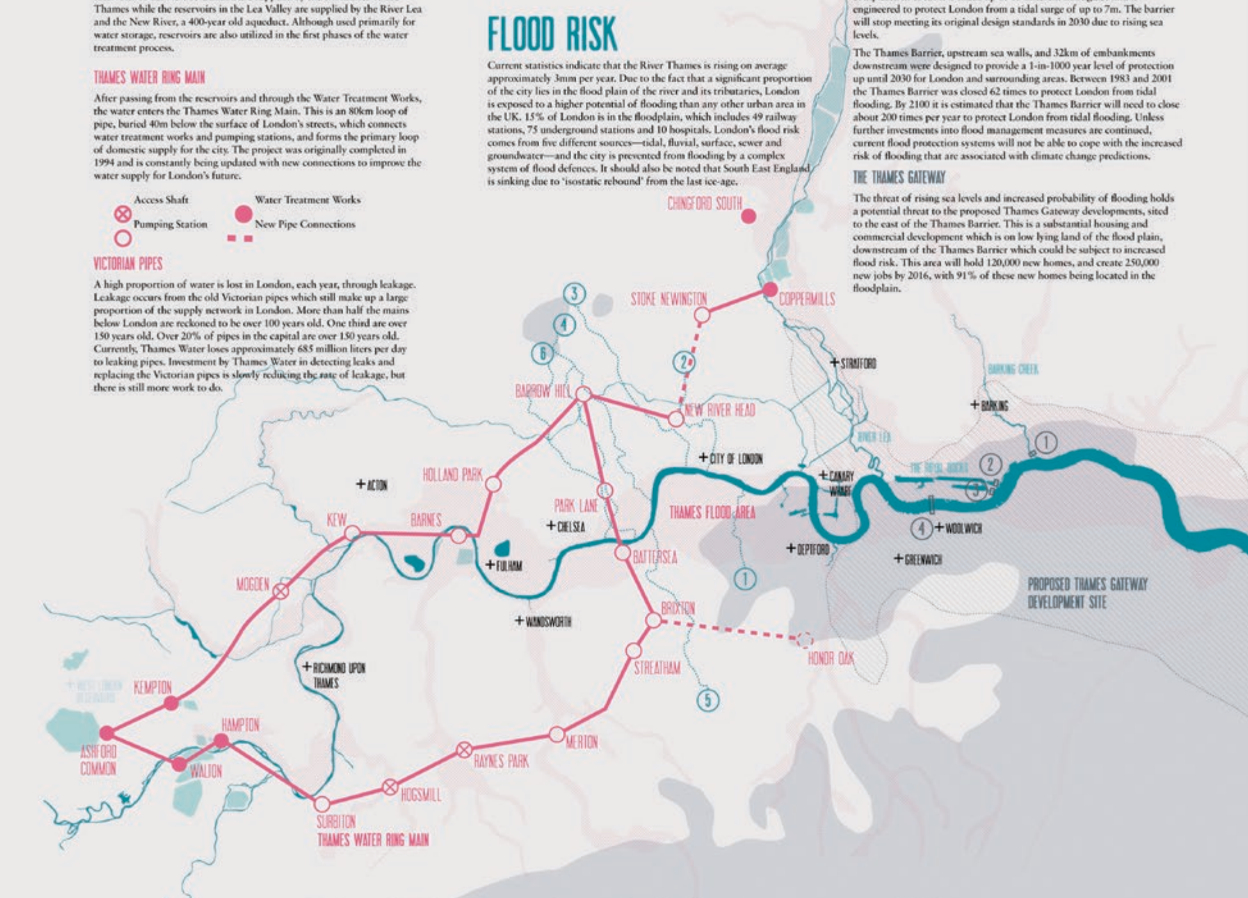
3 The King George V Flood Gate

4 The Thames Barrier. London's primary flood defense system was completed in 1983. It is made up of 10 different floodgates and is engineered to protect London from a tidal surge of up to 7m. The barrier will stop meeting its original design standards in 2030 due to rising sea levels.

The Thames Barrier, upstream sea walls, and 32km of embankments downstream were designed to provide a 1-in-1000 year level of protection up until 2030 for London and surrounding areas. Between 1983 and 2001 the Thames Barrier was closed 62 times to protect London from tidal flooding. By 2100 it is estimated that the Thames Barrier will need to close about 200 times per year to protect London from tidal flooding. Unless further investments into flood management measures are continued, current flood protection systems will not be able to cope with the increased risk of flooding that are associated with climate change predictions.

THE THAMES GATEWAY

The threat of rising sea levels and increased probability of flooding holds a potential threat to the proposed Thames Gateway developments, sited to the east of the Thames Barrier. This is a substantial housing and commercial development which is on low lying land of the flood plain, downstream of the Thames Barrier which could be subject to increased flood risk. This area will hold 120,000 new homes, and create 250,000 new jobs by 2016, with 91% of these new homes being located in the floodplain.



available water resources per head of population similar to those in Israel. Generally speaking, the quantity of water in the Thames and its tributary the River Lea and by 'abstraction' from the London Basin chalk aquifer is enough to meet London's current demands, but after sustained periods of low rainfall, water has to be drawn from a network of storage reservoirs to meet demand. The present balance of supply and demand in London is in deficit by approximately 180 million litres (39.6 million gallons) per day (Hunt 2005).

Water threatens the city in paradoxical ways. Much of London is built in the flood plain, including 49 railway stations, 75 underground stations and 10 hospitals. London's flood risk comes from tidal, surface, sewer and groundwater as well as fluvial flooding from the Thames and its tributaries. Consequently, flooding is controlled by a complex system of flood defences, including locks, overflow channels, weirs, embankments, flood relief channels and the Thames Barrier.

The threat of rising sea levels and increased probability of flooding holds a potential threat to the proposed Thames Gateway developments which will extend east, downstream from the Thames Barrier, to the furthest extent of the Thames Estuary. This substantial housing and commercial development of at least 120,000 new homes will sprawl through East London's predominantly low-lying brownfield land and extensive Thames flood plain (UK Environment Agency 2009). [fig. 3]

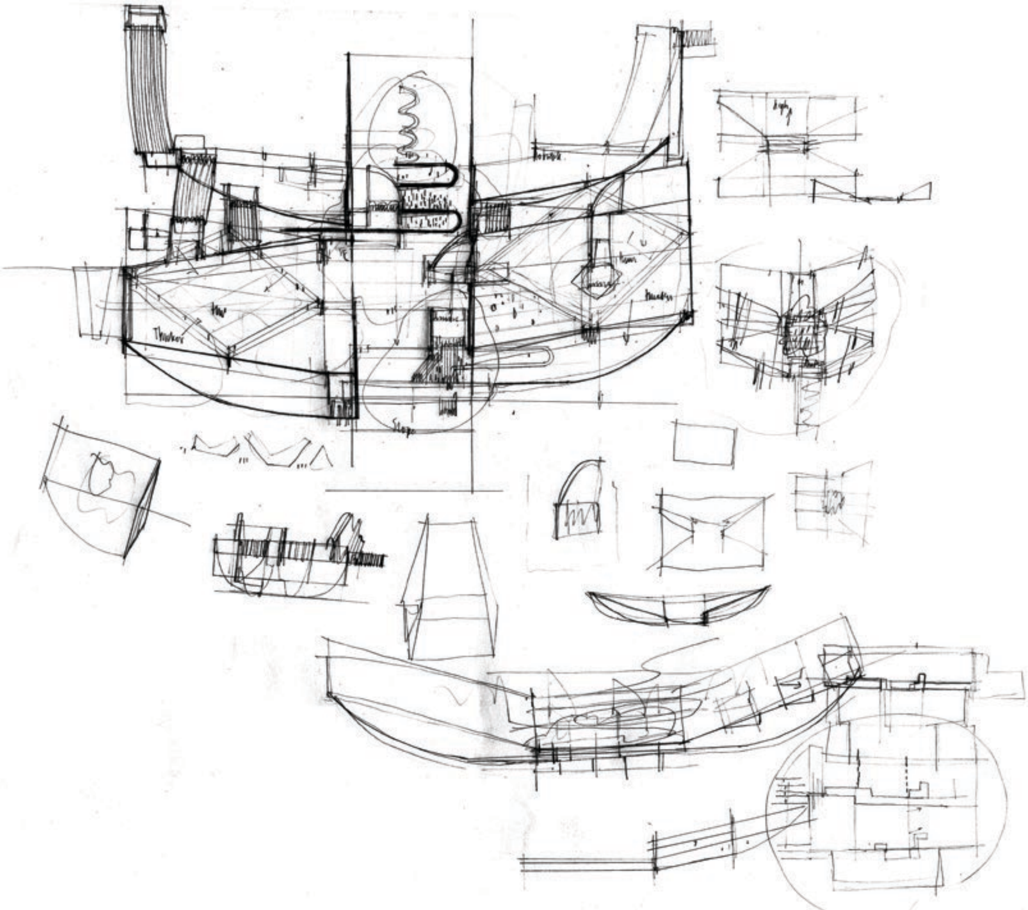
Material porosity towards flood prevention and water retention

Resilience against flooding from storm rainfall can be aided by sustainable drainage systems (known as SuDS), such as green roofs, wetlands, reed beds, drainage channels and porous driveways, which reduce flooding from runoff. The Flood Water Management Act 2010 requires developers to construct sustainable drainage for new construction projects; however, UK developers have attained a government reprieve until 2015 from incorporating SuDS into new developments (Landscape Institute 2013). [fig. 4 & 5]

'Green' and bioengineered infrastructural schemes mimic natural environments by providing permeable and vegetated surfaces which slow down water before it enters the watercourse or ground, and which help prevent surface flooding by absorbing or attenuating water into wetlands, ponds, swales (dry ditches) and basins. These methods can also provide filtration and remove sediment from surface water runoff in filter strips and bioretention areas. SuDS are effective in retrofit. Examples of new schemes include:

— The Tokyo Experimental Sewage System (1980), which covers 249 hectares of dense urbanised area, and uses permeable pavements and porous concrete blocks to attenuate water flow and tanks to store stormwater for toilets, irrigation, car washing, etc. (Fujita 1994).

— Augustenborg suburb in Malmö, Sweden, built in the 1950s, was disconnected from the down pipe



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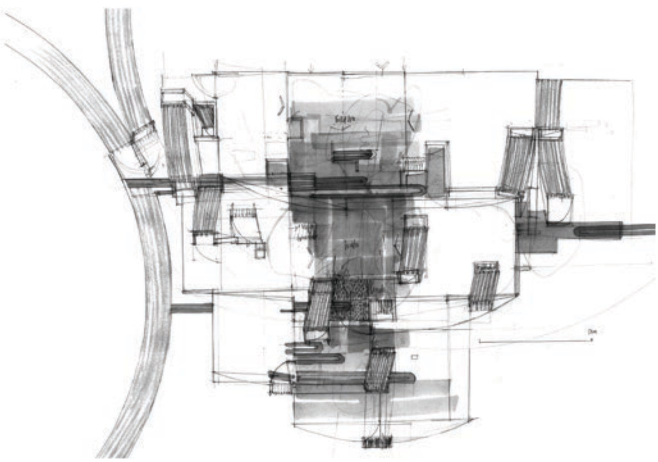


5

3 ***(previous page)***
Poster produced for Landscape Futures at the Nevada Museum of Art, Reno, 2012

4
Sketch studies of Wet Lands sustainable urban drainage systems

5
Sketch studies of Wet Lands porous surfaces

system in 1998 and now employs an open stormwater system of trenches, canals and retention ponds to manage rain and melt water, which are integrated into the streets and gardens.

— A contemporary example of the potential hybridity of infrastructure and recreational facilities is Rabalder Skate Park, Roskilde, Denmark, which integrates 40,000m^2 of sport and stormwater structures in the channels and overflow bowls that are used daily for skateboarding but which, when storm episodes occur, can accommodate even a 10-year rainfall event.

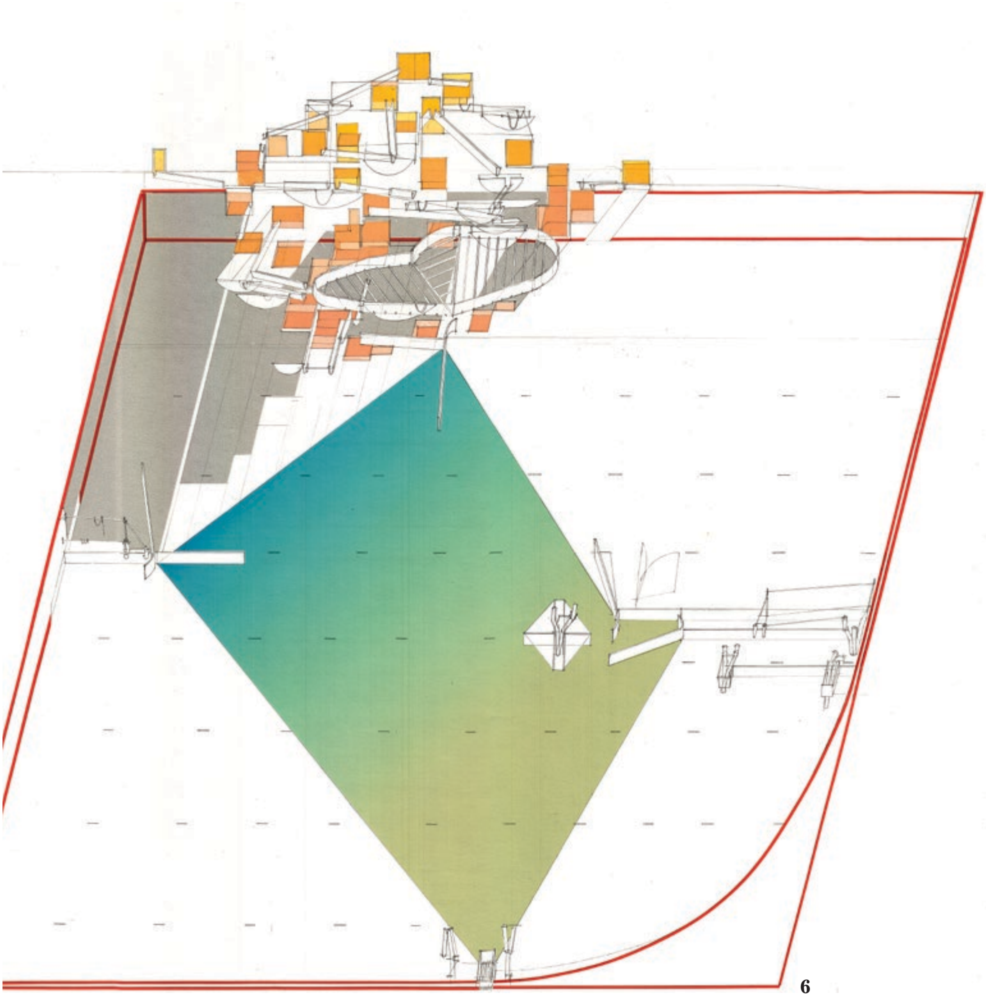
Methods

Examining the effects of increased climate variability on hydrological resources

While the impacts of climate change and of a warming climate are extremely varied, it is clear that warming increases both evaporation and the circulation of water in the atmosphere. This, in turn, effects changes in the size and frequency of rainfall patterns and river flow. Environmental modelling has been largely built on global predictions based on past climate conditions. Climate change induced hydrological variability now means that regional and even local conditions must be studied and interpreted in order to predict and accurately assess the impact of both drought and storm frequency on the landscape.

From a human-use perspective, increased variability makes the design of water policy and engineering projects extremely difficult. Variability is difficult to predict: river flow is in any case variable, but when direct human use of landscape – such as river water use for domestic, industrial and agricultural purposes – is factored in, the predictability of hydrological impacts decreases.

The Surface Tension kinetic installation in which the Wet Lands project is 'sited' uses time-based architectural devices to represent the variability of environmental processes and to communicate data related to environment change. The piece demonstrates the experimental potential of three-dimensional models as metaphorical, allegorical and sensorial assemblages, as well as instruments with technical precision and defined performance. This can be seen in the rhythms and patterns of movement that can be produced in the installation and the interrelationship of its dynamic components.



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6
Wet Lands model showing reservoir and housing design

Identifying and integrating architecture with hydrological infrastructures and technical design strategies that respond to these conditions

Wet Lands proposes an architectural, infrastructural and technological landscape that manages, distributes and displays conditions of water variability – river flood, sea surges, drought and rainfall. It deals with the commodity, excess and scarcity of water by concentrating and localising civil and domestic water infrastructures into the body of the surrounding landscape and into the architecture itself, as alternatives to the extensive and embedded water management systems upon which global cities rely. The scheme is envisaged for the Thames Gateway, where predictions of climate change generating river floods, sea-level rises and storm surges mean that strategic land use policies that incorporate infrastructural landscape and architectural design flood resilience measures are essential (London Assembly Environment Committee 2005). In this design a selection of flood-control technologies and riparian processes are integrated into the architectural infrastructure to both control and mitigate flood. The terrain forms an active and inhabitable architectural landscape that yields to the unpredictable variations in saturation and diverts water into a network of canals, subterranean cisterns and header tanks. [fig. 6]

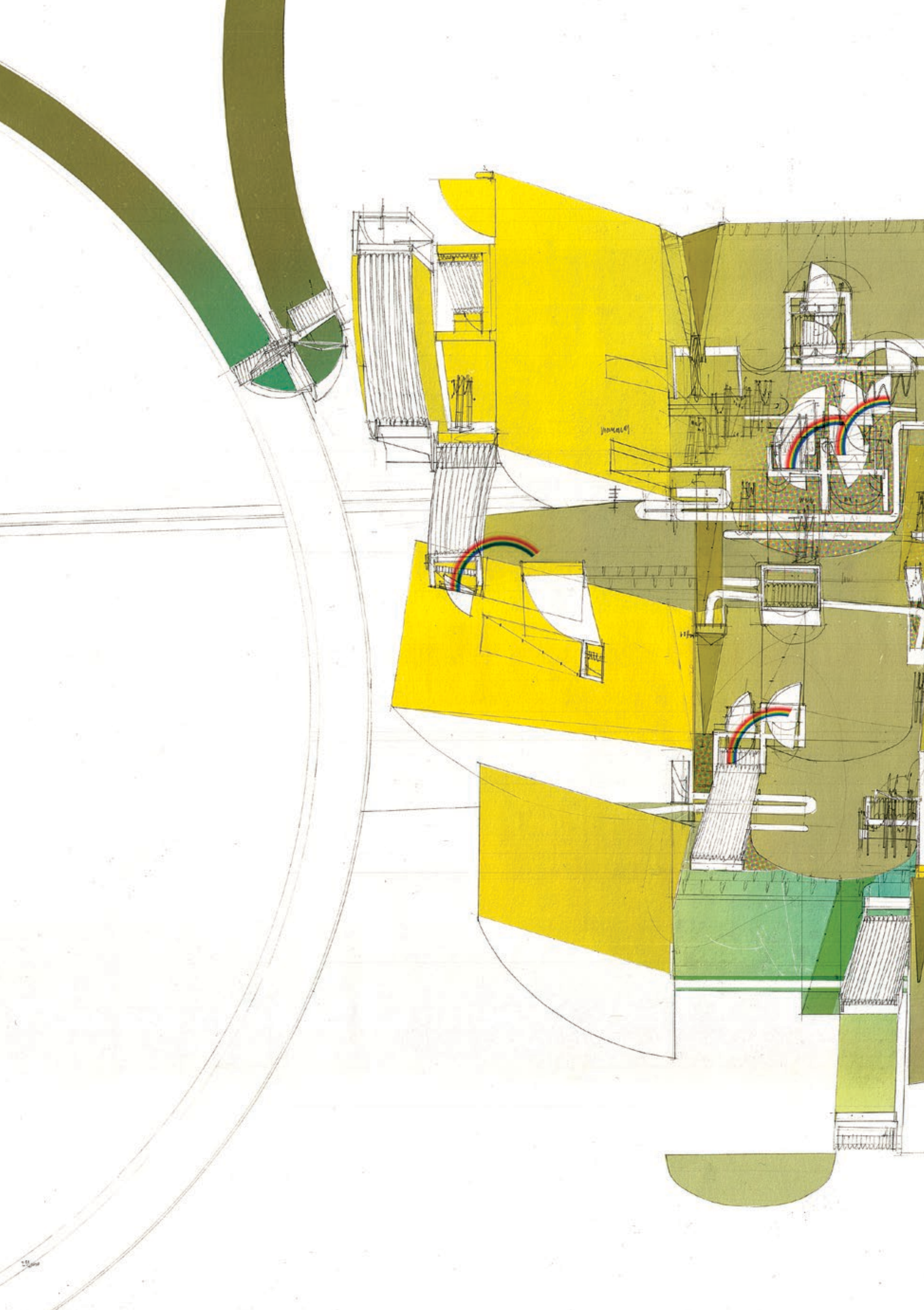
A large and spreading architectural landscape is sunk into the ground and incorporates dense housing and recreational facilities. It is encircled by a canal-like system of waterways and reservoirs to manage excess water and to structure the natural catchment of the flood plain. This is coupled with architecture that is essentially porous and responsive to its fluvial surroundings. The housing acts as an absorbent and permeable terrain to cope with and buffer the contrasting threats of water scarcity and abundance. The landscape is an embedded system that demonstrates an alternative response to both the engineering of water and the impermeability of architecture. At the same time, the scheme celebrates water's physical and meteorological properties, and even its immaterial qualities. Water's ephemeral and mythical nature is revealed in the form of rainbows, glories and halos. [fig. 7–9]

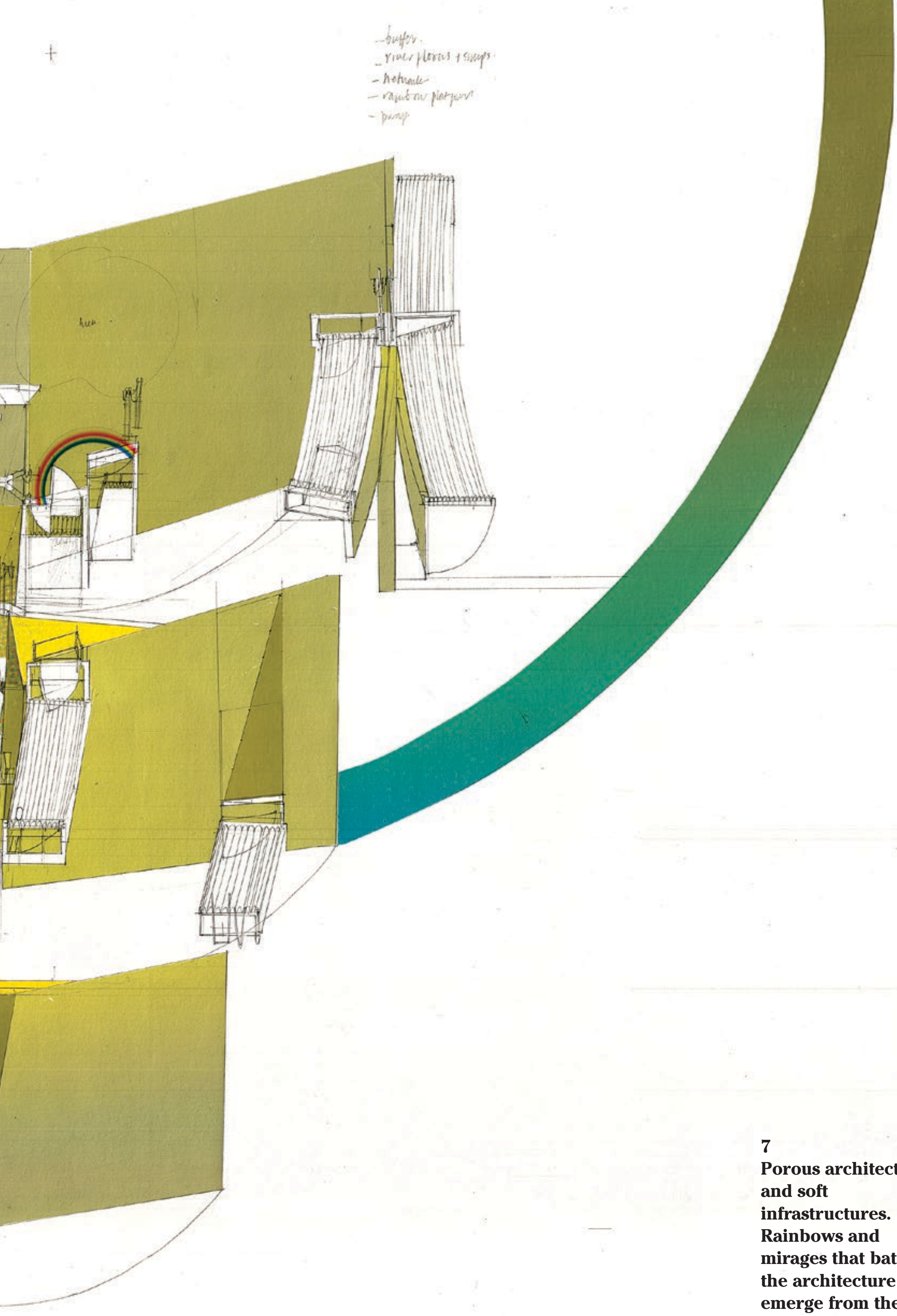
The architecture merges into an agricultural landscape in the form of a mechanised topography that envelops fields into systematic cultivation zones in which crops are protected from fluctuating sea and river levels as well as the vagaries of the weather. Here, the hydraulic power of water is deployed to lift up whole fields away from flood zones and unworkable landscapes, enabling the architecture to act as a register of its surroundings. Exhaust water is sprayed in drifts of mist, encouraging the manifestation of intangible optical phenomena. [fig. 10]

Developing fabrication techniques, systems and drawings that dynamically represent these changing conditions

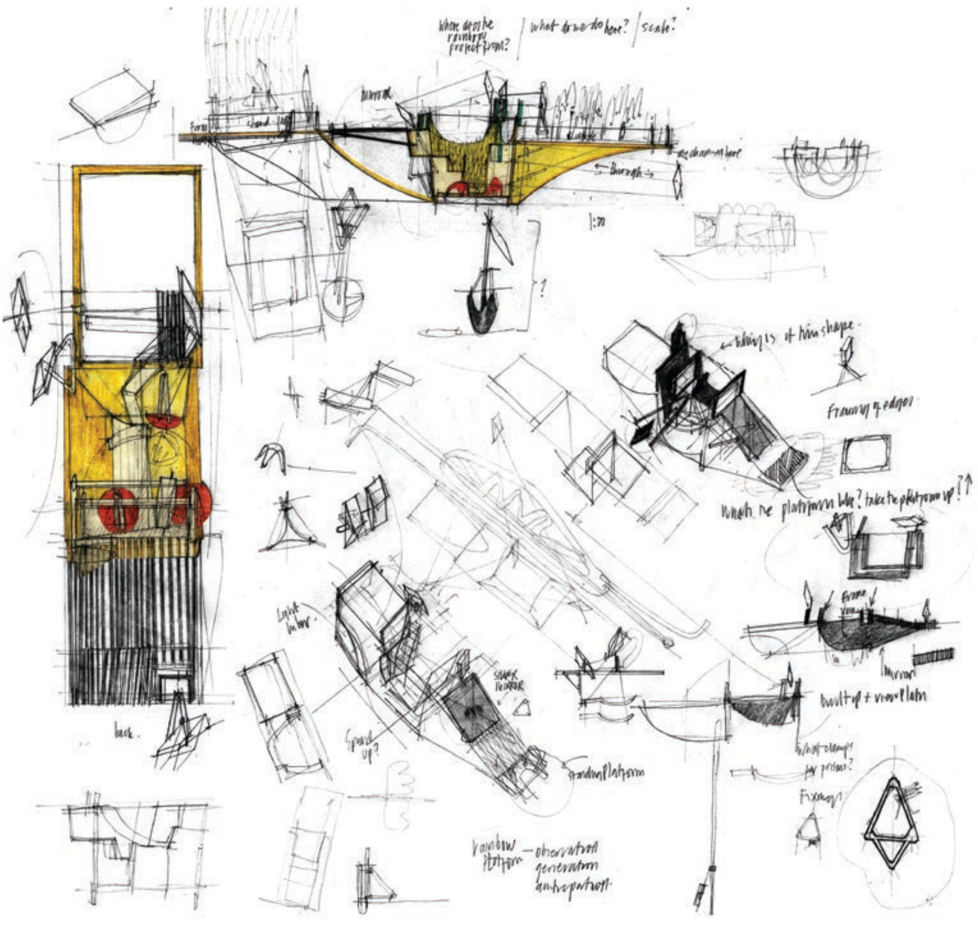
a. Design and speculation via drawing

Wet Lands was designed via sketching with pencil and toned hand-drawn techniques. The degree of explicit and scaled information varies in detail and in





7
Porous architecture and soft infrastructures. Rainbows and mirages that bathe the architecture emerge from the activated and responsive skin of the building that soaks up and reactivates water.



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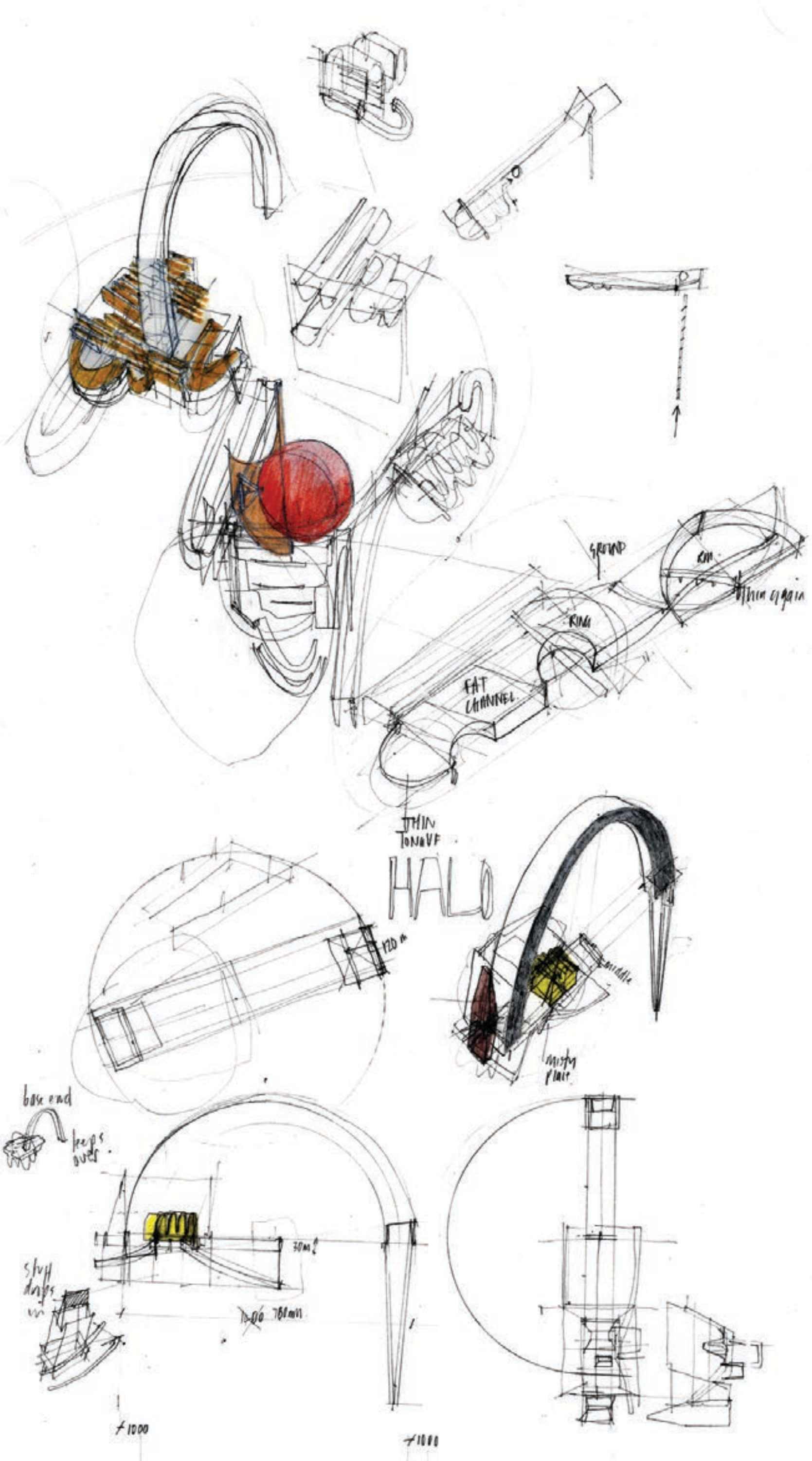
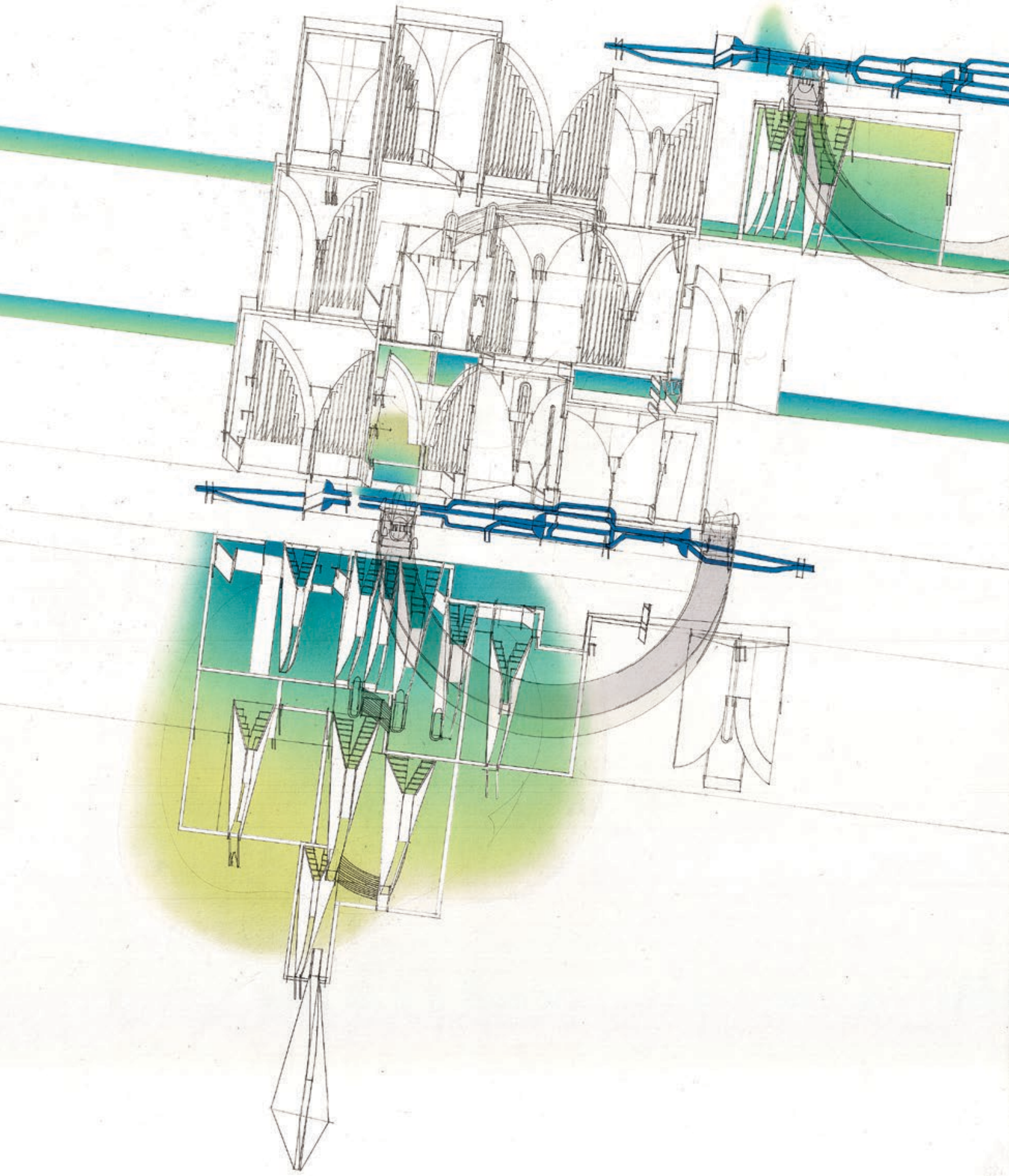
8 & 9
Sketch studies for the rainbow platforms and framing mirage device


RING
FAT CHANNEL
THIN TONGUE
HALO
base end
+1000
+1000



‘polish’ so that the drawings are removed from the level of resolution and realism associated with conventional architectural production and digital visualizations. Instead, these drawings are imagined as a kind of proving ground, one step removed from the sketchbook, but still incorporating numerous simultaneous iterations and unfinished lines. They are preliminary investigations that establish drawing design as a speculative method with which to examine the dynamic force of environmental and architectural processes. These drawings have the dual function of examining, as well as narrating, the spectacular qualities of the site for which they also act as a proxy. Drawing is a reflective activity that at once generates and informs speculative design. In the process it can take lyrical as well as pragmatic directions and follow ideas evoked solely by the drawing itself. Architecture is manifested in multiple states as ideas are overwritten by the palimpsestic nature of the design process. The drawings are essentially more scenic than orthographic, containing information about scale and materiality, and suggesting ideas of topographical detail and structure. [fig. 11]

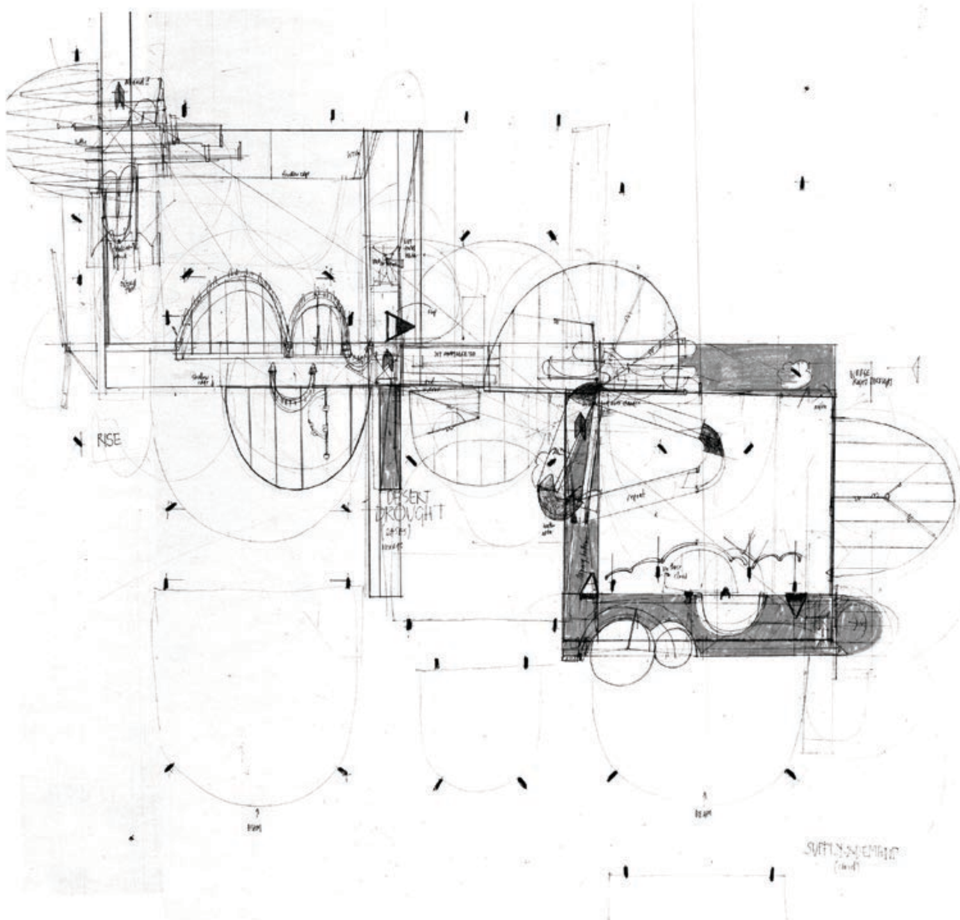
In this project the drawings are directly transformed into models. Three-dimensional form is created by elevating and layering duplicate copies of the drawings printed onto card, to create the space implicit in, or inspired by, the drawings. This process aims to stretch out and further define ideas already imagined for each of the proposed landscapes.

The models, notionally at the scale of 1:1,000, are maquettes for modelling at a much grander scale where, yet again, a process of iteration and redesign takes place. The Wet Lands proposal was reinterpreted for the Surface Tension installation, where the maquettes were translated into room-sized plywood models (at a scale of 1:100) with metal, Perspex and mirror attachments, and populated with model figures. Each of the three models (approximately 5m × 0.5m) was suspended in the midst of the installation, hanging above the wave platforms to be viewed from the gallery’s mezzanine gallery. [fig. 12 & 13]

b. Design- and performance-led fabrication

The Surface Tension installation is constructed from more than 2,300 components, the majority of which are custom made. It is the product of design-led prototyping and testing with full-size and smaller-scale working models as well as digital modelling produced in order to determine degrees of motion in the dynamic elements of the installation. [fig. 14–17]

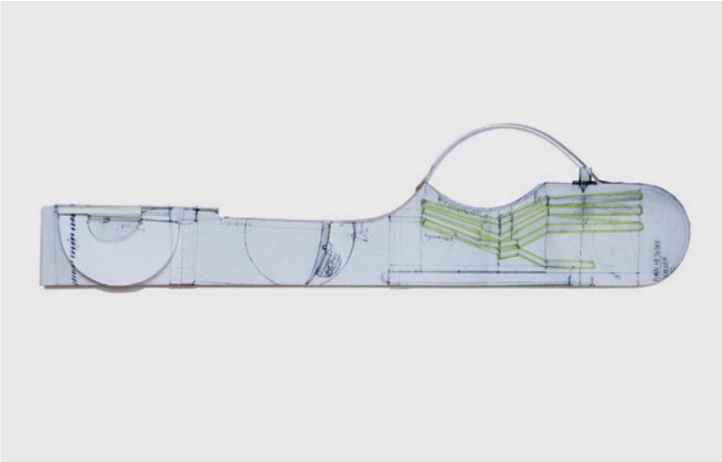
Handmade workshop processes, including metalworking, hard chroming, colour spraying and bluing (gun metal finishing), are used to ensure a level of finish where it is important to use discernment to gauge characteristics of movement and evaluate the quality of material finishes. Throughout, a hands-on method was considered a highly effective approach. This iterative and haptic design method is an efficient way of both exploring ideas and achieving a desired result. Digital manufacturing techniques such as CNC laser cutting and water cutting were used to test repeatable components and to produce multiples where dimensional accuracy was crucial.



11

10 ***(previous page)***
Waterscapes and mechanised topographies. Automated cultivation fields elevate and fold up in response to the rising water level and protect valuable agricultural land from inundation.

11
Sketch arrangement of Wet Lands models embedded within the Surface Tension installation.



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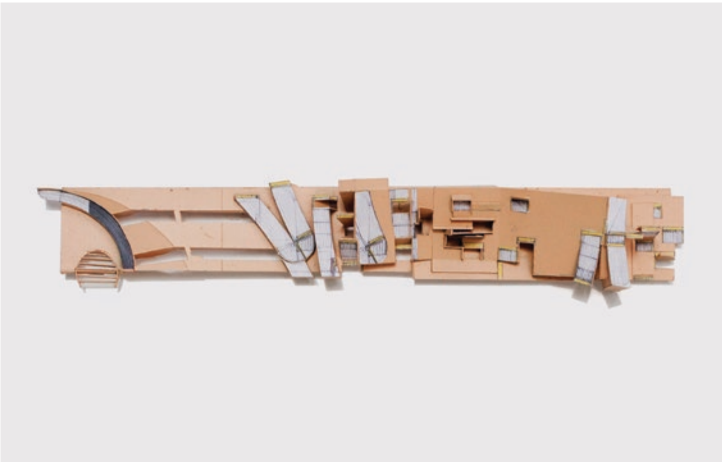

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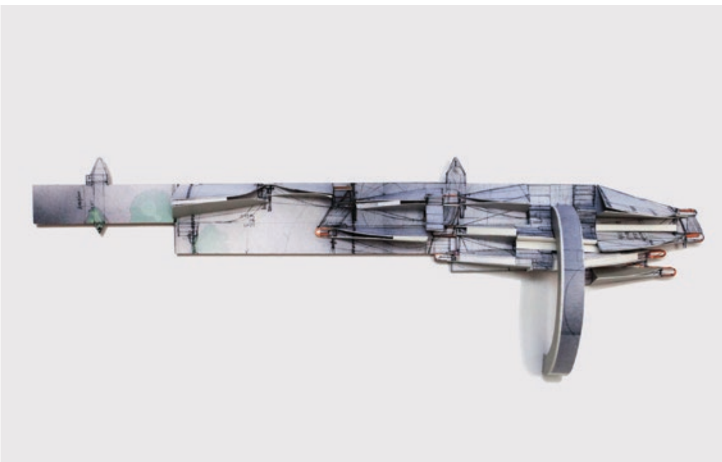

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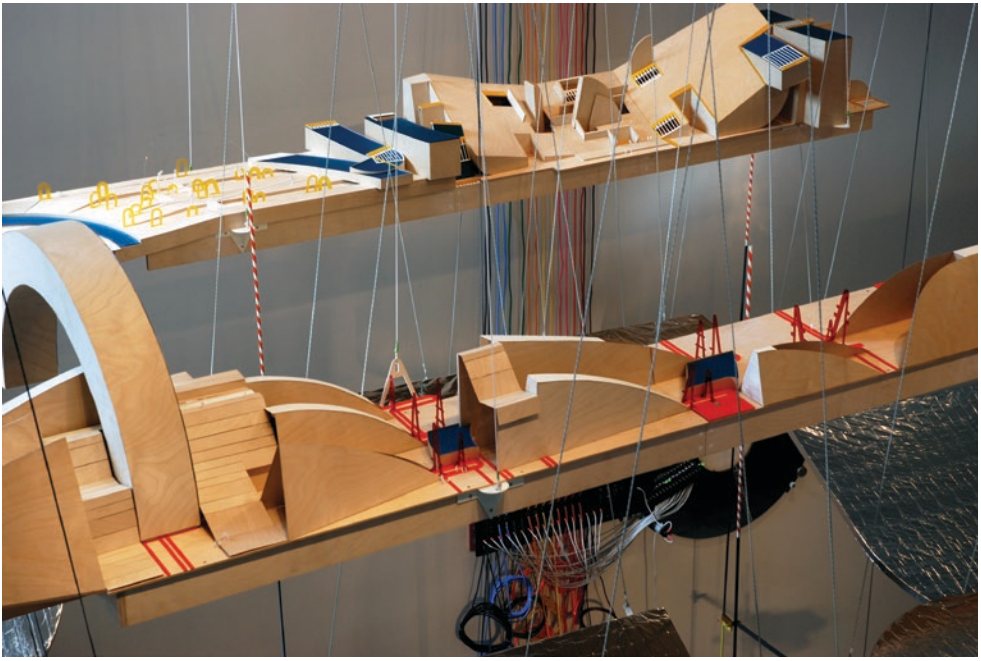
12
Modelling the Wet Lands. These paper-and-card models are constructed directly from duplicate copies of drawings and sketches, reimagining them in three dimensions.



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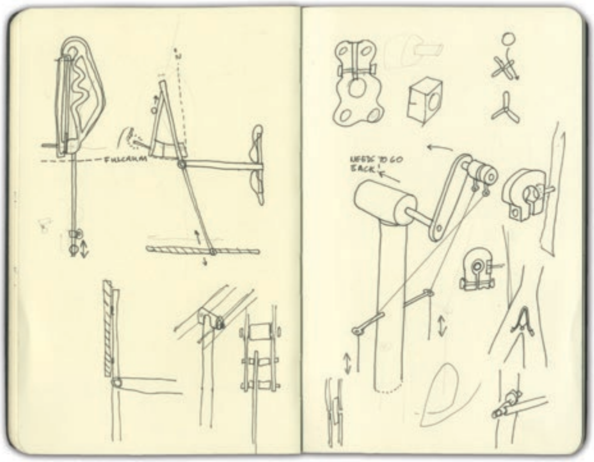
13
The Wet Lands model suspended in the Surface Tension installation

14
Sketchbook studies of kinetic mechanisms



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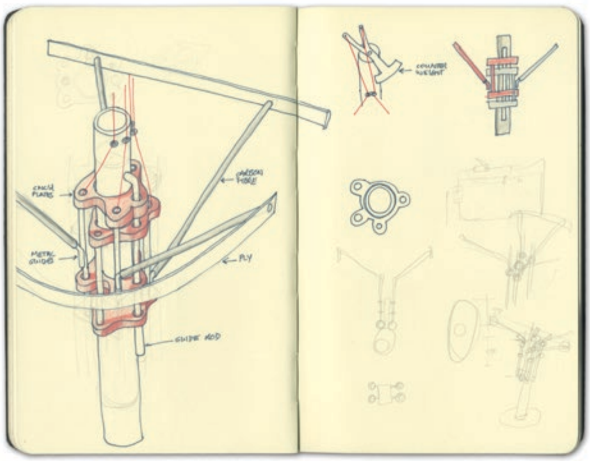

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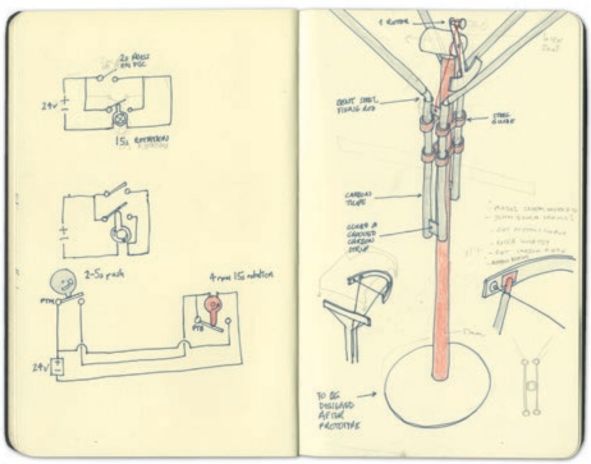

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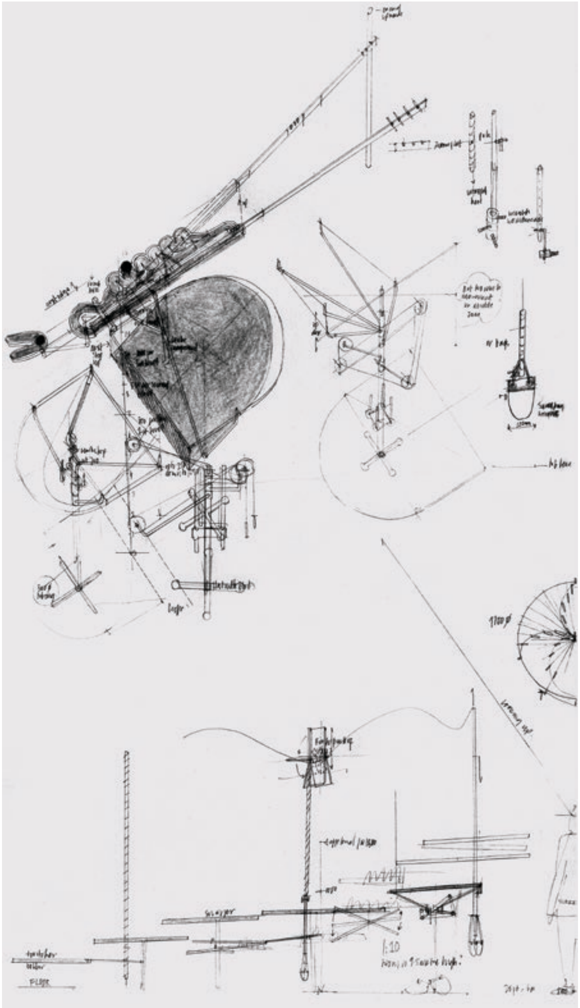
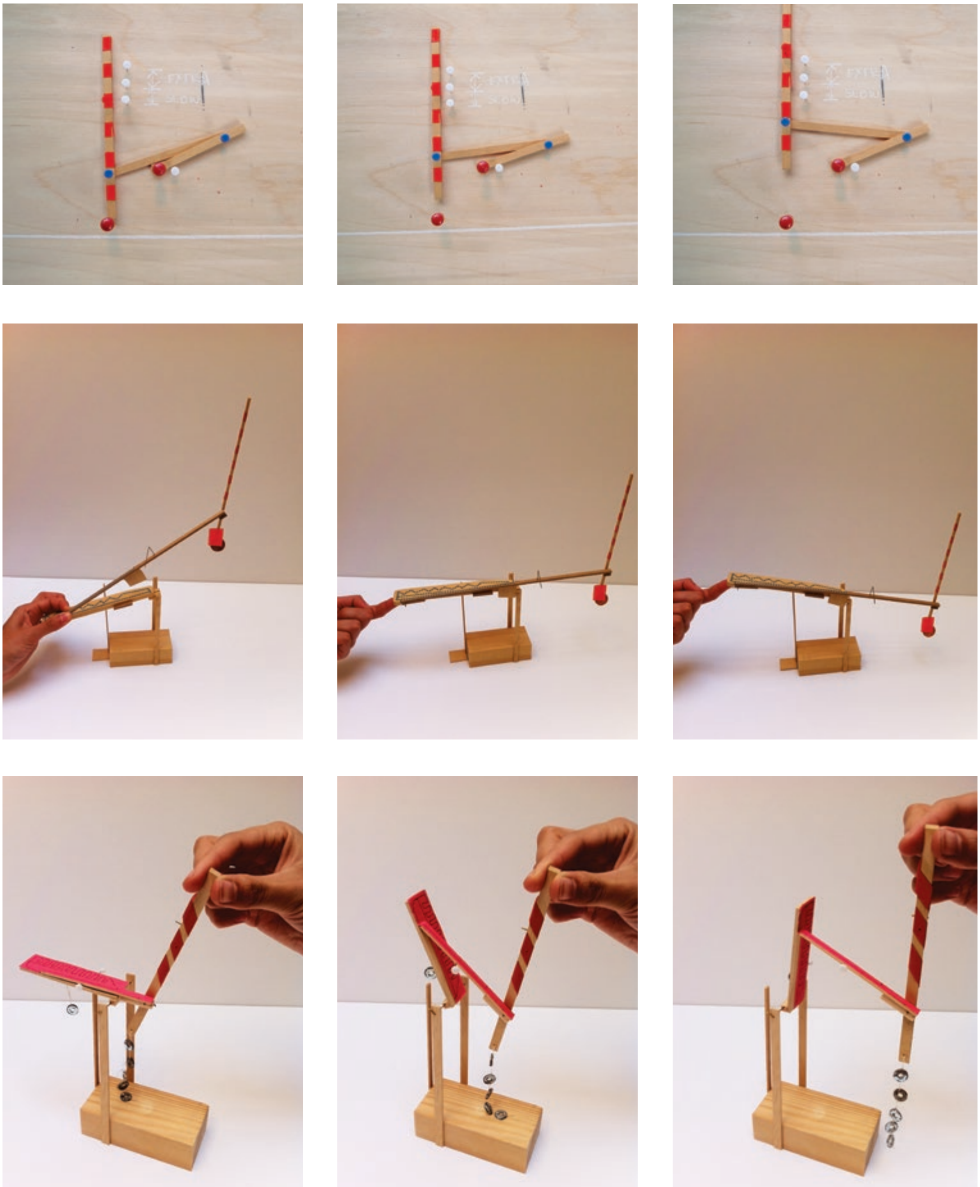


16

15
Prototyping the 'tilt-lift' mechanism. Study rigs showing initial floor-mounted design

16
Sketch designs for the floor-mounted 'tilt-lift' mechanism



17

17
Small wooden models were used to test the motion of the marble run regulators

18

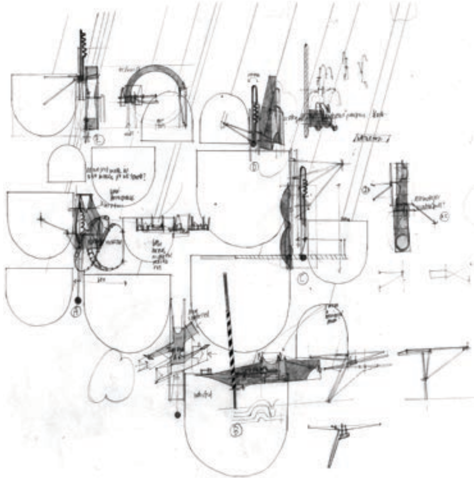
18
Wave motion revealed by multiple exposure photography

The installation is organised into three interdependent performative systems:

<u>Wave platforms:</u> Sixteen wave platforms of varying size, constructed from aluminium frames skinned with gold MPET Mylar sheet, are suspended from the ceiling hanging 2.4m from the floor. The platforms, in sequence, tilt, lift, sway and fall, creating rhythmic waves of motion. The dynamic performance is played out in the ephemeral aerial space through caustic reflections that dance across the gallery walls. [fig. 18 & 19]

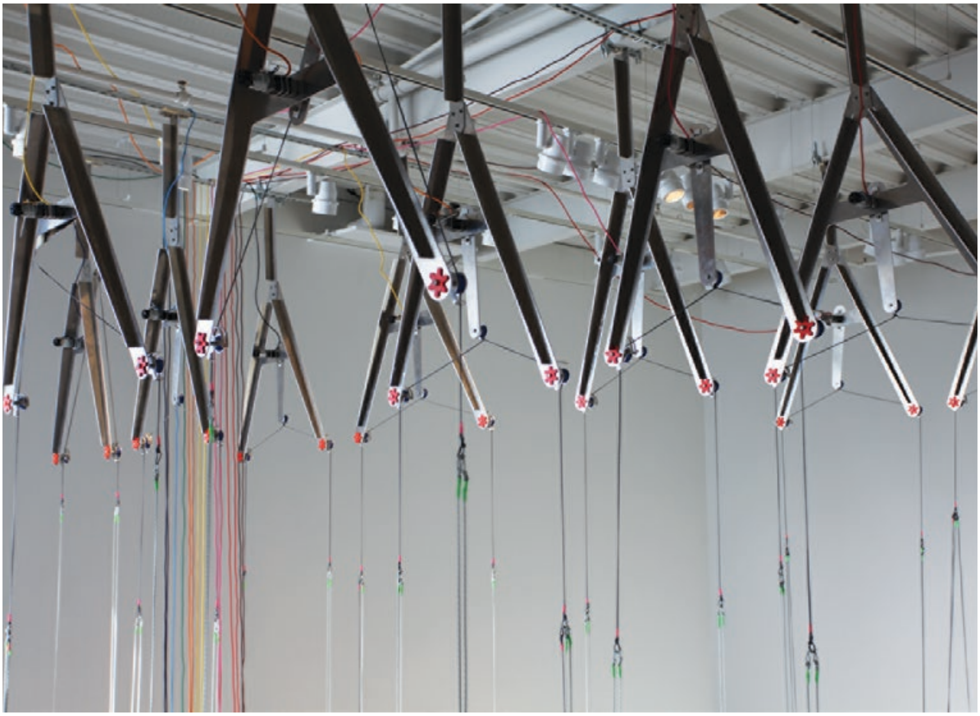
<u>Wave sequencer:</u> The wave sequencer controls the cycle and motion sequences of 16 suspended wave platforms. The sequencer comprises a system of 16 micro switches and a rotating chromed disc on which magnetic triggers can be placed. Each micro switch is connected independently to the celling-mounted A-frames, where a geared motor slowly rotates the crank arm on one of the frames to provide an asymmetric lift of the wave platform. [fig. 20 & 21]

The sequence and frequency of lift motion is determined by the arrangement of magnets across the wave sequencer disc. Visitors to the gallery can engage with the installation by rearranging the magnets on the disc, creating their own wave sequences and harmonic waves of the gold panels. The effect of moving the magnets is understood very quickly and, more often than not, the visitors would arrange them to create a 'ripple' across the gallery space. [fig. 22–24]



19

19
Sketch plan of wave platform arrangement



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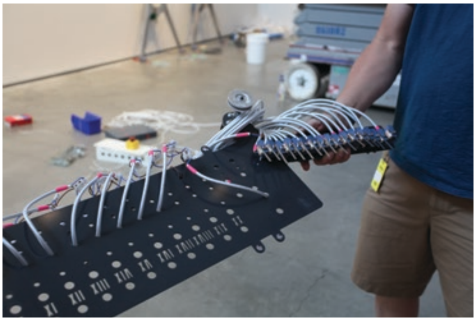


22

20
The ceiling is populated with aluminium A-frames that incorporate a lifting system. The suspension cables, threaded with retro-reflective material, reveal vertical dashes of light producing a rain effect falling from the ceiling.

21
The sequence and frequency of lift motion is determined by the arrangement of magnets across the wave sequencer disc. Magnets placed in a line radiating across the disc will produce regular sequences but their arrangement can be reorganised to produce regular oscillation patterns across the wave platforms or to produce disrupted and erratic sequences.

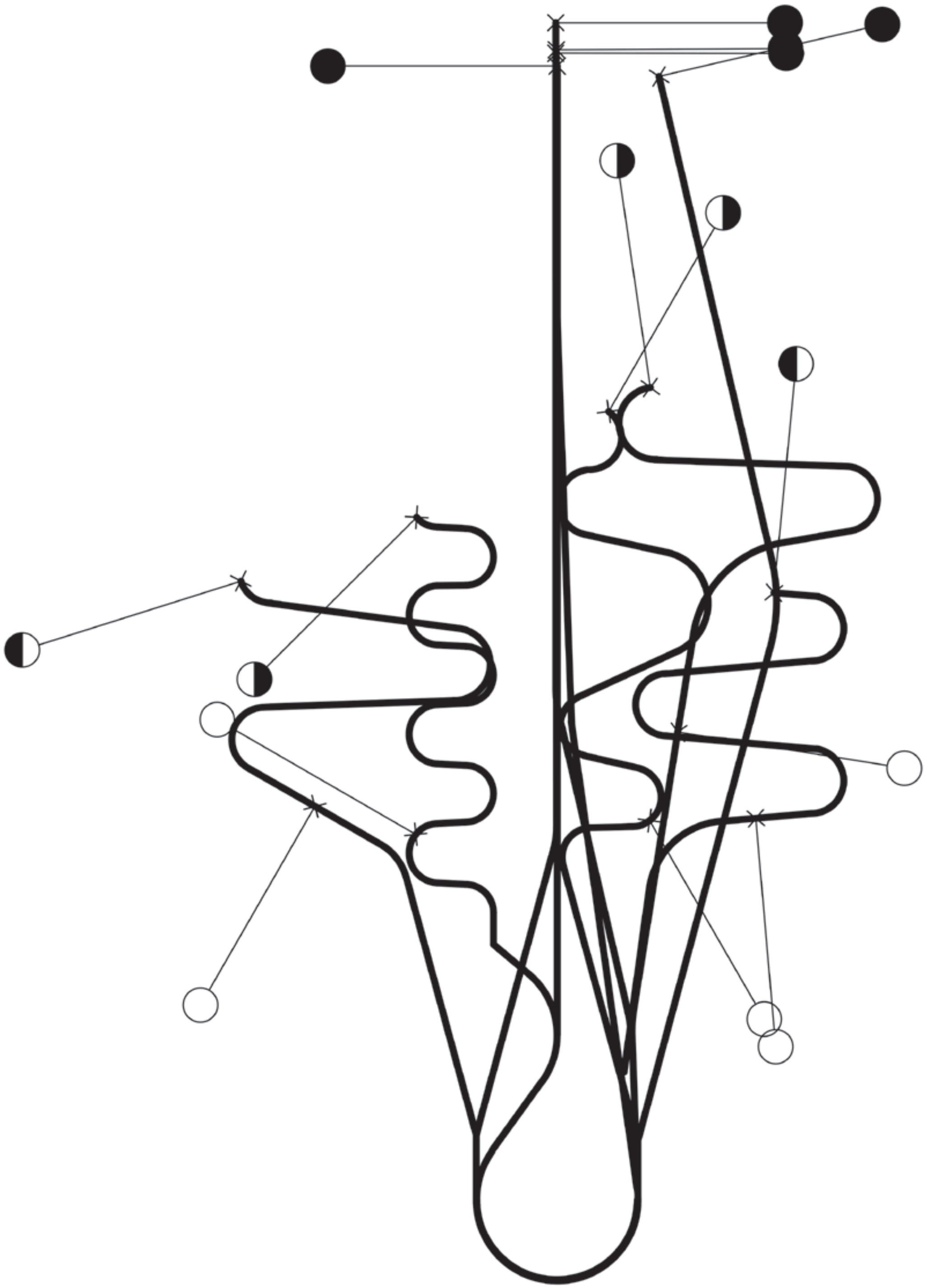
22
Details of wave sequencer being installed and calibrated

23

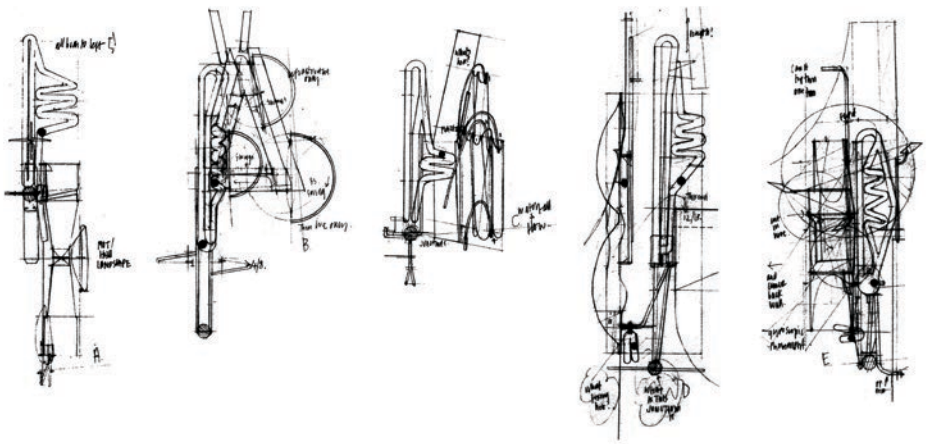
24

23
Ceiling mounted A-frames being installed

24
The wave platforms being installed at the Nevada Museum of Art



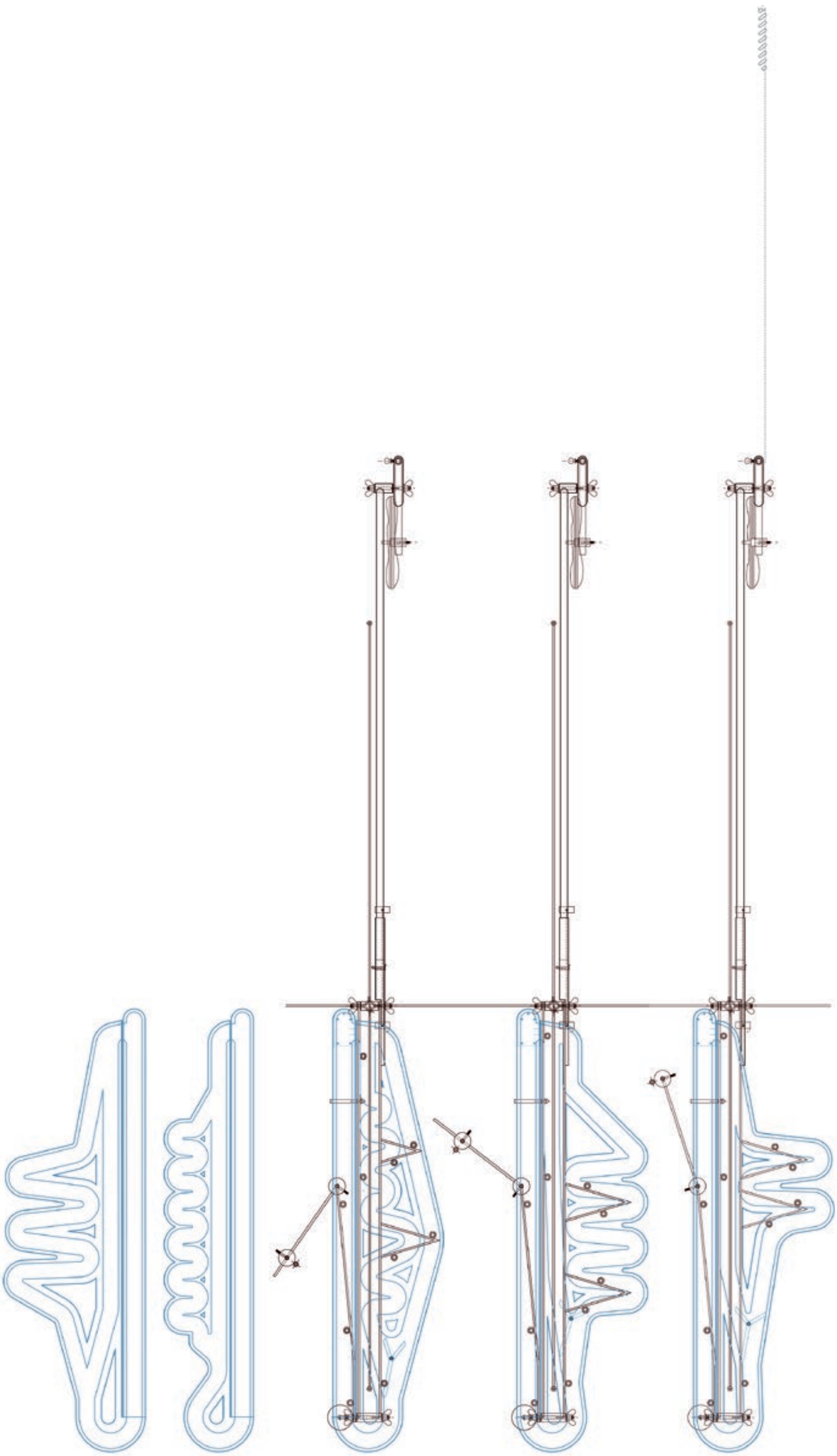
Marble run regulators: Five marble run regulators react to and moderate the motion of the wave platforms above. The regulators consist of counterbalancing platform (mounted on steel frames at eye-level) on which a sunken and meandering route for a 45mm steel marble is inscribed. A loading arm is raised by the motion of the wave platforms, which initiate the journey of the marble around the track. It runs forwards, disrupting the balance of the regulator, and rolls around the end of the track. The ball returns quickly via a direct path or more slowly via a meandering route, rebalancing the regulator platform as it goes. The marble is switched from the direct fast route to the slow route in sequence by means of a bistable switch mechanism which, in turn, is triggered by each passage of the marble. The marble run platform is connected to vertical registers which protrude up through the installation layers to activate events in the architectural landscape above. The register is analogous to the idea of measures and recording techniques in environmental analysis and landscapes. [fig. 25–30]



26

25
Meandering marble run routes provide a fast and a slow return of the marble which regulates the speed at which the wave platforms rise and fall. This composite drawing shows the beginning, middle and end points of the slow meanders, and indicates the range of speed sequences available.

26
Initial sketches of marble run testing circuitous routes



28

27
Technical drawing of the five marble run regulators

28
Marble run regulator showing bistable switch mechanism

29a

29b

29
Marble run regulators: details

30
Surface Tension installation

Dissemination

Exhibitions

Group: *Landscape Futures: Instruments, Devices and Architectural Inventions* (curated by Geoff Manaugh). Center for Art and Environment, Nevada Museum of Art, Reno, USA, 13 Aug 2011 – 19 Feb 2012.
Solo: *Envirographic Architecture.* University of Manitoba, Winnipeg, Canada, 23 Jan – 2 Mar 2012.

Invited talks

'Designing architectures for environmental change' (panel), Second Art and Environment Conference, Center for Art and Environment, Nevada Museum of Art, Reno, USA, Sep 2011.
'Envirographic architecture' at the University of Cambridge, Nov 2011.
'Envirographic architecture' at the University of Manitoba, Winnipeg, Canada, Feb 2012.
Flows, Systems, Atoms: Architecture in the Expanded Field, symposium at UC Berkeley, California, Feb 2012.
'London's hydro infrastructure' at the London School of Hygiene and Tropical Medicine, Mar 2013.

Journal articles

'Augmented landscapes and delicate machinery', *Drawing Architecture* (ed. Neil Spiller), *Architectural Design* 83.5 (Sep 2013): 88–93.
'Landscape Futures' (with Geoff Manaugh), *P.E.A.R. Paper for Emerging Architectural Research* (forthcoming, Oct 2013).

Book chapter

'Superscript: an interview with Mark Smout and Laura Allen'. *Landscape Futures: Instruments, Devices and Architectural Inventions.* Ed. Geoff Manaugh. Barcelona: Actar, 2013: 123–138.

Other

Exhibition film: 'Surface Tension', *Vimeo* (5,912 hits as of Sep 2013).
Permanent collection: Center for Art and Environment, Nevada Museum of Art, Reno, USA. Two works relating to the Surface Tension installation have been attained by the Center for their permanent collection.

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Mark Smout and Laura Allen, 'Augmented landscapes and delicate machinery', *Drawing Architecture* (ed. Neil Spiller), *Architectural Design* 83.5 (Sep 2013): 88–93.

Book chapter

pp. 46–62
Mark Smout and Laura Allen with Geoff Manaugh, 'Superscape: an interview with Mark Smout and Laura Allen'. *Landscape Futures: Instruments, Devices and Architectural Inventions.* Ed. Geoff Manaugh. Barcelona: Actar, 2013: 123–138.

pp. 63–75
Mark Smout and Laura Allen, [insert]. Landscape Futures: instruments, devices and architectural inventions. Ed. Geoff Manaugh. Barcelona: Actar, 2013: 139–186.

pp. 76–91
Mark Smout and Laura Allen, 'Neo-nature: envirogrammic prototypes for Lanzarote; Techno-nature: envirogrammic prototypes for the River Severn; London's hydro infrastructures: buffering scarcity and abundance; and Surface tension'. *Landscape Futures: Instruments, Devices and Architectural Inventions.* Ed. Geoff Manaugh. Barcelona: Actar, 2013: 218–233.

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