Reclaiming Porosity:
A Multi-Layered Scalar Approach to Retrofitting Infrastructure, Public Space, and Thresholds in Flood-prone Bangkok

by

Aaron D. Szeto

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CONTENTS

ABSTRACT

For centuries, the Thai have adapted to live with water by altering the landscape and modifying building methods. With increased climate change and urbanization, infrastructures must be reconsidered to handle the growing frequency and intensity of floods. This thesis examines the role of architecture in mitigating such impacts and reconnecting local communities with water. By studying historic and modern landform and water infrastructural systems in urbanized Bangkok, the thesis develops a multi-layered scalar approach that reintroduces porosities as a means to reconnect and control water by: (1) resurfacing historic canals, (2) connecting public space with blue-green infrastructure, and (3) retrofitting buildings with threshold connections that connect to ritual and flexible programming that celebrate intersections between the flow of people and water. The design strategy therefore reconnects urban inhabitants along the Chao Phraya Delta to water as a cyclical and celebratory element that reinforces the specificity of place and their culture.

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CHAPTER 1: INTRODUCTION

Context

Today, many urbanized deltas around the world such as Thailand are confronted by the threat of global warming and rising sea levels. With an acceleration of climate change, there is an increase in severe storm events and flooding of their low-lying delta areas. Although Thailand experiences widespread flooding on a regular basis due to its monsoon climate and its geography, these events will only worsen with climate change.

The country's climate consists of three main seasons: the cool (from December to February), the hot (from March to May), and the rainy (from June to November). The rainy season occurs for over half the year and is largely caused by the dumping of moisture gathered by the southwest monsoon from the Andaman Sea and the Gulf of Thailand.[1] During this season, the pluvial flooding caused by extreme downpours can heavily saturate water drainage systems with over 754,000 million cubic metres of rain per year—of this amount, only 5.7% will be collected and held in reservoirs.[2] These issues are further compounded by the geography of the landscape, which directs and holds the water in the deltaic zones.

The collateral damage of floods—especially in poorer areas that lack the appropriate resources to provide relief to affected communities—is immense. Major impacts include the loss of potable water, wastewater treatment, electricity, and other urban infrastructures—which then results in the loss of human and ecological health and economy. For example, due to the major floods of 2011, there were disruptions to many industries which resulted in the loss of employment and income to many citizens—as well as the degradation of healthy living conditions, causing deaths: "Widespread floods [...] killed more than 900 people and caused major disruption to industry, cutting economic growth that year to just 0.1 percent."[3] With an increase in flood events expected due to climate change, both the degradation of environmental conditions and economic impacts will only be exacerbated.

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1 Lucy Ridout, "Best Time to Visit Thailand," *The Rough Guides*, 2017. https://www.roughguides.com/destinations/asia/thailand/when-to-go.

2 Daniel Maxwell, "Thailand: Breaking the Cycle of Flooding and Drought," *Asian Correspondent*, 2016. https://asiancorrespondent.com/2016/10/thailand-breaking-cycle-flooding-drought/#KKip66WPfyqVEqMX.97.

3 "Thai Floods Kill 21 and Hit Rubber Production," *Reuters*, 2017. http://www.reuters.com/article/us-thailand-floods-idUSKBN14T0F8.

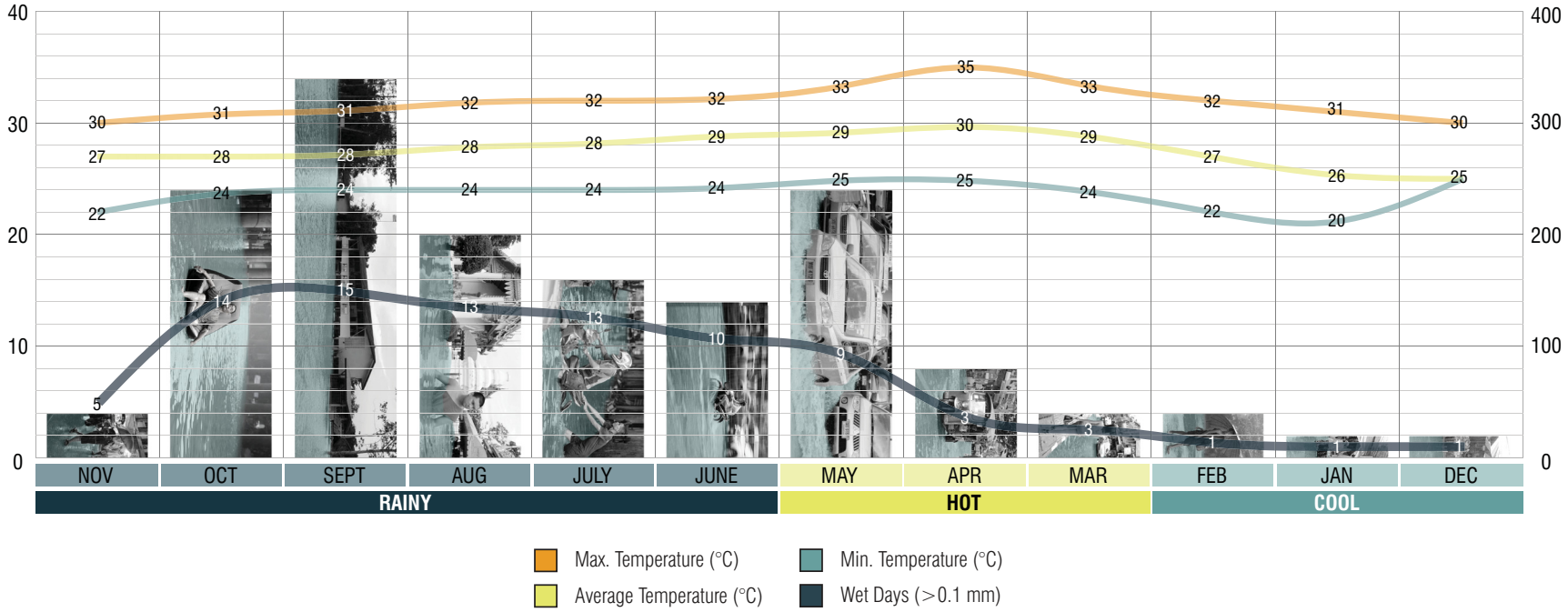


Diagram of Thailand's three main seasons and total annual precipitation averages with visual representations of the human relationship to low-high level flood times throughout the year. Data extrapolated from *Climatemps.com*, "Bangkok Climate & Temperature."

The Chao Phraya Delta

The Chao Phraya Delta begins at the confluence of four major rivers (the Ping, the Wang, the Yom, and the Nan), which travel south from the northern regions through the central plains of Bangkok—eventually culminating in the Gulf of Thailand. The effects of precipitation experienced along the Chao Phraya Delta vary considerably due to the topography, access to the coast, and spread of rainfall throughout the year, which have resulted in the formation of several diverse subregions: (1) the mountains and forests, (2) the agricultural plains, and (3) the coast.

The northern regions are characterized by mountainous, forested areas and broad plateaus used to grow high-value crops; however, since the region is relatively removed from the coast and from the main urban centres, it has resulted in a lower agricultural productivity and a higher incidence of rural poverty.[4] In contrast, the central area has been referred as the "historical rice basket" of the country, as it consists of many rich fertile, low-lying lands located near major urban centres for the commercial production and exportation of rice.[5] Further along the coasts of the southern peninsula, the ecological conditions have created ideal environments for the immense growth of rubber trees, as well as the mangrove forests which contribute to Thailand's growing economy in the shrimp-farming industry.[6] Combined, these diverse hydrographical conditions for cultivation along the river make up the natural landscape of the Chao Phraya Delta.

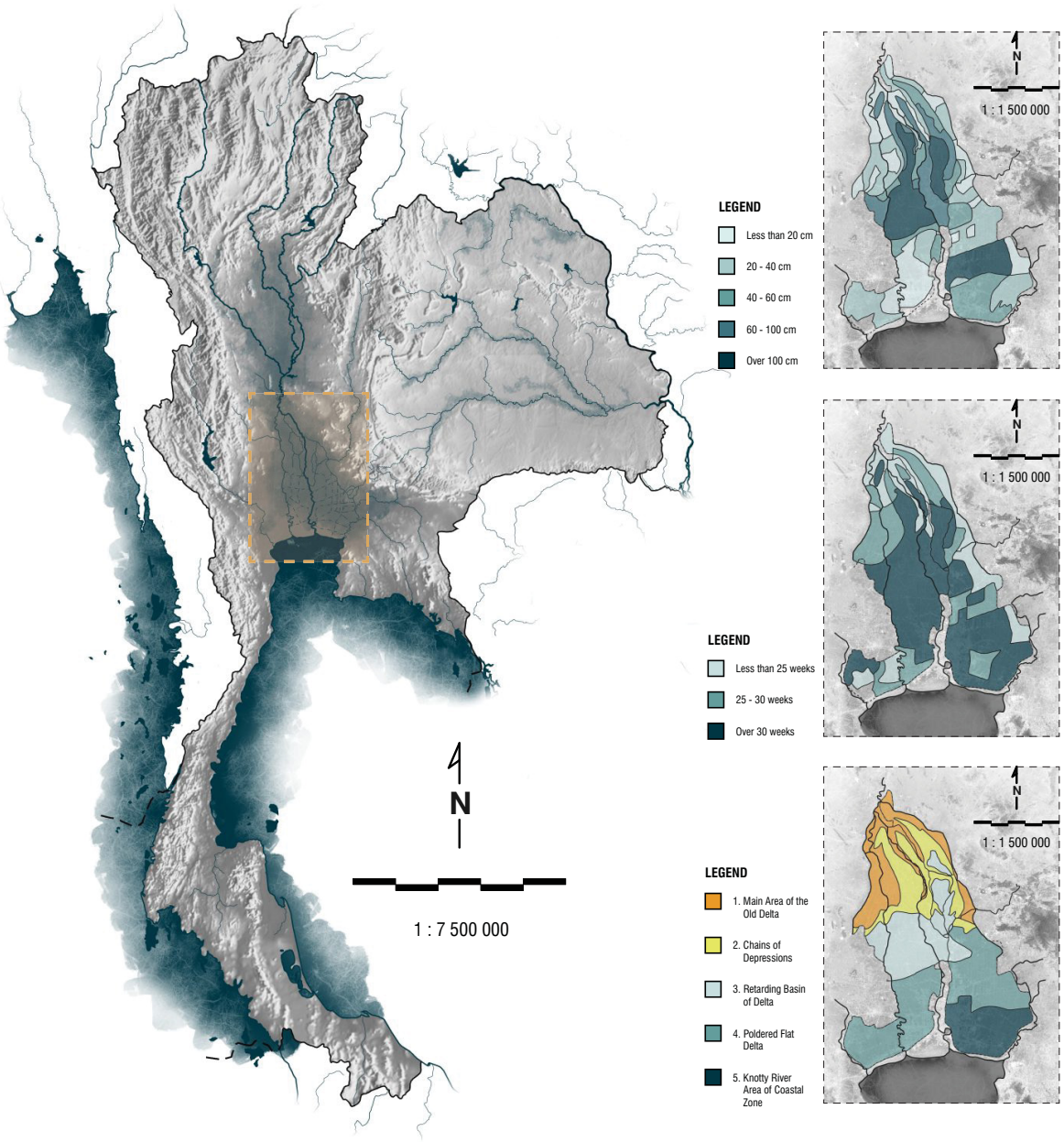
Due to the low topography of the central Bangkok and Ayutthaya area through which the Chao Phraya Delta passes, a 'bowl' effect is created in which the water returns slowly—thereby prolonging inundation periods throughout the deltaic subregions. Annual inundation levels can range from less than 20 centimetres per year to over 1 metre during major flood times, and these areas can remain inundated for over a month before the water can return to the natural environment.[7] As a result, this central area becomes a critical site of study to address flood issues within Thailand.

4 Overseas Development Institute, *Thailand's Progress in Agriculture: Transition and Sustained Productivity Growth* (London: ODI Publications, 2011), 4.

5 Ibid., 4.

6 Ibid., 4.

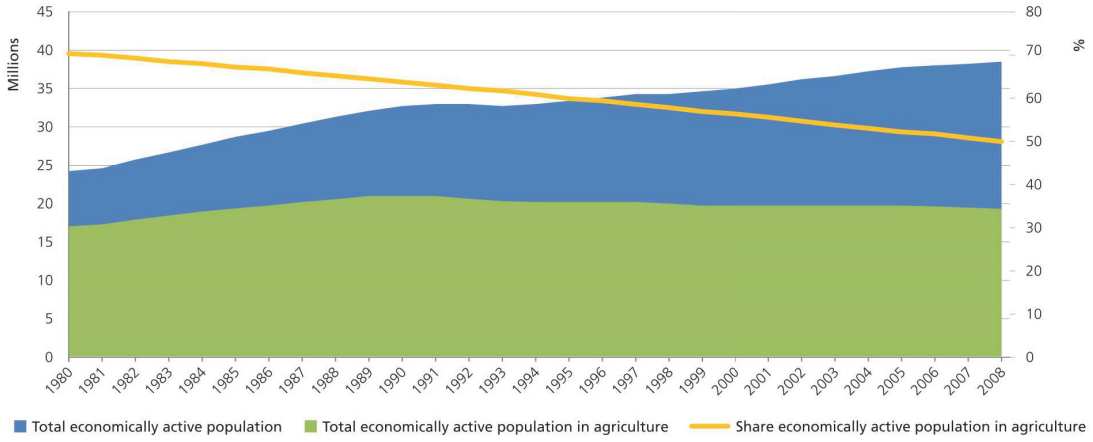
7 Yoshihiro Kaida, "A Subdivision of the Chao Phraya Delta in Thailand Based on Hydrographical Condition: Water Condition in Deltaic Lowland Rice Fields," *Southeast Asian Studies* 11, no. 3 (1973), 411.



Maps of the maximum depths / periods of inundation and hydrographical subregions of the delta, adapted from Yoshihiro Kaida, “A Subdivision of the Chao Phraya Delta in Thailand Based on Hydrographical Condition: Water Condition in Deltaic Lowland Rice Fields,” *Southeast Asian Studies*, 1973. Base map images from Google Earth.

Shifts in Urban Ecology

Although the Thai were historically well-connected with the land as an agrarian society, the rapid transition to urbanity has greatly altered their relationship with the landscape. Hagan defines the connections between ecologies of the delta and the cultural settlement or urbanization of that landscape as urban ecology: "the interactions between human culture and the natural environment, such as it is, in cities [that results from] changes in urban land use over time."[8] This places a particular emphasis on natural ecosystems that are interrupted by urban systems. In the case of the Chao Phraya Delta, the transformation of the ecological landscape by urban systems took place over two main processes of modernization: (1) when Thailand became the world's leading rice exporter in the early 20th century, and (2) through the industrial shift in agricultural production to export manufacturing by the end of the 20th century.[9] As a result, the Chao Phraya Delta's historic culture around rice farming is now defined by a complex socio-economic relationship of structures, functions, and changes, as many of the inhabitants have had to experience long periods of adaptation and resilience to deal with the massive alterations tied to land-based modifications caused by the growing global market.[10]



ODI, Agriculture's declining share of the workforce from 1980-2008, from *Thailand's Progress in Agriculture: Transition and Sustained Productivity Growth*.

8 Susannah Hagan, *Ecological Urbanism: The Nature of the City* (New York: Routledge, 2015), 21.

9 Danai Thaitakoo, Brian McGrath, Suebsiri Srithanyarat, and Ying Palopakon, "Bangkok: The Ecology and Design of an Aqua-City," in *Resilience in Ecology and Urban Design: Linking Theory and Practice for Sustainable Cities* (Dordrecht, Netherlands: Springer Science+Business Media, 2013), 428.

10 Yoneo Ishii, *Thailand: A Rice-growing Society*, trans. Peter and Stephanie Hawkes (Honolulu: University Press of Hawaii, 1978), 339.

Shifts in Industry

The economic growth of Thailand has been defined by a transition from agriculture to industrialization through manufacturing and exportation. In the first half of the 20th century, the country's economy was largely supported by the export of agricultural products (most prominently their rice), to neighbouring countries. The Chao Phraya Delta was transformed in the early 1860s from a swamp forest to a mixed urban / rural rice field complex as a result of the commercial cultivation of rice for export. Traditionally, both the people and the landscape evolved closely together through rice cultivation: "The rice economy was significantly influenced by water availability, thus traditional water distribution management was in place for irrigation and flood control at a small scale according to hydrological and topographical characteristics with unique local social organization."[11] However, this understanding of the surrounding landscape's value has dissipated over the years due to increased migration to urbanized centres—thus disconnecting the people from the land.

In 1950, Thailand established the National Economic and Social Development Board (NESDB), which sought to modernize their economy to emulate that of similar neighboring countries in the Far East—notably the "Four Asian Tigers."[12] Under this direction, Thailand began to focus its resources on developments around manufacturing and exportation—resulting in a spatial shift towards the urbanization of central hubs of production and an alteration of the natural landscape to accommodate the growing demands in agricultural exports.[13] Between 1980 to 1996, the Overseas Development Institute reported a mass transition in the population from rural farming areas to more urban sectors, which provided better job opportunities and income.[14] The economic consequences of such urbanization can be seen in the nation's demographics: of the 7.1 million who were determined to be living in poverty by 2014, over 80% of these people still resided in agrarian zones.[15]

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11 Thaitakoo, "Bangkok: The Ecology and Design," 430.

12 Antonia Hussey, "Rapid Industrialization in Thailand 1986-1991," *Geographical Review* 83, no. 1 (1993): 14.

13 Office of the National Economic and Social Development Board, "Summary: The Twelfth National Economic and Social Development Plan (2017-2021)," *Bangkok: The Board*, 2017. http://www.nesdb.go.th/nesdb_en/ewt_dl_link.php?nid=4345.

14 ODI, *Thailand's Progress in Agriculture*, 20.

15 World Bank Group, *Getting Back on Track: Reviving Growth and Securing Prosperity for All*, 2016. http://documents.worldbank.org/curated/en/855161479736248522/pdf/110396-REVISED-4-26-WB-TH-SCD-REPORT-BOOKLET-159PAGE-RevisedApr26.pdf.

Despite the significant leaps in economic growth over the past 60 years, much of Thailand's efforts on industrialization remain centered around the Chao Phraya Delta—particularly around the Bangkok metropolitan area. Although the government has begun to set up a strategic framework to address the economic gap between its urban and rural populations, it remains limited due to financial shortcomings in the planning and implementation processes. Moreover, the rapid urbanization of the floodplain has only increased flood risks that threaten urban dwellers.

By examining the network of canals that make up much of the historic urban areas in Bangkok, a better understanding of the impacts of industry on the Chao Phraya Delta's urban ecology has been developed. Additionally, other existing water management systems in the different subregions along the delta in Thailand, which demonstrate the processes of absorbing, distributing, and retaining water during the dry and wet seasons, can also allow us to better understand the region's hydrological cycles and the inextricable connection between infrastructure and day-to-day living on the delta—thus providing a set of potential strategies that can be used to rethink the infrastructure of urbanized Bangkok.

Comparison of the dry (right) and wet (left) seasons in the outskirts of Bangkok along the river. Original image by Paula Bronstein from Alan Taylor's "Bangkok Underwater" in *The Atlantic*, 2011.

Current Responses to Water in Thailand

To meet the many challenges of adapting to floods, topographical, architectural, and infrastructural responses have been developed at various scales within the different subregions of the Chao Phraya Delta (see map on page 4). Such responses include the retention basins, the poldered flats, and the canal system. This thesis examines these local precedents in coastal, rural, suburban, and urban conditions as not only potential strategies to anticipate and accommodate fluctuating water levels in flood-prone zones of urbanized areas, but also as ways of linking deltaic communities to their past and reconnecting them with the ecological landscape of the Chao Phraya Delta.

Coastal: The Mangrove as Ecological Protection

Mangrove forests are well-known for their vital role in the sustainability of Thailand's coastal ecosystems: not only are they a source of food for animals and local people, but they also provide nutrients to the surrounding seas and help to retain coastal land soil. The mangrove serves a unique role in acting as a "green" buffer against heavy winds and waves, which threaten to erode the coastlines.[16] The forests also protect against heavy flooding by lessening the impact of storm surges during the monsoon season. However, the gradual erosion of mangrove forests has been accelerated by heavy aquaculture—namely shrimp farming, which damages soil and disrupts the natural water supplies.[17] Although approximately 60% of coastal zones used to be occupied by the mangroves, these forests have seen a 28% decrease from 320,000 to 230,000 hectares between 1975 to 2007 due to the effects of deforestation and the damming of rivers upstream.[18] To preserve these delicate ecosystems against the rising intensity of coastal storms, man-made emergency barriers such as bamboo or concrete revetments are often required to break the ocean tides as they approach settlements along the coast. These constructions can also reduce the impacts of heavy water flow during floods, which could be applied further upstream.

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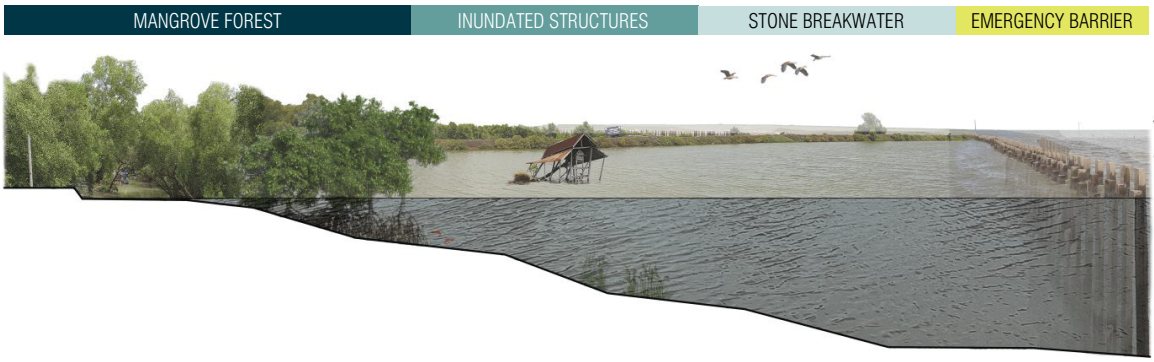
16 Mark Spalding et al., *Mangroves for Coastal Defence: Guidelines for Coastal Managers & Policy Makers* (Cambridge: Wetlands International and The Nature Conservancy, 2014), 42.

17 Brian Szuster, "Coastal Shrimp Farming in Thailand: Searching for Sustainability," in *Environment and Livelihoods in Tropical Coastal Zones: Managing Agriculture-Fishery-Aquaculture Conflicts* (UK: CABI, 2006), 87.

18 Nathsuda Pumijumnong, "Mangrove Forests in Thailand," in *Mangrove Ecosystems of Asia* (New York: Springer Science+Business Media, 2014), 65.



Conceptual section drawing of the mangrove forest and emergency barriers along the coast.

Khun Samut Chin offers a good example of the delicate relationship between humans and the mangrove ecosystem. Over the past few decades, the village has gradually declined due to the combined impact of both the advancing water from the rising sea levels and the downstream watershed from the Chao Phraya Delta. Many of the villagers have had to move their homes up to eight times, going further inland and away from the rising sea, while numerous families have been forced to leave the area altogether.[19] To slow the damage and destruction of their settlements, the local villagers have built temporary makeshift seawalls from bamboo and concrete. The concrete emergency barriers are constructed as triangular columns, which are placed in multiple layers to break incoming waves as much as possible whilst allowing porosity for ebb and flow. Although this response is not strong enough to prevent flood destruction altogether, it provides a potential strategy for water interruption and control that could be used in more urbanized areas.

On-site photos of the mangrove forests and bamboo + concrete revetments of Khun Samut Chin.

19 Jack Picone, “Thailand’s Village of Samut Chin: Turning the Tide,” *Al Jazeera*, 2015. http://www.aljazeera.com/indepth/features/2015/11/thailand-village-samut-chin-turning-tide-151122115118755.html.

Rural: Dams + Retention Basins

In the rural areas of northern and southern Thailand, dams are often used as the main infrastructural response to protect the hinterland from fluvial flooding. These dams have two-sided flood defence profiles and are controlled by the Royal Irrigation Department.[20] In addition, retention basins such as small ponds may also be used to separate the land in areas that seasonally flood from the rain. Natural parks and ecosystems typically form around these areas in the aftermath of dam construction due to the collection of water. Along the Chao Phraya Delta, 12 main water-retention fields in the upstream area help to absorb substantial amounts of northern run-offs and floodwater before it reaches the central region: for instance, the Chai Nat's Chao Phraya Dam currently "receives above 2,500 cubic metres of water per second."[21]

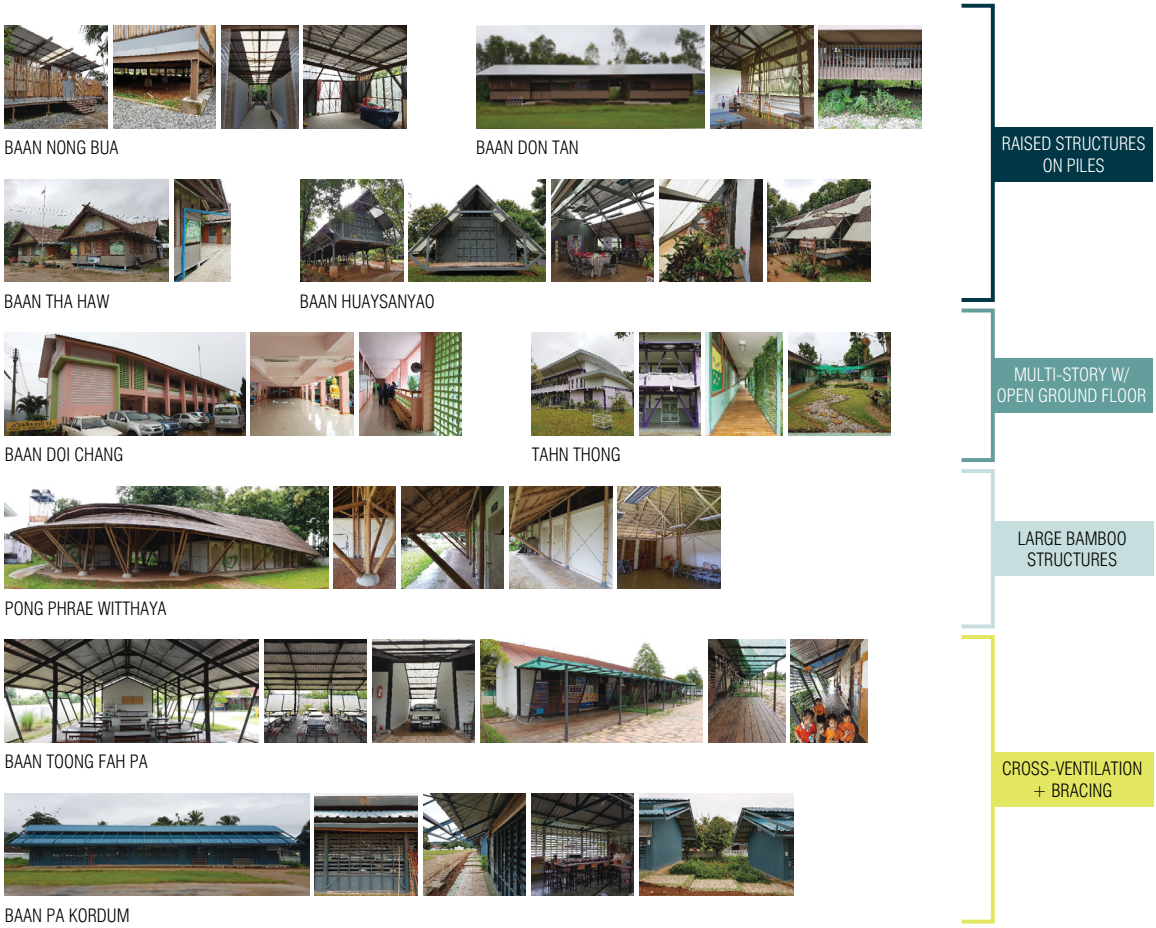
Infrastructural and spatial systems in these rural zones are often multi-hazardous rather than hazard-specific, as earthquakes tend to occur in the northern areas as well. Any small damages to (or overflow of) these systems can cause tremendous flood impacts to downstream areas—thereby requiring each operating dam in the northern regions to have effective mitigation plans that establish preventative measures against disasters. These strategies provide a potential opportunity to use water retention basins and their surrounding area to create more sustainable ecological systems that can bring greenspace back into urbanized centres.

Conceptual section drawing of the dams / locks and storm surge reservoirs of rural areas.

20 Pratch Rujivanarom, "Bangkok in Danger of Flooding Unless Old Drainage Improved, Say Academics," *The Nation*, 2017. http://www.nationmultimedia.com/detail/national/ 30329529.

21 Ibid.

The province of Chiang Rai in northern Thailand can serve as a rural case study that uses easily constructed, local building methods to deal with multi-hazard disasters. In 2014, the Thailand Research Fund (TRF) launched a major project to educate local engineers / handymen to repair and rebuild earthquake-damaged homes on their own.[22] Other initiatives such as Design for Disasters have built new disaster-resistant schools in high-risk areas, which are designed as multi-hazardous responses by raising the buildings to allow for flooding and using lightweight materials to reduce horizontal momentum.[23] Such projects not only improve social determinants of health like education, but also strengthen local communities by encouraging civic engagement.



Categorization of the design strategies employed for the nine new earthquake-resistant schools in Chiang Rai that were created as part of the disaster mitigation and adaptation initiative by D4D.

22 "The Thailand Research Fund Works to Promote Earthquake-Resistant Buildings in Chiang Rai," *Chiang Rai Times*, 2016. http://www.chiangraitimes.com/the-thailand-research-fund-works-to-promote-earthquake-resistant-buildings-in-chiang-rai.html.

23 Ibid.

Suburban: Polder Dikes + Building on Stilts

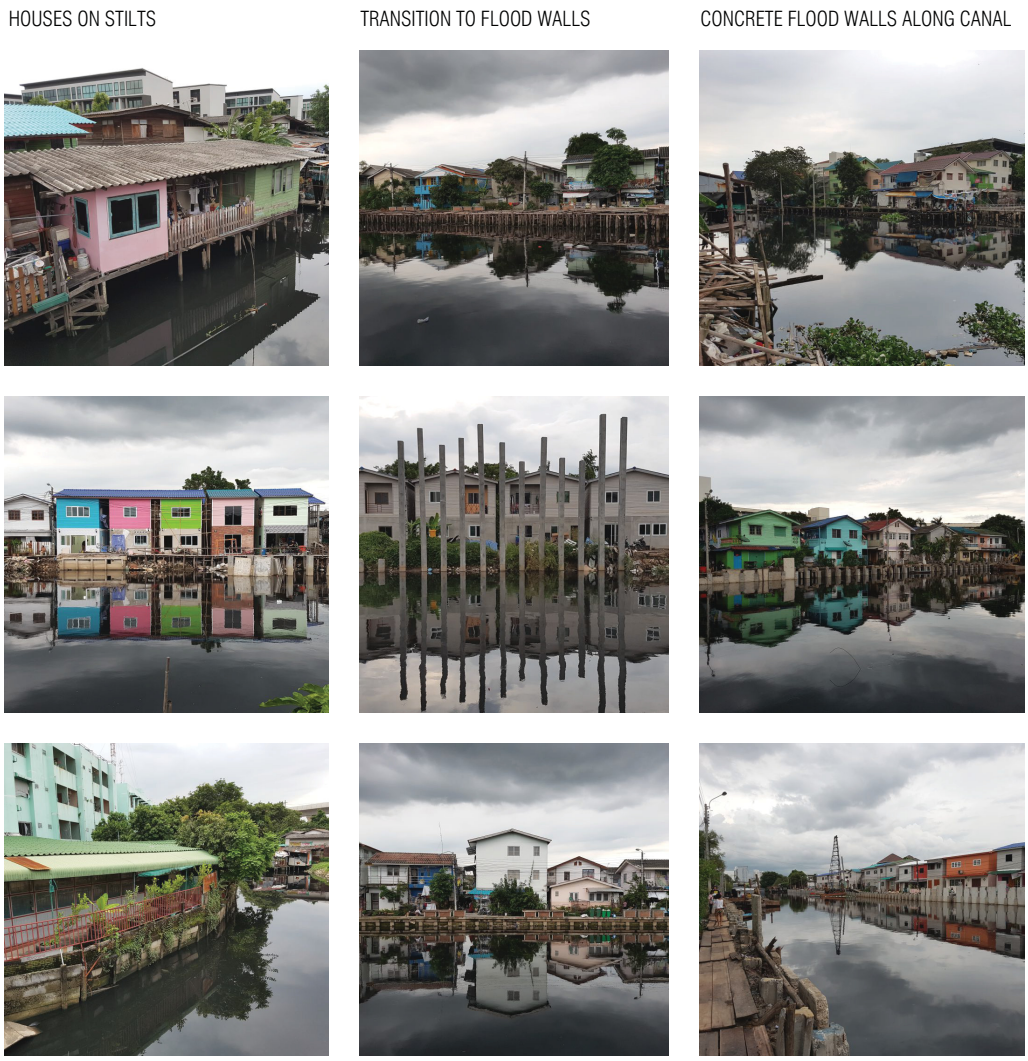
In the suburban areas of Thailand, infrastructural responses to flooding have taken on the form of polder dikes which allow the water to be artificially managed. If the water is not pumped out, then the polder will be flooded. The settlements along the canal / *klong* communities have been traditionally constructed on top of stilts rising out of the water. However, with the growing push for modernization, the government has begun to install concrete flood walls in the canals, covering up the stilts and reducing the ability of the neighbourhood to allow water to flow. These suburban areas thus provide a primary look into the current urban conditions of communities transitioning to modernization.

The reconstruction projects that have been planned and approved by the government aim to create more productive land use of waterside areas and clean up the canals for better irrigation and prevention of floods in the future. However, this clean-up process requires the mass relocation of families squatting along the canals: “The Bangkok Metropolitan Authority estimates more than 10,000 families are encroaching along 9 major canals.”[24] Without the needed resources for relocation upon eviction, short-term strategies must be determined to accommodate residents waiting for new housing—who are currently encroaching in informal settlements along the canal while the government continues to move forward with its plans to modernize the suburban areas.

Conceptual section drawing of the polder dikes and informal settlements in suburban areas.

24 Komgris Sutthivaiyakit, “Temporary Shelters with Floating Technology for Evicted Families along Canals in Bangkok Metropolitan Area,” in *ICAADE 2015, First International Conference on Amphibious Architecture, Design and Engineering*, ed. Elizabeth English and Natasha Klink (Kitchener, Ontario: M&M Printing, 2017), 276.

An on-site study of the Bang Bua *klong* community north of Bangkok illustrates how many of the homes have already been covered up by the concrete retaining walls. In addition, the government has implemented a policy that requires a 35-m minimum width for the canals.[25] The mandate has pushed several homes back to meet requirements without much consideration of the residents and has led to serious implications further along the delta—resulting in the formation of many informal settlements along the river. The current slum conditions of these suburban communities demonstrate the effects of inconsiderate modernization and the need to maintain historic ways of building on stilts.



Categorization of the various design strategies employed for the 9 new earthquake-resistant schools in Chiang Rai as part of the initiative by D4D.

25 Wijitbusaba Ann Marome (faculty at Thammasat University), email from author, 2017.

Urban: The Canal System

As a part of the irrigation system to supply rice agriculture in the central Chao Phraya Delta, canals were excavated using basic local technology and simple maintenance. In the early years, these canals functioned largely as water highways that radiated outward from the city center to provide access to agricultural market towns along the waterways. Although the massive network of waterways has historically characterized urban zones, the rise of urbanization has heavily diminished local water management systems—leading to water pollution, canal deterioration, and even the total destruction of irrigation systems.[26]

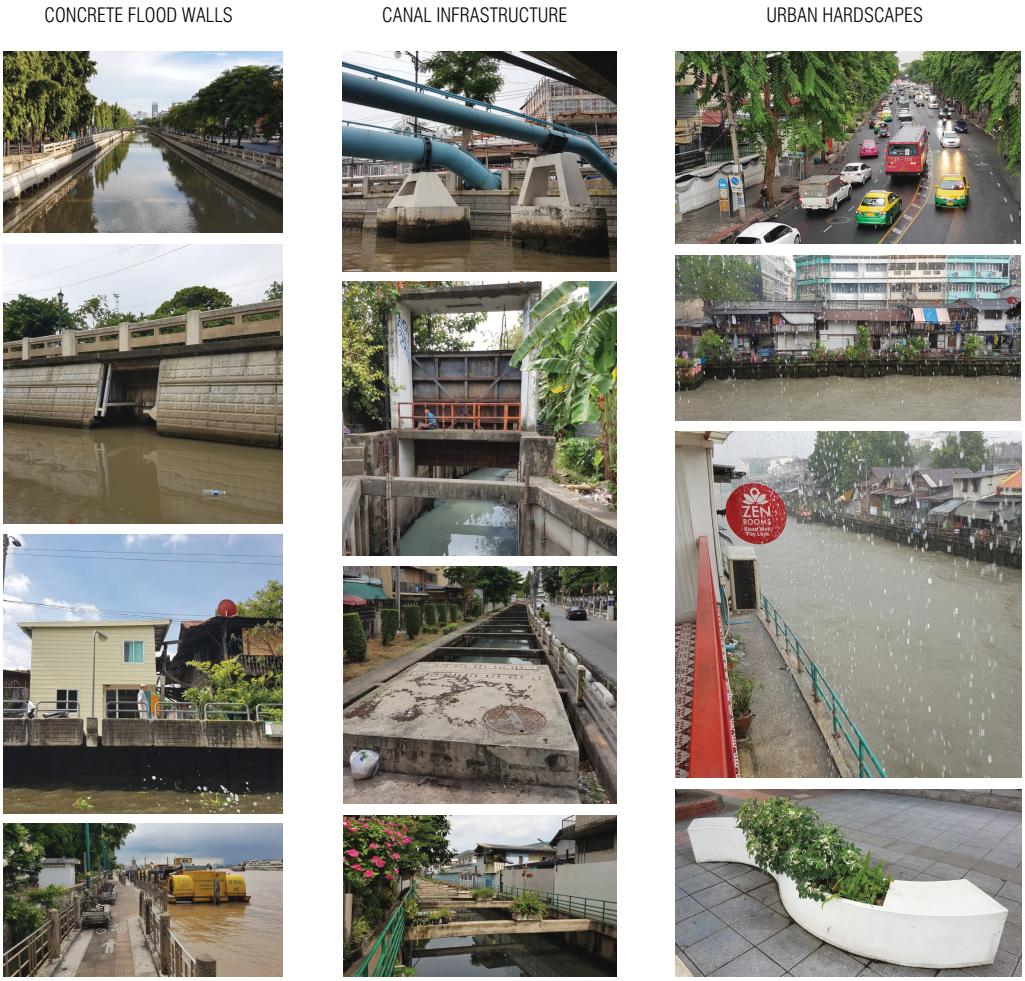
In major urban centres such as Bangkok, the canals were closely connected to the city's sewage system and suffer from combination of lack of maintenance, land sinkage, and garbage and sediment clogging—all of which greatly reduce the drainage capacity. The lack of separation between the household garbage and rainwater drainage also hinders drainage, as more than 10 million citizens in Bangkok release around 6 million cubic metres of wastewater into the system every day.[27] Moreover, the construction of flood walls along the Chao Phraya River increases its water levels to higher than that in the drainage system and canals, thus making water drainage to the river hard and slow.

Conceptual section drawing of the canalization and implementation of concrete flood walls in urbanized areas.

26 Vudipong Davivongs, Makoto Yokohari, and Yuji Hara, "Neglected Canals: Deterioration of Indigenous Irrigation System by Urbanization in the West Peri-Urban Area of Bangkok Metropolitan Region," *Water* 4, no.1 (2012): 13.

27 Pratch Rujivanarom, "Bangkok in Danger."

Due to the immense growth of modernization in major urban centres, many residents are now disconnected from the traditional way of living in homes raised on stilts or temporarily / permanently floating. This issue is especially evident in central Bangkok where many concrete flood walls have already been put in place due to urbanization, which worsens the situation since they decrease the width of the canals and prevent porosity within the city to address in-flow of water. In addition to trapping water, the flood walls create a two-tier system in which various areas are protected at the expense of others (usually the urban poor).[28] Due to the prevalence and severity of these issues in Bangkok, the city will be explored as the main urban site of study for new opportunities to reintroduce porosity through canals, blue-green infrastructure, and thresholds within the urban fabric.



Photographs of the various conditions and infrastructures that exist in urban zones.

28 Thin Lei Win, “Bangkok Struggles to Protect Slum Dwellers as Floods Worsen,” *Reuters*, 2017. https://www.reuters.com/article/us-thailand-floods-bangkok/bangkok-struggles-to-protect-slum-dwellers-as-floods-worsen-idUSKBN19A0KL.

CHAPTER 2: URBAN EXPANSION OF BANGKOK

Urban Transformations and New Infrastructures

Situated in the middle of Southeast Asia's tropical monsoon belt, Bangkok is located on the predominantly flat, low-lying floodplain of the lower Chao Phraya Delta. This region extends about 200 km to the north from the Gulf of Thailand and 175 km from east to west—characterized by a meandering belt of about 10-km wide floodplains that have developed along the river as it courses south.[29] The lower floodplain around Bangkok consists of a network of canals that was made when the area was first urbanized during the Ayutthaya period (1350-1767): "vast network[s] of mixed fruit orchards and market towns [were] planted within [the] harsh landscape that alternated between a vast flooded marsh in the rainy season and a parched grassland in the dry season."[30] At first, many canals were constructed and functioned as highways, with the lands in-between serving as fruit orchards and rice paddies. However, extensive development of the Chao Phraya Delta for rice cultivation and exportation triggered Bangkok's rapid urbanization.

The city has grown from a population of less than 50,000 in 1822 to approximately 9.6 million people today, accompanying the industrial expansion of the manufacturing and exportation industry in the 1930s.[31] During this sudden surge in population, Bangkok experienced an increased need for land-based infrastructure and road constructions for transportation—impacting its urban structure, as well as its resilience to water and floods. The accelerated growth of built-up areas was made at the expense of the cultivated land, which resulted in the disappearance of waterscapes. Almost all of the historic canals have now been in-filled with concrete roads and pavement—which further reduces the capacity and porosity of urbanized areas to embrace flooding by trapping rainwater and exacerbating flash floods. With the rise of climate change and the growing issues surrounding such hardscapes, a rethinking of the canal system is required to provide alternative measures for reclaiming porosity within Bangkok.

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29 Thaitakoo, "Bangkok: The Ecology and Design," 428.

30 Terdsak Tachakitkachorn, "A Comparative Study on the Transformation Process of Settlement Developed from Orchards in the Chao Phraya Delta" (doctoral dissertation, Kobe University, 2015), 19. http://www.lib.kobe-u.ac.jp/handle_kernel/D1003450.

31 World Population Review, "Bangkok Population 2017," *World Population Review*, 2017. http://worldpopulationreview.com.

Evolving Urban Form: Industry

To gain a better sense of the impacts that the loss of the canal had on the urban form of Bangkok and to analyze its potential to be resurrected so that water can flow back into the city, a deeper understanding of its modernization must be formed. With its establishment as an important trading post with European nations in the 18th century, Bangkok experienced an influx of European influences, including land-based systems such as roads and railways which are commonly observed today.[32] After WWII, Thailand began to shift its economy from agricultural exports to manufacturing exports and services. In Bangkok, this transition was evident in the sudden boom of modern facilities (e.g., banks, hotels, hospitals, universities, libraries, and museums), which developed alongside the land-based transportation routes.[33]

With these developments, Bangkok grew into an uncoordinated system of redundant water- and land-based transportation systems, with roads frequently running alongside canals. However, with the post-war reconstruction boom in 1945, the lack of central urban planning led to spatial conflicts that resulted in the loss of key water-based infrastructures.[34] Along with the growth of industry in Bangkok, populations rose to over 10 million in the 1990s, and people began to settle within the historic center for employment opportunities in the new developments.[35] The modernization of Bangkok is also supported by its tourism industry: in 2016, Bangkok topped MasterCard's "Global Destination Cities" with over 21 million visitors—further exacerbating the city's issues with ecological urbanism.[36]

In the wake of Bangkok's rapid urbanization and economic development, most of the traditional infrastructure that accommodated Thailand's heavy floods were removed and replaced by structures such as concrete dikes. While this transformation has enabled the city to maintain its status as an industrially booming modernized city, it has also come at the price of increased flooding and damage to the surrounding provinces.

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32 André Sorensen and Junichiro Okata, *Megacities: Urban Form, Governance and Sustainability* (Tokyo: Springer Science+Business Media, 2011), 140.

33 Ibid., 141.

34 Ibid., 142.

35 Ibid., 142.

36 Yuwa Hedrick Wong and Desmond Choog, "MasterCard Global Destination Cities Index," *MasterCard*, 2017. https://newsroom.mastercard.com/documents/mastercard-global-destination-cities-index-2017-report.

Impacts of Urbanization on Connection to Water

The issues of climate change compound the complex and delicate relationship that has evolved out of conflicts between the delta landscape and the city due to rapid industrial and population growth. Wandeler suggests that "cities, rather than being reified, [are] viewed as a common realm of people's lived experiences, an expression of the collective unconscious, constantly adjusting to new experiences."[37] Modern land-based urbanization fails to recognize the natural hydrological processes and indigenous knowledge of living with the natural cycles of the wet and dry seasons—by association, it also fails to recognize the connection between humans and the landscape. This separation is most noticeable in the development of Bangkok, as its modern urban form bears little remembrance of or resemblance to the historic infrastructures and landscapes for rice cultivation.

Evidence of how humans have traditionally adapted to live with water has vanished within Bangkok: almost all of its historic canal networks have been filled in for the construction of new road infrastructure, while others have now become stagnant and non-navigable for transportation as wastewater and drainage ditches.[38] Furthermore, the rapid urbanization has replaced the traditional Thai house on bamboo rafts and rows of floating shop-houses with the modern high-rise building, which further impacts the hydrological features of the Chao Phraya Delta landscape. Recent urban growth has resulted in a sprawl east of Bangkok into where the paddy fields are now located on the urban-fringe area, with new settlements being created on top and within historic agricultural zones.[39]

With the hard-edged canalization of water networks and the growing loss of porosity in the hydro-agricultural landscape, the Thai are becoming further removed from the traditional ways that once enabled them to live with flooding. Today, Bangkok must look to its historic connection to water in order to develop an understanding of historical resilience and adaptability to living with water and create new design models of urban ecosystems.

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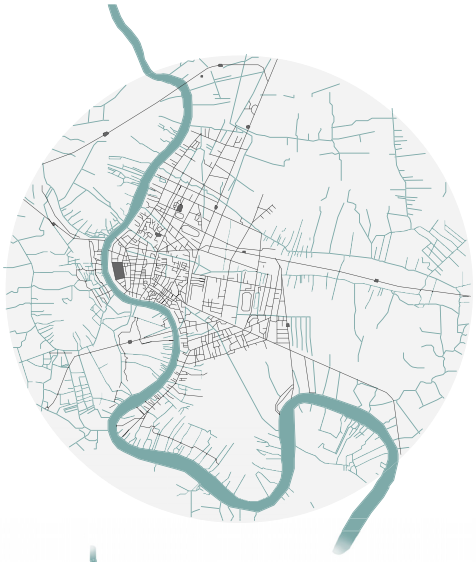
37 Koen de Wandeler, "The Urban Edge: Bangkok *Soi* as Mediators of the Global and Local," in *Cross-cultural Urban Design: Global or Local Practice?*, ed. Catherin Bull (London, New York: Routledge, 2007), 57.

38 Thaitakoo, "Bangkok: The Ecology and Design," 432-433.

39 Thanawat Jarupongsakul and Yoshihiro Kaida, "The Imagescape of the Chao Phraya Delta into the Year 2020," in *Proceedings of the International Conference: the Chao Phraya Delta: Historical Development, Dynamics and Challenges of Thailand's Rice Bow*l (Bangkok: Kasetsart University, 2000), 13.



URBAN FORM OF BANGKOK (CIRCA 1935)

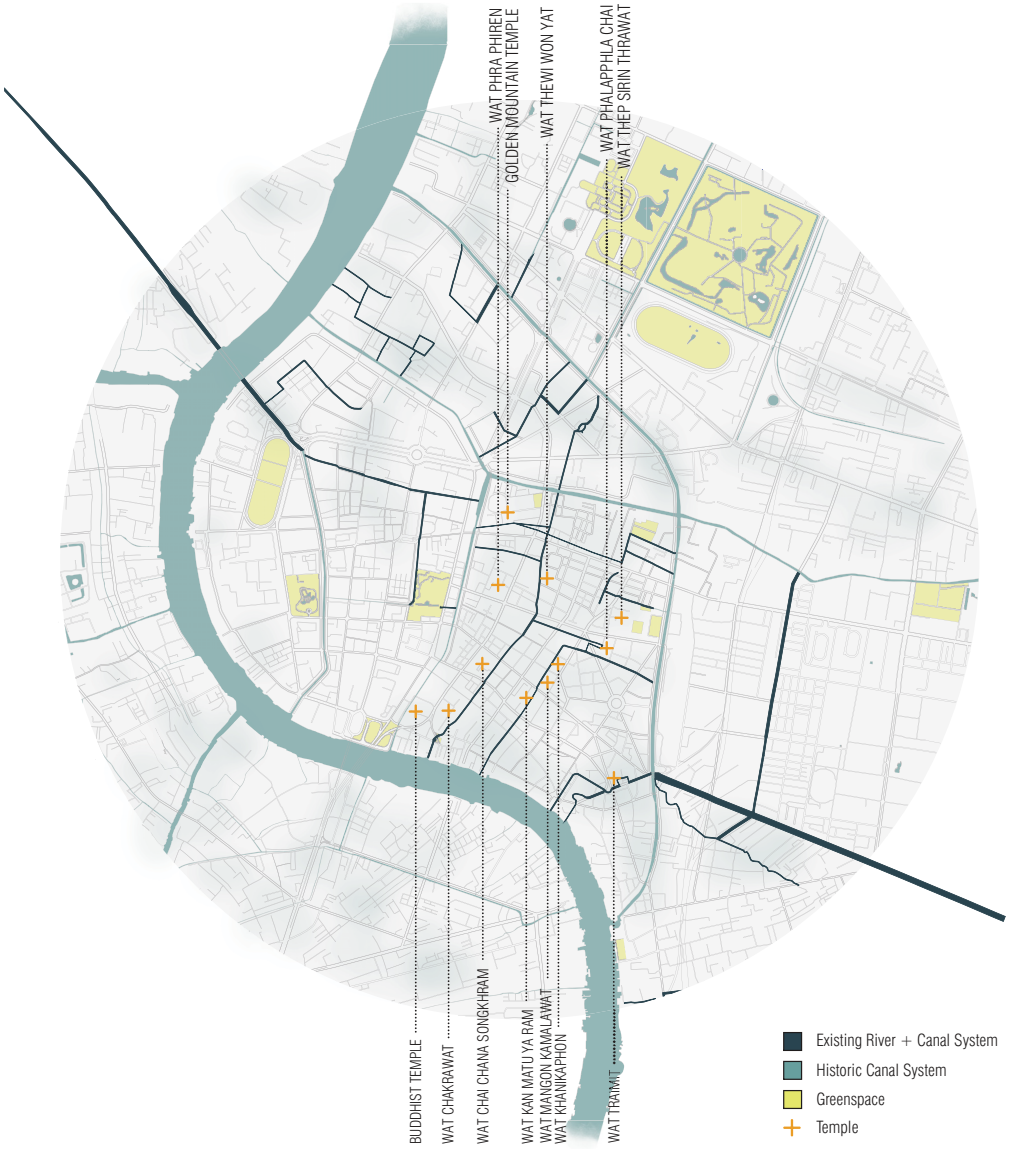
URBAN FORM OF BANGKOK (CIRCA 1955)

URBAN FORM OF BANGKOK (CIRCA 1975)

Photographs and maps depicting the rapid urban expansion of Bangkok. Original images by Danai Thaitakoo, which were adapted from Sternstein, 1982.

Reintroducing Water into the Urban Structure: Canals + Temples

Within Bangkok's new urban expansion, industrial, commercial, and residential developments now make up the majority of buildings that face the city's in-filled canals. However, in studying the other building types along the old canal infrastructure within Bangkok's historic centre, a very close connection was found between the edges of the past waterways and another key urban structure: the temple compound. The temple compound, with its large surface areas and public spaces along the historic canals, has the potential to be developed into floodable areas that can reconnect Bangkok to water.



Map of the existing and historic canals of Bangkok and their connection to many temple compounds.

Water has always held great cosmological significance for the Thai: it had a very important role in their material and spiritual lives and was used as a sacred ‘object’ in temples for customs around purification and protection.[40] As such, the diminishing connection to the water impacts not only the relationship between the Thai and the delta landscape, but also the spiritual connection to their religious beliefs. The loss of water is not just about flooding, but it is about the loss of culture as well. In the process of dealing with the ecological and urban landscapes, the cultural landscapes must also be considered because they are so inextricably linked. This is not as simple as just going back in time, but must evolve with both the modern and the traditional to create a more sustainable life.

By tapping into its historic connectivity to the canal infrastructure, as well as the indigenous processes and programs that are associated with it, I have chosen to study the temple as a potential strategy in this thesis to bring back the previous connection between people and water. The temples not only served as spatial centres of the city in the past, but continue to remain a significant part of Bangkok’s urban form today despite urban sprawl and modernization: they are usually the first structure to be rebuilt during flood disasters, which emphasizes the importance of spirituality in the Thai culture.[41] As such, water can be used to not only link spaces, but give cultural and spiritual form to historic places and bonds for people to gather and be brought together. This strategy is used to adapt a new model of urban ecology that would accommodate for flooding within the city while linking inhabitants back to their history and culture around water.

40 Dang Thi Oanh, “Water Symbol in Thai Culture in the North West of Vietnam,” *Journal of Literature and Art Studies* 7, no. 5 (2017): 621.

41 Thaitakoo, “Bangkok: The Ecology and Design,” 433.

Evolving Temple Form: Water

Despite the central role that water historically played in Buddhist beliefs, its physical presence in the temple compound has diminished over time. The temple's evolving form and its connection to water can be traced by studying the major cities within Thailand's three most important historical periods: Sukhothai, Ayutthaya, and present-day Bangkok.[42]

Buddhist temple architecture can be traced back to the Hindu temples of the Khmers who had previously occupied the region for over six centuries. During the Sukhothai period (1240 – 1438), elements of the Khmer temples were adapted and transformed uniquely into the architectural design of the Thai Buddhist monuments to reflect a more distinct identity for the newly formed Sukhothai kingdom, which had begun to follow the socio-political ideologies of Theravada Buddhism.[43] This change was particularly reflected in the spatial layout of the temples: in contrast to the rigid plans of concentric enclosures of the former Khmer temples, the Sukhothai kingdom articulated a freer distribution of temple buildings within the enclosed sacred space of the monastic compound—an orientation that has been adapted in many of the temple compounds within Bangkok today.[44]

The adapted presence of a canal around the temple is shown in Wat Mahathat of Sukhothai, which used the water to surround the enclosure wall and mark the separation between the monastic and the sacred. A new variation of water bodies was also introduced during this time in the form of water ponds, which came from the Theravada Buddhist customs of Sri Lanka.[45] Wat Mahathat featured four large ponds—each located in the three quadrants with the *ubosot*, which gained importance due to their orientation to water. In other temples such as Wat Traphand Thong and Wat Traphang Ngoen, ordination halls were situated right in the middle of the ponds.[46] However, in the Ayutthayan period (1350–1767), the Thai began to emphasize the ornamentation and decoration of Buddhist monuments to express cosmological symbolism in the place of physical water. This feature remains prevalent in Bangkok today, emphasizing the loss of water within the temple compound.

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42 Vikram Lall, *The Golden Lands: Cambodia, Indonesia, Laos, Myanmar, Thailand & Vietnam*, (New York: Abbeville Press, 2014): 193.

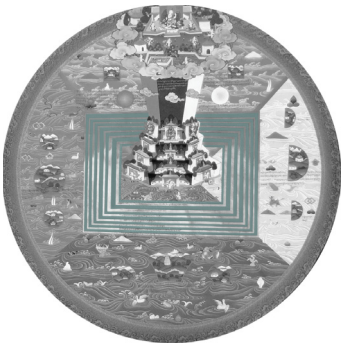
43 Ibid., 193.

44 Ibid., 204.

45 Ibid., 196.

46 Rita Ringis, *Thai Temples and Temple Murals* (New York: Oxford University Press, 1990), 37.

The mythical *naga* serpents, which represented the threshold between the profane and the sacred, were often used to adorn the roofs or balustrades of temples and replace the physical presence of ponds within the monastic complex. This transition is further demonstrated in Wat Phra Pai Luang of Ayutthaya: although there is the presence of a canal, it is often broken up and does not completely surround the temple complex.[47] Moreover, there is only one small pond located within the monastery located adjacent to the temple, which further reinforces the loss of water within the compound.



COSMIC OCEANS AROUND MOUNT SUMERU

CURVED BOAT FEATURES

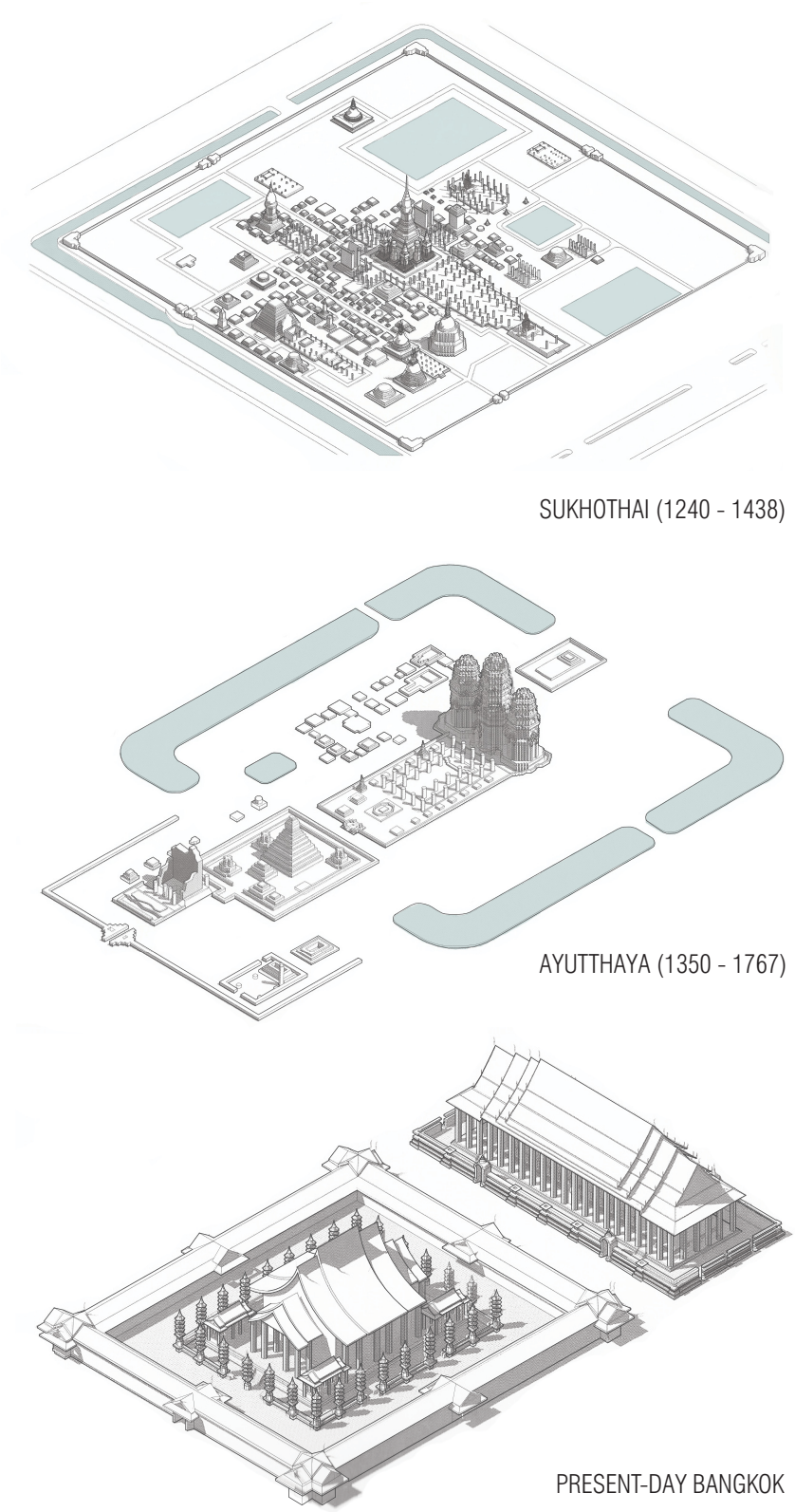
NAGA ORNAMENTATION

Diagrams of the water symbolism in the sacred. Images adapted from Greenwood, “The Meru Cosmos in Buddhist Art and Culture” and Araleya, “Naga Stairs in Buddhist Temple in Thailand.”

While present-day Bangkok continues to use the principles of planning from Buddhist monastic designs from the Sukhothai and Ayutthaya periods, the modern temple has evolved to remove the canal around the complex altogether and simply emphasize the enclosure wall. For example, in Bangkok’s Wat Suthat, the presence of both the canal and water ponds has vanished completely from the monastic complex.[48] This lack of water in Bangkok’s temples represents the growing disconnection of the modern city with its waterscape due to urbanization. In seeking to bring back the presence of the canal and water ponds to the temples in Bangkok, the typology of the temple can be reconnected to its history and return the cultural and spiritual value of water to the city’s urban ecosystem.

47 Lall, *The Golden Lands*, 207.

48 Ibid., 234.



A series of axonometric drawings of Sukhothai's Wat Mahathat (top), Ayutthaya's Wat Phra Pai (center), and Bangkok's Wat Suthat (bottom), illustrating the loss of water over time. Adapted from Vikram Lall's *The Golden Lands: Cambodia, Indonesia, Laos, Myanmar, Thailand & Vietnam*, 2014.

Over time, two distinct spatial zones have emerged from the temple complex, consisting of the profane (the *Sanghavasa*), and the sacred (the *Buddhavasa*). Whereas the profane zone contains teaching halls, quarters for the monks, and libraries, the sacred contains the assembly hall (*viharn*), the ordination hall (*ubosot*), and the central shrines (*stupa* / *chedi* / *prang*).[49] The *viharn* and the *ubosot* closely resemble the shape of boats and use the masonry construction—which alludes to the structures as 'vessels' for followers progressing across the seas of life. The symbolism of the boat is visible not only in the material use of wood, but also in the geometry of the bases and platforms of all the sacred structures during the Ayutthaya and Bangkok periods through the use of the curve.[50]

Moreover, every temple and hall would be oriented to face a body of water—either in the form of the canal or water ponds that helped to separate the profane from the sacred. These sacred buildings would also enclose at least one primary relic chamber within the wall enclosure that separated them from the profane.[51] A temple with a greater number of thresholds before reaching the relic chamber for prayer / meditation tended to be higher in its importance within the monastic complex. Furthermore, these thresholds would often take the shape of the bell-shaped *chedi*, or the Khmer-inspired *prang*, or the rectangular gathering hall for either assembly or ordination.[52] The ogival form and geometry of the *prang* is multi-tiered and takes on a 'mountain' form to represent the planes of existence and the seven abodes of Mount Sumeru—thus connecting humans vertically to the heavens.[53] By understanding the meaning behind these sacred geometries, similar design principles can be used to add value and adapt new spaces and thresholds within the temple.

Although the physical presence of water is being lost in the temples due to modernization and urban encroachment, water is still symbolically integral to Thai spirituality. By bringing water back into the temples and turning these complexes into potential reservoirs, this thesis aims to improve public spaces, pay homage to both the history and the religion, and accommodate floods for surrounding areas in connection to the past canal infrastructure.

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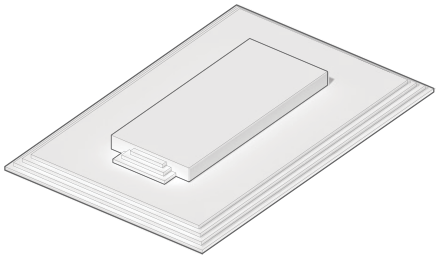
49 Lall, *The Golden Lands*, 222.

50 Ringis, *Thai Temples*, 76.

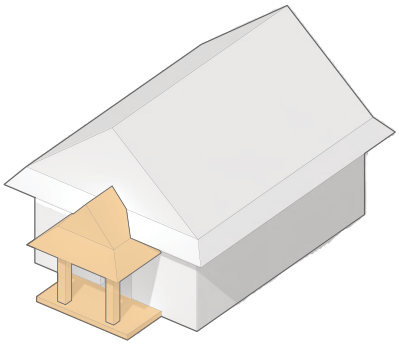
51 Micah Box, "Thai Temple Architecture: Symbolism, History, and Design" (master's thesis, California State University, Dominguez Hills, 1999), 28, http://ezproxy.library.dal.ca/login?url=https://search.proquest.com/docview/304552083?accountid=10406.

52 Ibid., 28.

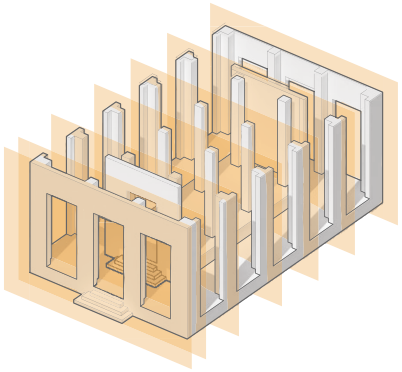
53 Lall, *The Golden Lands*, 217.



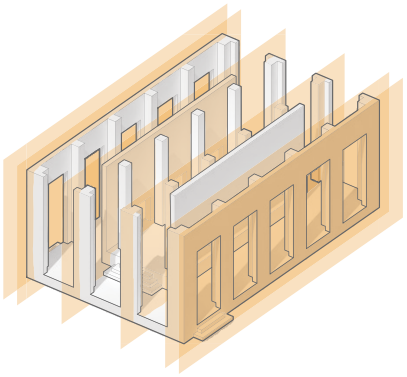
RAISED MOUND



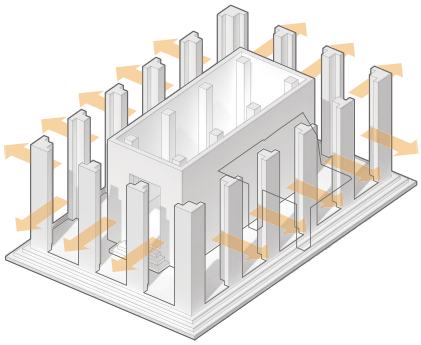
ENTRY VOLUME



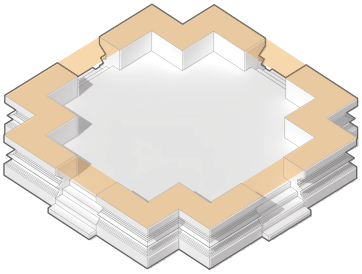
TRANSVERSE THRESHOLDS



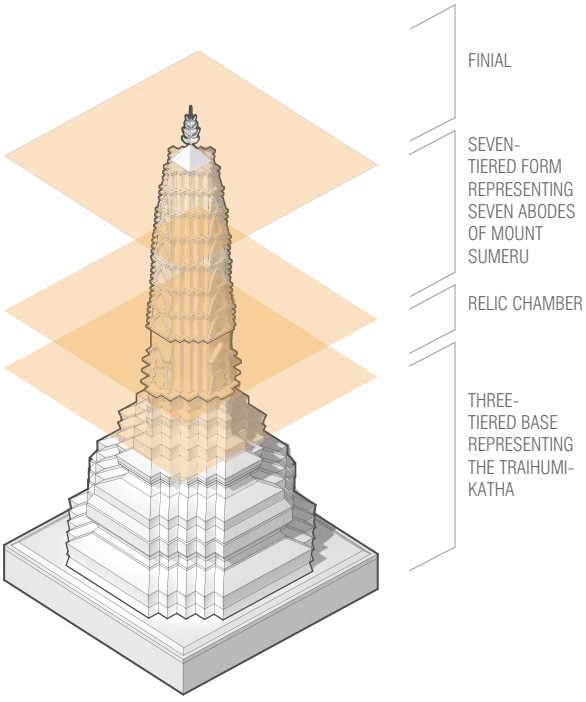
LONGITUDINAL THRESHOLDS



GALLERY VIEWS



LOTUS-SHAPED BASE



VERTICAL PLANES

Diagrams of the sacred geometries and symbolism typically found in temple complexes.

Water as Social + Religious Infrastructure

To further understand the deeply ingrained symbolism of water in Thai culture and spirituality, as well as the potential of water as a social and religious infrastructure, one must first establish a good framework of the Buddhist cosmological worldview. The universe is believed to be centred around Mount Sumeru—a sacred golden mountain where the gods live, which passes through the centre of earth and supports the heavens.[54] This mountain is encircled by seven concentric mountain chains, which are separated by the cosmic waters (usually represented by canals in the temple complex).[55] The *naga*, or guardian of the cosmic waters, is also a common symbol of water found in Thai temples: if not surrounded by a canal, the temples are symbolically 'immersed' in water by the presence of the *naga* on the roof or on the balustrades along stairs going up to the temples.[56] As seen in previous case studies, the temples themselves often serve as symbols of boats: for example, the *ubosot* (or main temple) is designed as a spiritual 'boat' that carries you to the heavenly realms. Some monasteries even have a water chapel which is surrounded by water—thus evoking a visual image of a boat floating in the middle of the ocean.

The social dimension and importance of water can be best observed in the long-developed cultural traditions which remain integral throughout Thailand, such as the religious rituals and annual major festivals to cleanse and repel bad luck. Within the temple, water is used for three main purposes: (1) purification, (2) offering, and (3) prayer or reflection. The water ponds of temple complexes were often used for ritual bathing during ordination rites to physically cleanse the body while purifying the mind and soul.[57] This act of washing is important in achieving both purity and clarity within the body, speech, and mind to attain true enlightenment: "It reminds us to diligently cleanse ourselves of our spiritual defilements of attachment, aversion, and delusion through the generating of generosity, compassion, and wisdom."[58] As such, a loss of water in the temples prevents individuals from being able to fully pursue true enlightenment and to connect with the surrounding cosmos.

54 Lall, *The Golden Lands*, 215.

55 Ibid., 215.

56 Box, "Thai Temple Architecture," 16.

57 Lall, *The Golden Lands*, 198.

58 Shen Shi'an, "Significance of Water in Buddhism," *Moonpointer: Buddhist Blog of Everyday Dharma*, 2011. https://moonpointer.com/new/2011/02/significance-of-water-in-buddhism.

The major Thai festivals are further rooted in this Buddhist ritual of cleansing. During the Songkran (New Year) festival, every town and village hosts a three-day water fight with both the young and the hold as a way of cooling off during the hottest month of the year. In both private homes and temples, the Thai will gather to sprinkle sacred water of images or statues of Buddha as a form of ritual bathing.[59] This act of bathing the relics serves as a reminder of self-purification, so water will often be sprinkled in consecration ceremonies during chanting services and homes for blessing. The Loi Krathong celebration also seeks to offer back to the water gods to thank them for their abundance over the year: banana stalk floats of incense and orchids are released by the Thai into the city's waterways, carrying their prayers for love, fortune and success.[60] Similarly in the temple, lotus-shaped candles are often offered at shrines.

CLEANSING / PURIFICATION

OFFERING

PRAYER / MEDITATION

Diagrams of the ritual uses of water in the temple. Images adapted from Thitayarak, "Thai Monk Clean a Head of Man by Water After Hair Shave for Ordination Ceremony in Buddhist in Thailand, Process in Vintage Style"; Aphai, "Water Pouring to Buddha Statue in Songkran Festival Tradition of Thailand"; and Saneha, "Buddhist Monks Praying for the Loy Krathong Festival at Wat Phan Tao on November 14, 2016 in Chiang Mai, Thailand."

These precedents of spiritual and cultural rituals and activities help to provide strategies for flexible programming around water as social infrastructure, which can be integrated into the architectural framework for a multi-layered scalar approach to increasing porosity within urbanized Bangkok and creating gathering places for people to connect with each other and the water.

59 Tourism Authority of Thailand, "Why Rivers and Water are at the Heart of Thai Culture," *Tourism Authority of Thailand Newsroom*, 2016. https://www.tatnews.org/why-rivers-and-water-are-at-the-heart-of-thai-culture.

60 Ibid.

CHAPTER 3: DESIGN FRAMEWORK

A Multi-Layered Scalar Approach to Flood Adaptation

This section provides an introduction to the overall design strategy for mitigating flood effects caused by mass urbanization in Bangkok and reconnecting its communities with the Chao Phraya Delta. The design strategy includes returning historic waterways and making blue-green thresholds, seeking opportunities for adaptation, connectivity (i.e., water parks / rain connection), and retrofitting buildings with ground and thresholds to reconnect people with water. As part of this strategy, the temple will be used as a potential typology to store water and link inhabitants back to their history and culture with water.

Infrastructure

Although modern infrastructural interventions have transformed the Chao Phraya Delta landscape from a water-based network to a road-based society, several opportunities for adaptation can be found by looking at the spatial development of constructed waterways. Instead of undertaking measures to keep water out, the historic canal infrastructures can be resurrected to invite water back into the city and reconnect communities with the delta.

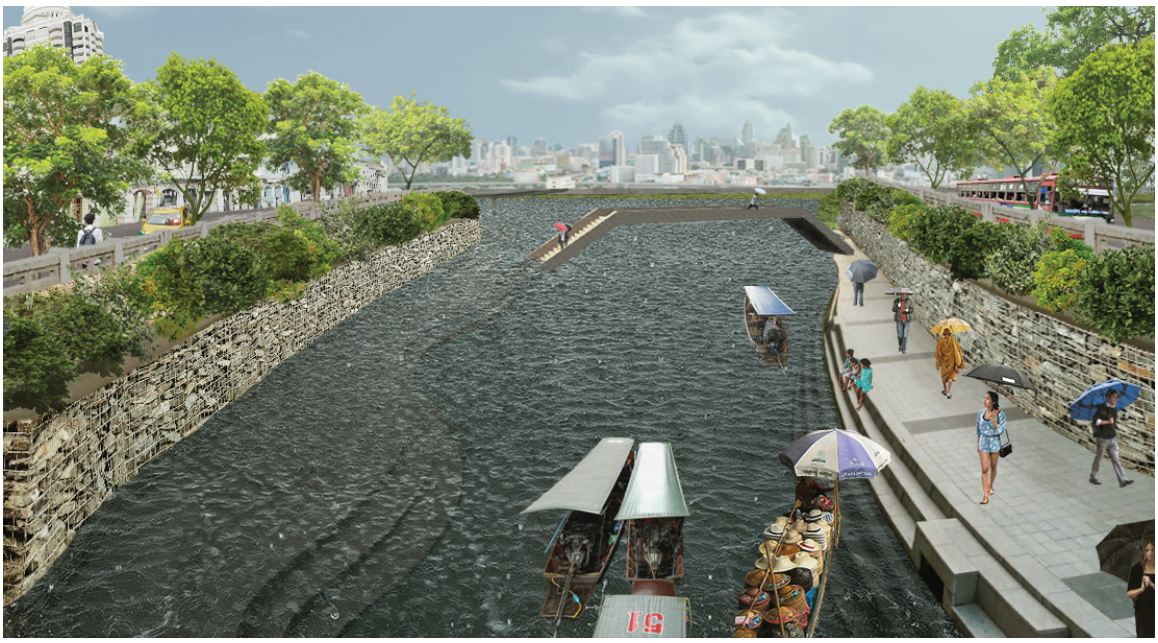
A precedent that uses the canal as an integrated urban infrastructure is Venice. Due to its location inside a lagoon across an archipelago of 118 small islands, the city is vulnerable to floods from high tides coming from the Adriatic Sea near the Po delta.[61] For centuries, Venetians have adapted by embracing the canals as the 'veins and arteries of a living organism,' which provide vitality in fishing, transportation, and agriculture.[62] While other strategies include raising pavements and the MOSE Project, primary efforts are placed on dredging canals and repairing stonework to preserve the waterways as landscapes of built memory and cultural geography—an approach that can be translated to Bangkok.[63]

61 T. Spencer, J. da Mosto, and C. A. Fletcher, "Introduction: ecological and environmental context," in *Flooding and Environmental Challenges for Venice and its Lagoon: State of Knowledge*, ed. C. A. Fletcher and T. Spencer (New York: Cambridge University Press, 2005), 17.

62 G. Caniato, "Between Salt and Fresh Waters," in *Flooding and Environmental Challenges for Venice and its Lagoon: State of Knowledge*, ed. C. A. Fletcher and T. Spencer (New York: Cambridge University Press, 2005), 9.

63 T. Spencer, J. da Mosto, C. A. Fletcher, and P. Campostrini, "Venice and the Venice Lagoon: Creating a Forum for International Debate," in *Flooding and Environmental Challenges for Venice and its Lagoon: State of Knowledge*, ed. C. A. Fletcher and T. Spencer (New York: Cambridge University Press, 2005), 4.

Rendering of how a floating market can potentially be introduced along the new canal to return a cultural vitality around water to Bangkok during the dry season.



Rendering of the potential shift in activity and pathways that may happen during the wet season due to increased water levels along a new canal infrastructure.

Public Space

Since current infrastructural responses have become inadequate on their own for major areas of urbanization due to the lack of consideration around maintaining the urban ecology along the Chao Phraya Delta, the design strategy seeks ways to connect these systems to public spaces. New opportunities for adaptation is needed by combining and retrofitting existing infrastructures with open spaces to work in concert with nature and reduce the risk of future floods. One approach to transforming our urban spaces is opportunistic adaptation, which requires a systems perspective to perceive the city as a collection of interacting components that are constructed with variable temporality or permanence.[64] Using this urban strategy, components are renewed individually or as groups (e.g., a complete street including buildings, street, pavement, gardens, sewage network and other utilities).[65] By understanding the urban systems and potentials of intervention to retrofit and redesign infrastructure to embrace water, adaptation measures can be integrated into new designs (or replacements) to transform the existing urban fabric of Bangkok.

Rotterdam provides a strong precedent of public space integration with infrastructure. Despite their similar struggles with water, the Dutch have become well-known for their ability to make water their ally—to the effect that "the Netherlands lives with water" has now become the title of the government's major campaigns for public education.[66] With approximately a third of the country consisting of water, the Dutch have had to adapt to push the water back, prevent floods, and reclaim lands: primary flood defences include sea dikes which protect against water from the sea and large rivers, whereas secondary canal and small river systems provide regional flood defences.[67] In the mid-1900s, the government launched the Room for the River project to accommodate water which involved removing tree groves that impede water flow to relocating a dike to widen the river bed.[68]

64 Polpat Nilubon, William Veerbeek, and Chris Zevenbergen, "Amphibious Architecture and Design: A Catalyst of Opportunistic Adaptation? - Case Study Bangkok," in *ICAADE 2015, First International Conference on Amphibious Architecture, Design and Engineering*, ed. Elizabeth English and Natasha Klink (Kitchener, Ontario: M&M Printing, 2017), 213.

65 Ibid., 213.

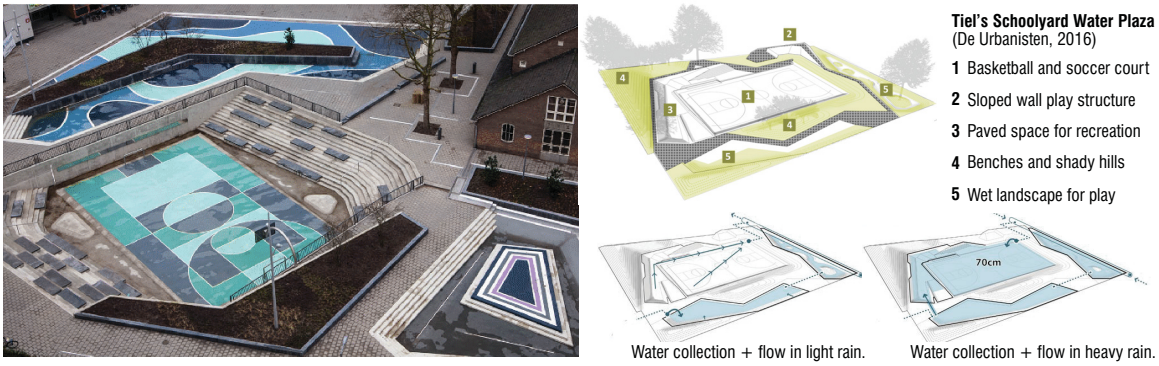
66 Tracy Metz and Maartje van den Heuvel, *Sweet & Salt: Water and the Dutch* (Rotterdam: NAi Publishers, 2012), 97.

67 Hoogheemraadschap van Rijnland, "Flood Control in the Netherlands: A Strategy for Dike Reinforcement and Climate Adaptation," *Rijnland Water Control Board*, 2009. https://www.rijnland.net/downloads/floodcontrolrijnland-1-1.pdf.

68 Metz and van den Heuvel, *Sweet & Salt*, 133.

The spatial planning of making room for the river has influenced the urban development of vulnerable delta cities in the Netherlands, including Rotterdam. The inner-dike city of Rotterdam is located in the delta of the rivers Rhine and Meuse, with its lowest point at approximately 6.67 metres below the mean sea level.[69] As a result, the city experienced many problems with its sewage and drainage systems. In the mid-nineteenth century, architect W. Rose established the 30-km canal system with locks and pumping stations to continually refresh water.[70] Although it is still vulnerable, the dams, dikes, and land reclamations have reduced the dangers and risks of flooding in Rotterdam. The government further drew up a Water Plan for the first time in 2000, and recently released a Climate Change Adaptation Strategy in 2013 to continue working with the delta landscape.[71]

Using the idea of making room for the river, Rotterdam has begun to develop new ways of enhancing the safety and spatial quality around water. For example, the Grebbedijk dike project by LOLA Landscape Architects demonstrates how the traditional dike can be re-evaluated with a more holistic lens as a vital component to the community, rather than an isolated object.[72] Joep van Leeuwen also designed the stepped dike which features sloping embankments or terraces to provide space for roads, buildings, parks, and recreation.[73]



Photograph and diagrams of the Water Square design by De Urbanisten.

69 City of Rotterdam, "Rotterdam: Climate Change Adaptation Strategy," *Rotterdam Climate Initiative*, 2013. http://www.rotterdamclimateinitiative.nl/uk/file/climate-adaptation/projects-climate-adaptation/Rotterdam%20Climate%20Change%20Adaptation%20Strategy?project_id=180&.

70 Metz and van den Heuvel, *Sweet & Salt*, 175.

71 Ibid., 175.

72 Ibid., 93.

73 Ibid., 177.

The concept of living with water is most well-manifested in the water plaza by De Urbanisten.[74] This innovative idea is part of a sustainable urban drainage system: when heavy rain falls on the hardscapes over a short period, it does not pour all at once into the sewers and overflow them. Instead, the water is used to create beautiful public squares, which collect stormwater runoff from the surrounding environment into storage basins. Following a rainfall, water is absorbed into the ground, evaporated, and reused in the municipal sewer when the system is under less stress. As a result, water plazas can be used as a way to bring environmental, economic, and social benefit to their communities—they provide opportunities for various recreational and educational uses which enhance not only social interactions, but also the connectivity between people and the land.

Early program ideas that make room for water to flood and connect urban public spaces to the historic canal infrastructure during the dry (top) and wet (bottom) seasons.

74 De Urbanisten, “Water Square Benthemplein,” *De Urbanisten*, 2013. http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein.

Rendering of a potential design intervention that introduces a floodable park connection to the new canal infrastructure, where a water square can be used for recreation during the dry season.

Rendering of the floodable park during the wet season, in which the water square is used for water leisure and the boardwalk can move to allow water to rise and flow underneath.

Thresholds

The design strategy integrates both traditional and modern ways of adapting to water to retrofit existing buildings, resurface canal infrastructures, and transform open spaces into places of connection with water. These innovations can help to transform present-day interactions between people and water—promoting a more socially and culturally sustainable way of living with water. In the temple typology, the interface between the sacred, the profane, the canal, the city, and the river becomes thresholds where ground connections and flexible programming can be developed to enhance the interconnections for people and water as they flow between the buildings and the canal system.

An example for designing temple thresholds in a way that highlights the interactions between people and water is the Persian Garden, which connects water elements symbolically and functionally. The geometrical structures and layout of the garden, sequences of water and landscape elements, and the position and activity of the person in relation to the water enhance the experience and connectivity with water. These principles could also be applied to the movement of people and water as they interact between the temple wall enclosure and the canal system in Bangkok.[75]

To further define these thresholds, architectural components and details can be developed to respond to the changing levels of water throughout the year. Such pieces can be added to existing urban structures, which would allow for adaptation and transformation spatially and temporally to meet specific programmatic needs. As an example, there could be walls and platforms that move and relate to traditional methods of social interactions with water—which include dynamic floatation devices (e.g., the pontoon), static structures raised on stilts, and houseboats. Other modern examples include the well-known studies of structural foundations for high-risk flood zones that were conducted by Chutayaves Sinthuphan of Site-Specific Co., Ltd.—a firm that designed and built the first amphibious house in Ban Sang village and has become heavily involved with designing to accommodate water in Thailand.[76]

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75 Jamal-e-Din Mahdi Nejad, Hamidreza Azemati, Esmaeil Zarghami, and Ali Sadeghi Habib Abad, “The Role of Water in Persian Gardens,” *Open Journal of Ecology* 7 (2017): 43.

76 Alisa Tang, “Thailand Tests Floating Homes in Region Grappling with Floods,” *Reuters*, 2016. http://www.reuters.com/article/usdisaster-risk-architecture-idUSKBN0M100N20150305.

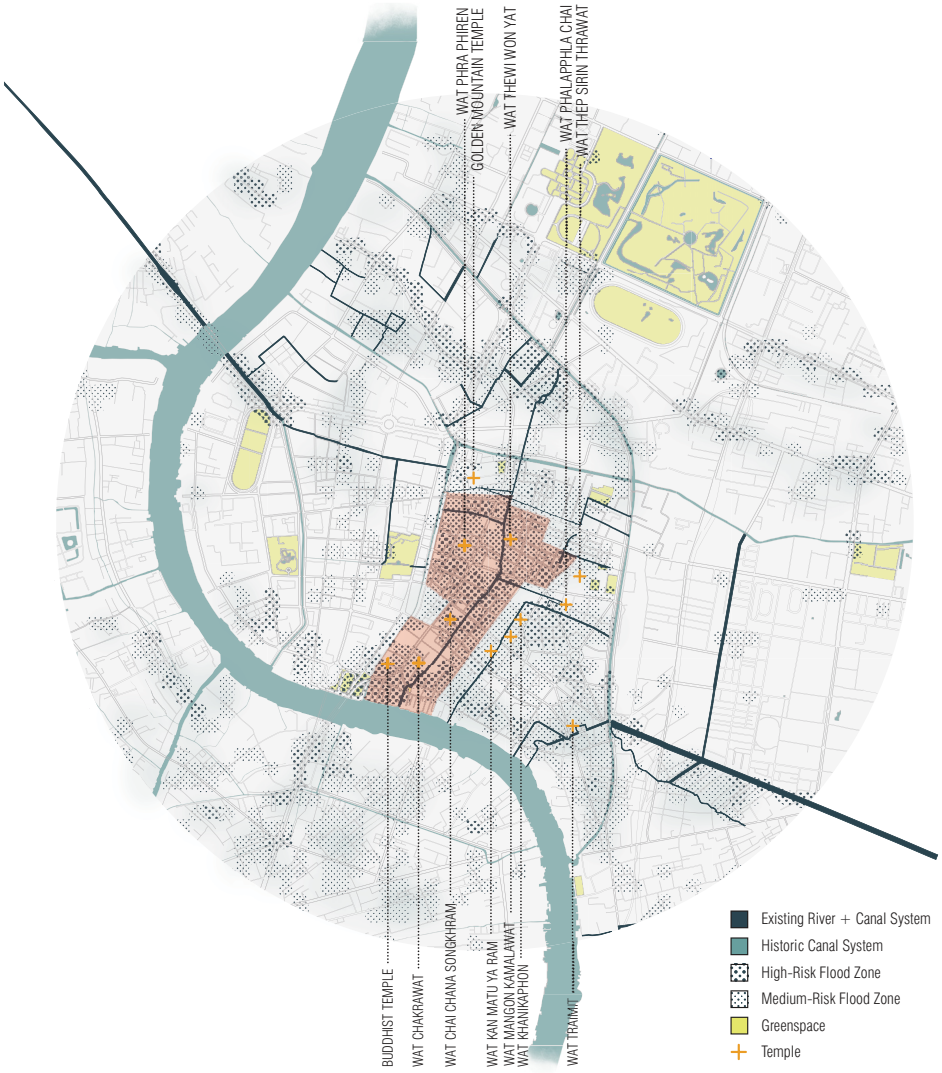
Rendering of a potential threshold condition that may exist along the edge of the Chao Phraya River, where permeable bamboo or concrete revetments can be used as barriers against floods.

Rendering of how a structure can be retrofitted to be amphibious and float up within the concrete foundation to respond to flood events during the wet season.

CHAPTER 4: SITE ANALYSIS

Creating New Opportunities Along the Canal

The design proposal aims to reconnect Bangkok with its historic water system by daylighting key canals to return water to the city and alleviate the flow of water during flood times. In studying the flood mapping of Bangkok, the central zone between Rop Krung Canal and Hadung Krung Kasem Canal was pinpointed as the most high-risk flood zone within the old city centre. The historic canal system was then examined with the temple compounds as a potential network for how and where water could be brought back into the urban fabric—increasing porosity and retention capacity.



Urban map created of Bangkok's medium- and high-risk flood zones using ArcGIS data extrapolated from Sithiprom's "Urban Flood Hazard and Risk Resolution 100 Meter in Bangkok," 2016. The historic canal system is highlighted to select potential sites that will alleviate flood levels.

Zoomed-in diagram that illustrates the daylighting of Maha Chak Road and highlights the six temples that are connected to the historic canal. Base map image from Google Earth.

The presence of many temples was also identified along these canals, which provide a lot of unused, open spaces that could potentially work with the new canal to allow for water to flow within the city. Using the design methodology, a new waterway along Maha Chak Road is proposed to resurrect the historic canal—which is connected to six temple sites—to help carry water out from the central zone. These temple compounds will be used in this thesis as potential sites for creating new opportunities to reconnect the existing urban fabric with its historic waterways and restore the social value of water to the delta community. For the purposes of this thesis, the Wat Chakrawat site has been selected as our main area of study, as it is the closest temple compound to the Chao Phraya River along Maha Chak Road.

Wat Chakrawat

Wat Chakrawat first dates back to the Ayutthaya Period, when the temple used to be called Wat Sam Pleum. In 1819, Chao Phraya Bodindecha (a.k.a. Sing Singhaseni), the leading general in the reign of King Rama III, began to rebuild the temple.[77] Upon final completion in 1835, the complex was presented as a royal temple to the king and given the current name Wat Chakrawat (which translates to “cyclone” or “storm”). Today, Wat Chakrawat houses one of the largest communities of monks and novices in Bangkok.[78]

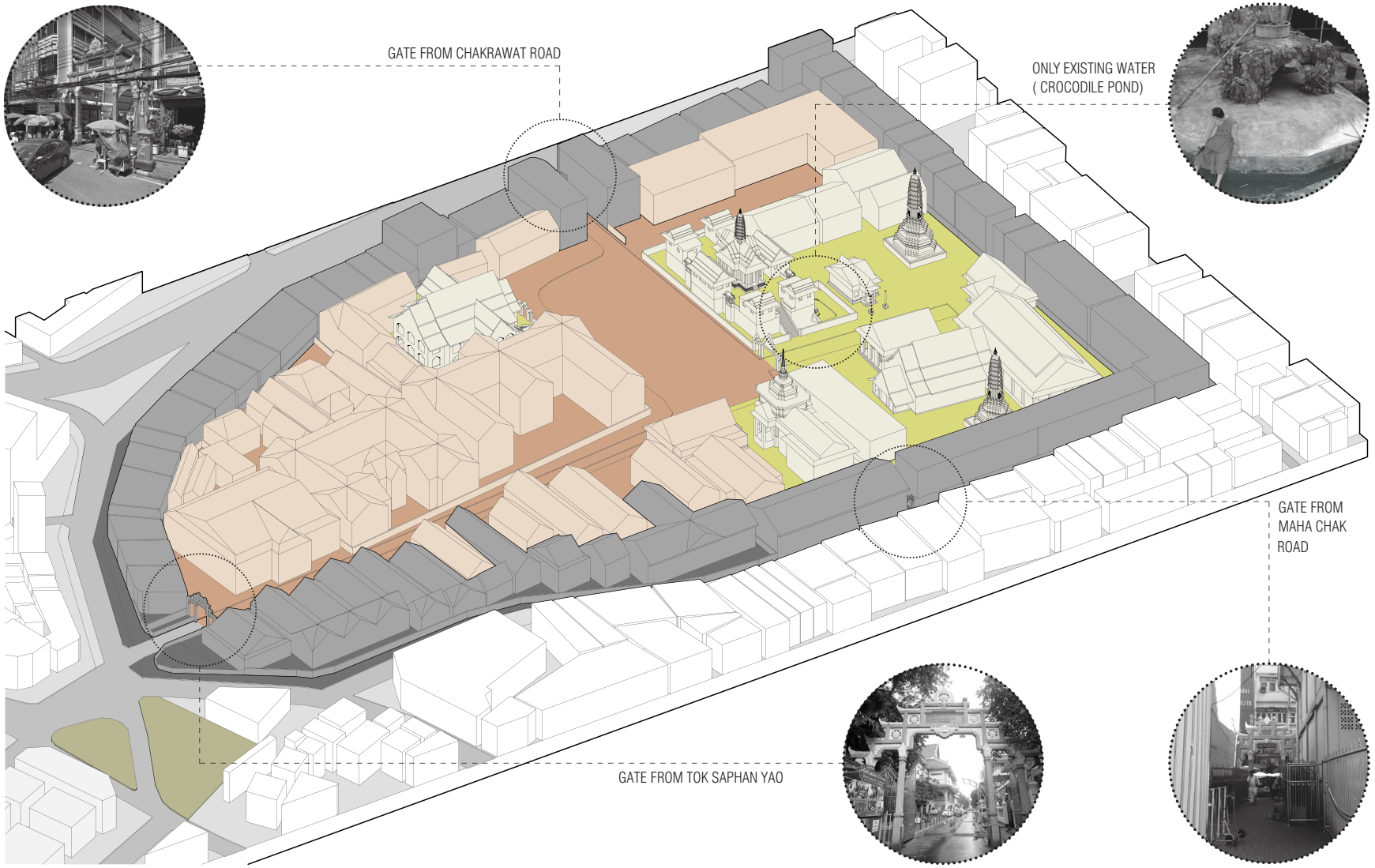
The small temple complex is comprised of three main zones: (1) the urban (beyond the wall enclosure), (2) the profane, and (3) the sacred. On the urban fringe of the temple, commercial stores and informal markets have been set up facing the streets. In the profane zone, there is a school where monks teach kids from the nearby communities, as well as monastic dormitories and teaching halls. Often, the grounds are mistaken as a car park due to the vast parking space located in the centre: “It seems that the whole neighbourhood is parking their cars are the temple ground or just offering their merits to Buddha.”[79] Many of users of this parking space tend to be visitors or merchants of Bangkok’s Chinatown district, which begins east of Wat Chakrawat across from the Maha Chak Road.

Photos of the parking space located in the centre of Wat Chakrawat, which separates the profane and the sacred zones. Original photos from Vipavee Kunavichayanont.

77 Autthapon Eiumkitteepathara, “Wat Chakrawatrachawat Woramahawihan (Wat Sam Pleum),” *Thailand Guide Travel*, 2013. https://thailandguidetravel.blogspot.com/2013/08/wat-chakrawatrachawat-woramahawihan.html.

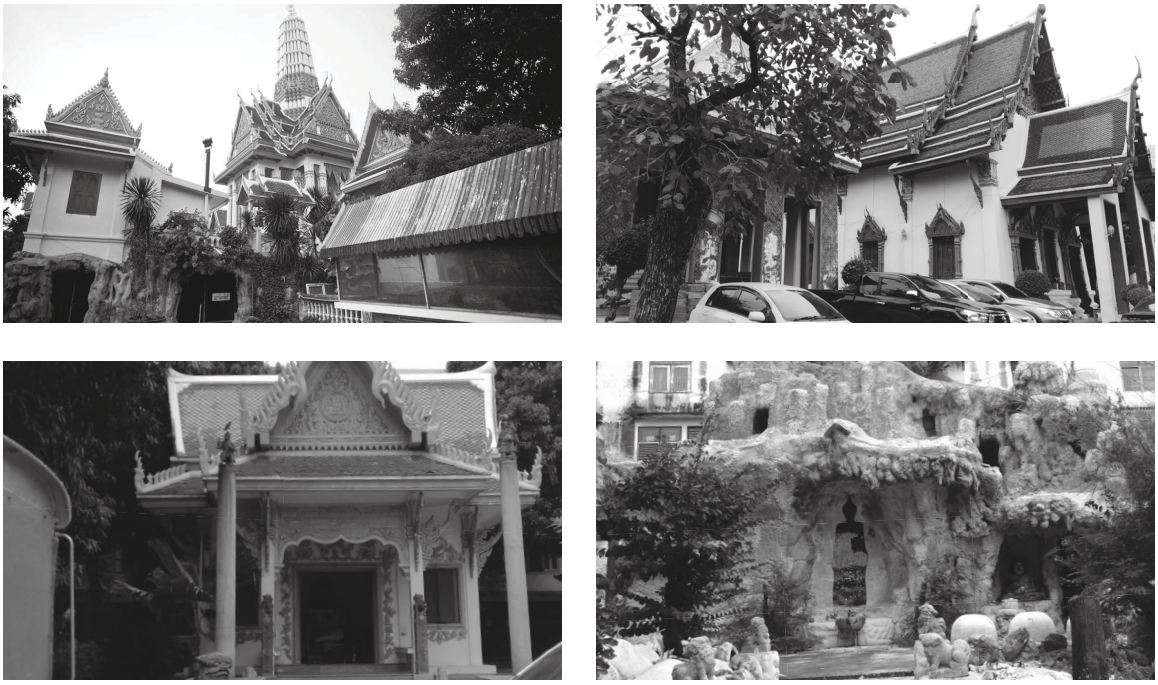
78 David Luekens, “Wat Chakrawat,” *Travelfish*, 2017. https://www.travelfish.org/sight_profile/thailand/bangkok_and_surrounds/bangkok/bangkok/111.

79 J. J. Smith, “Wat Chakrawat,” *Temples in Bangkok*, 2018. http://templesin bangkok.com/wat-chakrawat.



Axonometric drawing of the existing site analysis, showing the three main zones. Original photos from Nathayu Sutarasuwan and Google Street View.

Upon passing through the gate into the sacred zone, there is a stairway located on the left which leads to a platform with a *mondop* (or shrine housing a Buddha relic) topped with a *prang*. On the right of the gate, there are two *viharn* and a concrete grotto with small memorials for departed relatives and a black shape on the wall (known as 'Buddha's shadow'), which is covered in gold leaf offerings from visitors.[80] This structure is a unique part of the ritual process in Wat Chakrawat which celebrates and pays tribute to the cycle of life and death. As it is located next an open space within the sacred zone, it also provides an opportunity for water to be connected and ingrained into the spiritual symbolism / rituals.



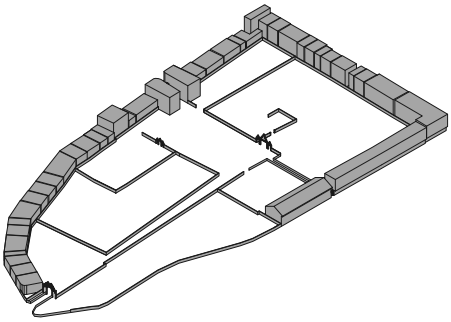
Photos of the main temple structures and unique concrete grotto memorial seen upon entering the sacred zone. Original photos from Nathayu Sutarasuwan.

Another key aspect that separates Wat Chakrawat from other temples is that its *ubosot* does not traditionally face where water used to be, but westward towards the Emerald Buddha of the Grand Palace—which further demonstrates how the temple compound has become disconnected to the water.[81] The temple structures are typically raised up on mounts as a means of lifting the architecture off of the ground to address issues of raising water levels caused by heavy rain falls and floods around the compound.

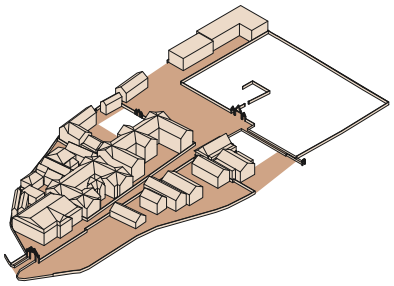
80 Smith, "Wat Chakrawat."

81 Ibid.

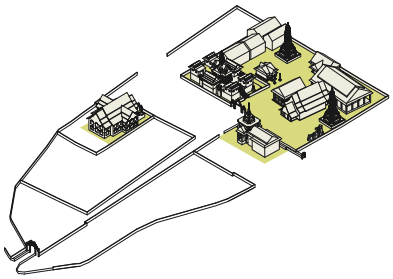
THE URBAN



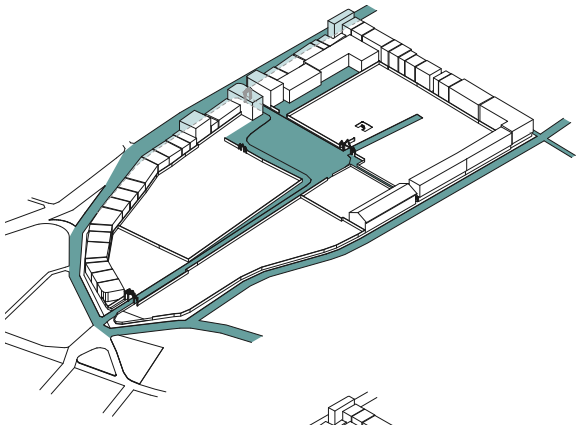
THE PROFANE



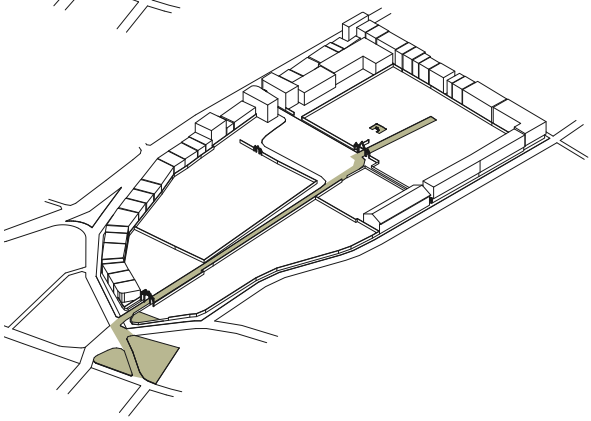
THE SACRED



OPEN SPACE–ACCESS CORRIDORS



EXISTING WATER + GREEN SPACE CONNECTION



A series of layered diagrams analyzing the site. Original photos provided by Nathayu Sutarasuwan.

The Enclosure: Wall–Building

Similar to the historic temples, Wat Chakrawat is surrounded by an enclosure of exterior walls and buildings that acts as a barrier between the temple compound and the rest of the city. As Wat Chakrawat was first constructed during the Ayutthaya period, it can be assumed that the sacred spaces were originally separated by the presence of a moat surrounding the compound. This divide has now been simply replaced by the use of the 'buildings-as-walls': although it may have once consisted of only walls that surrounded the temple compound in the past, buildings began to take the place of these walls with the expansion of Bangkok. This concept of the 'buildings-as-walls' is presumed to be the case on at least three sides of the site, which allowed the historic temple to open towards the previous canal where Maha Chak Road is currently built upon. Today, the historic wall can only be observed on the southern edges of the street, with buildings replacing the wall as the enclosure on the northern edge of Maha Chak Road to where a small gate enters into the site. Furthermore, with the development of the road and the buildings along the enclosure, new live-work programs have begun to emerge on the edge of the old canal.

The growing presence of marketplaces on the outskirts of the temple are evidence of the ongoing relationship between spirituality and capitalism. This typology of small market spaces facing the streets is a common sight today in urbanized Bangkok, although some of these market spaces are only temporary and simply set up off these walls. The growing influences of the market economy in the 1970s catalyzed this new typology as the range of spiritual practices became more associated with worldly material gain with the rise of export manufacturing and services. Two spatial forms of market spirituality have come about in Wat Chakrawat as a result of the development of vendors along the fringe of the temples: (1) public shrines in connection to major commercial buildings, and (2) smaller personal shrines erected by individual merchants that are simply set up in-store or on a cart.[82] Just as economic changes are shaping the religious landscape of Bangkok, so too are spiritual practices influencing the practice of everyday economy. This complex relationship requires an appropriate architectural response in order for users of the commercial space to be reconnected with both the temple and the water systems that surround it.

82 Ara Wilson, "The Sacred Geography of Bangkok's Markets," *International Journal of Urban and Regional Research* 32, no. 3 (2008): 632.

Photos of the informal markets set up off the ‘buildings-as-walls’ enclosure around the temple along Maha Chak Road. Original photos from Vipavee Kunavichayanont and Nathayu Sutarasuwan.

Open Space + Pathways

Similar to its historic precedents, the profane and sacred spaces of Wat Chakrawat are separated through the open space in its core—although it may have once been a large pond that separated the two zones, there is now a large parking lot in the middle of the temple. Surrounded by Wat Chakrawat’s monastic residences and teaching halls, the open space is accessed from both the western Chakrawat Road and the southern Song Wat Road through wide pathways marked by temple gates into the complex. A very narrow pathway with a small temple gate also enters into the site from the eastern Maha Chak Road, which may been a point of water passage into the temple complex from the historic canal. Today, the open space is used predominantly by cars; however, the vast area provides an opportunity to transform it back into a water pond to accommodate for floods.

Photos of the main gate and access pathway into the temple compound from Maha Chak Road. Original photos from Vipavee Kunavichayanont.

Existing Water + Greenspaces

In the sacred zone adjacent to the platform that the *mondop* sits on lies a small pond containing a couple of crocodiles. Two stuffed crocodiles also lie in a dusty display next to the pond. The story goes that the four creatures were found swimming along the Chao Phraya River and were brought to the temple as it was closest to the river. Today, part of the duty of the monk is to care for these sacred pets since the crocodiles represent deities of strength and power in Thai folklore.[83] As with many temples in urbanized Bangkok, the reptilian symbols of the crocodiles and the *naga* serpent ornaments that adorn the roofs and balustrades of the temples has replaced the physical presence of water within the complex. Since this small pond is the only existing body of water within the temple, there is a great potential to bring back historic ponds to the temple and provide more opportunities for flexible programming that would allow for greater spiritual interactions with water.

Photos of the only existing pond and greenspace. Original photos from Vipavee Kunavichayanont.

In addition, the only greenspace around the Wat Chakrawat complex is located outside the southern gate of the wall–building enclosure. Although it contains several trees and plants, the space is not accessible—instead, it is encircled with metal fencing. Outside of this boundary, food cart vendors have set up small stalls. The only connection that this greenspace has to the existing water within the temple complex is via the path / road accessway that extends through the gate of the sacred zone to the southern gate. The greenspace is also connected to the Chao Phraya River along this north-south axis through Song Wat Road and Trak Saphan Yao—thereby marking the centre of the green-blue corridor that connects from the water pond in Wat Chakrawat to the river. This greenspace provides a possible area for rainwater to be collected and stored to mitigate flooding.

83 Anna Harriette Leonowens, *The English Governess at the Siamese Court* (Boston: Hardpress Publishing, 2010), 192.

CHAPTER 5: DESIGN

Application of Framework

In addition to the new canal infrastructural system, a second water management system will be used to address the collection and filtration of rainwater from the roofs of surrounding buildings. The three zones are used as a method of organization so that each zone has an isolated rainwater system: first, rainwater will be collected from the roofs of the surrounding temples and buildings and drained into reed beds for filtration. This water will then enter waterways in the ground that will be pass through various stages of filtration as they weave through the spaces and form various programmatic spaces. Afterwards, the water enters a purification pond, where it can be more fully filtered using aquaponics and phytofiltration. Clean water will then enter a storage pond, which serves as a reservoir for holding the water for various activities. During flood times when the water levels surge and overflow, any excess / unused clean water will then be routed back towards the river.

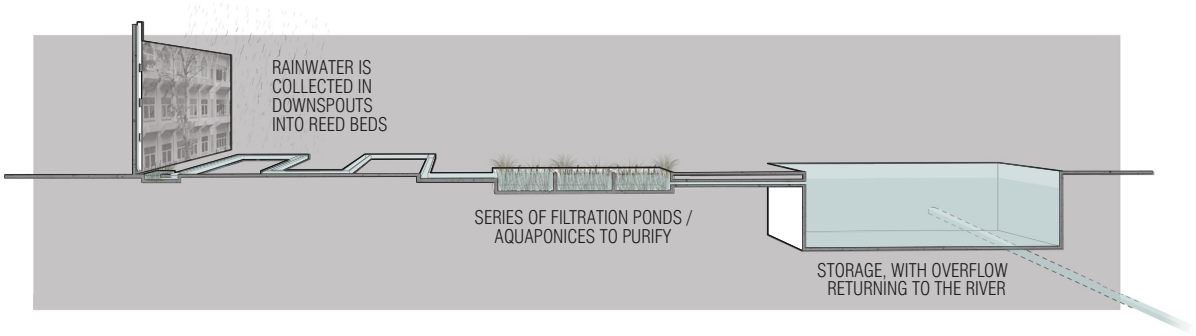
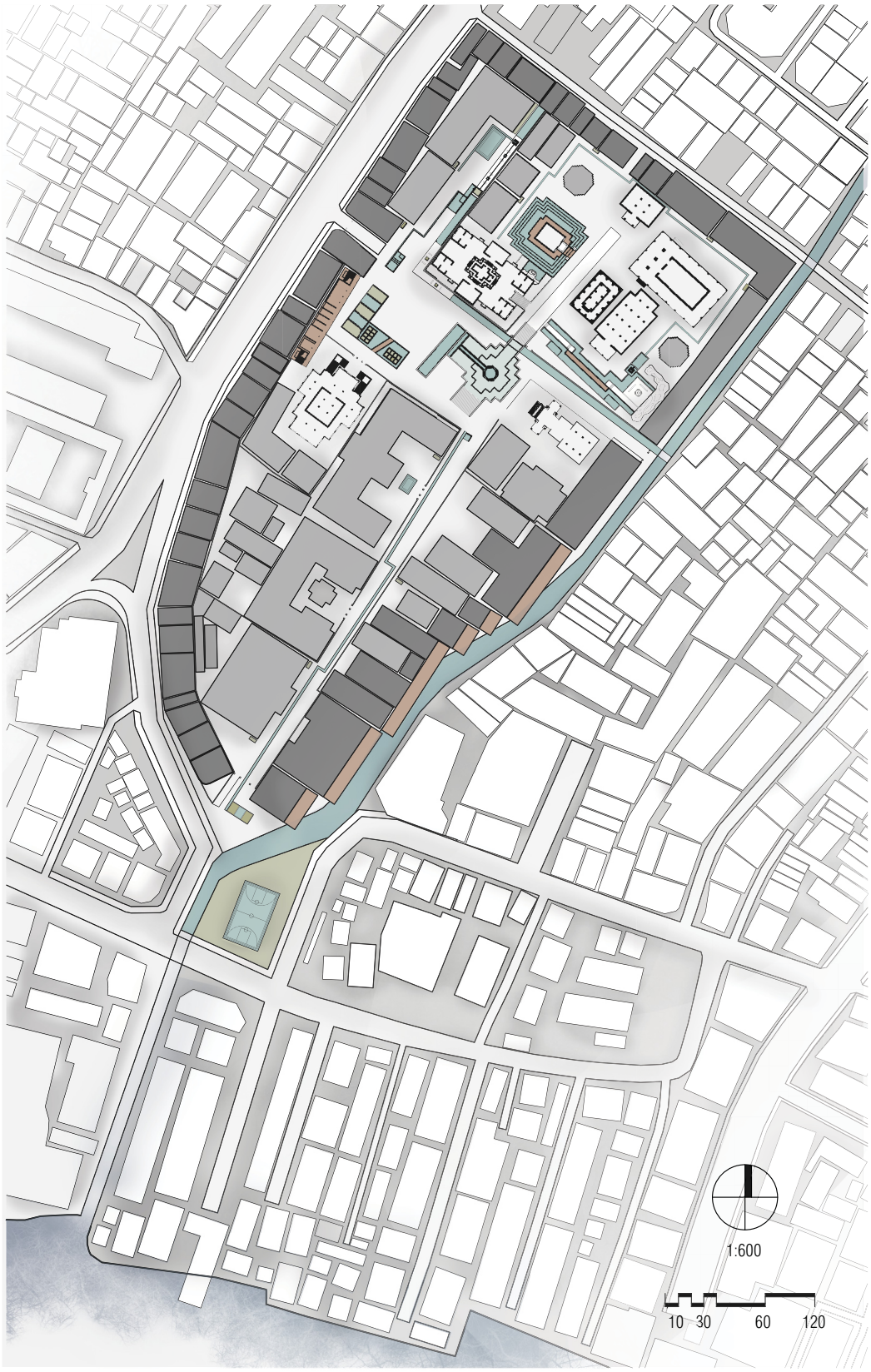


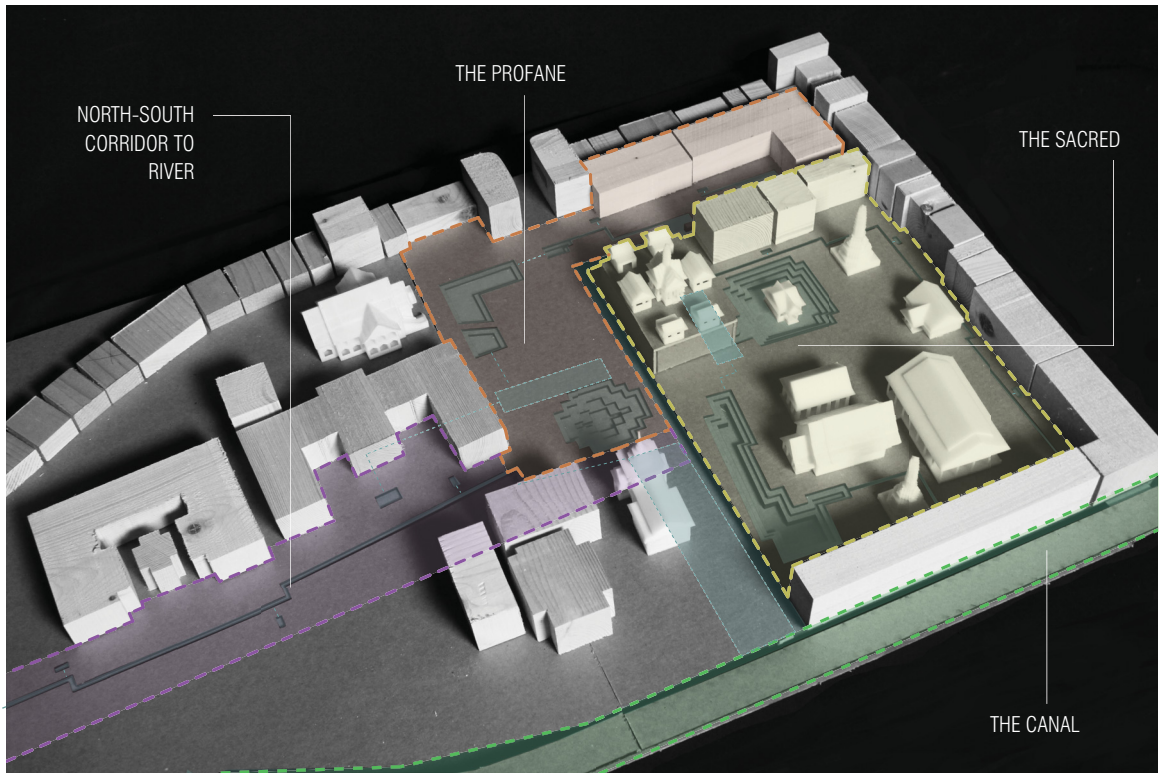
Diagram of the overall water system in the design strategy, illustrating the processes of collection, purification, and retention / storage for rainwater.

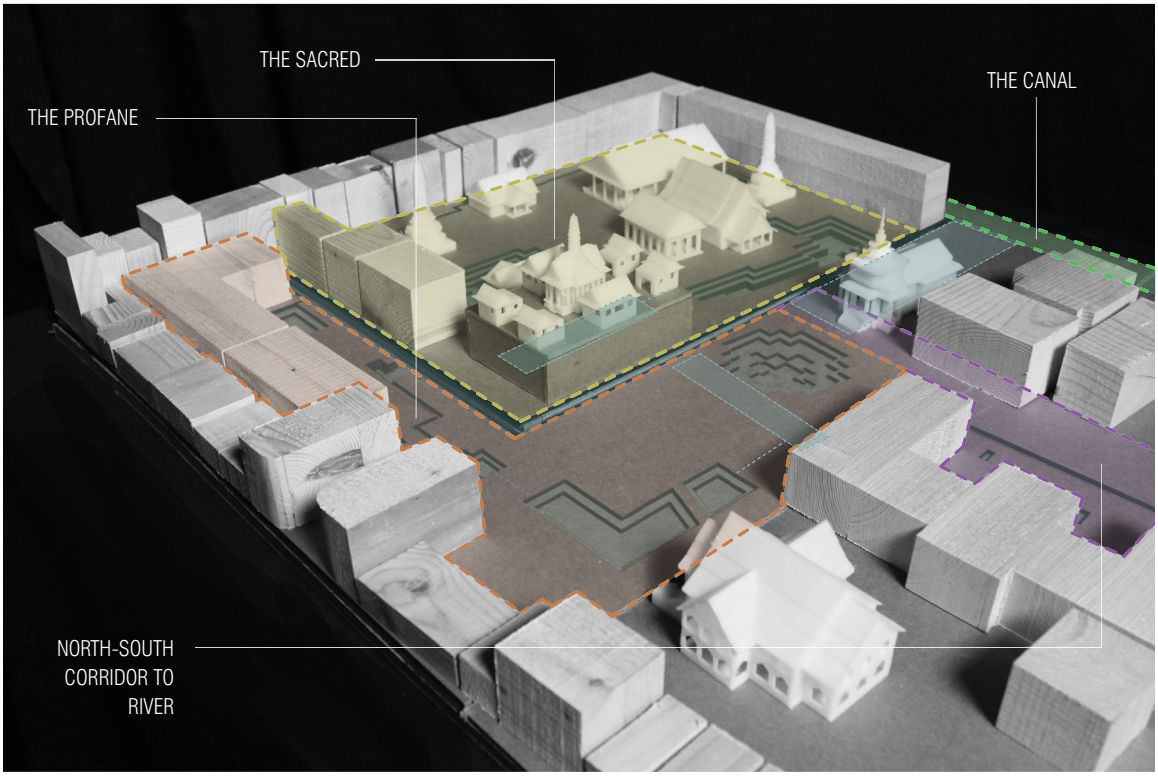
Although it acts as the same system in each of the three zones, it can be adapted as needed in each case to provide flexible programming so that each pond offers a different experience and glimpse of the water purification process. The dimensions for each pond have been calculated according to the amount of water that is collected from the surface area of the roofs for buildings located nearby. As part of this calculation, an average precipitation level of approximately 350 mm per square metre was used to determine the storage needed for the highest month of precipitation during the wet season.[84]

84 "Bangkok Climate & Temperature." *Climatemps.com*. 2017. http://www.bangkok.climatemps.com.



Site plan of the proposed design strategy. Base map image from Google Earth.

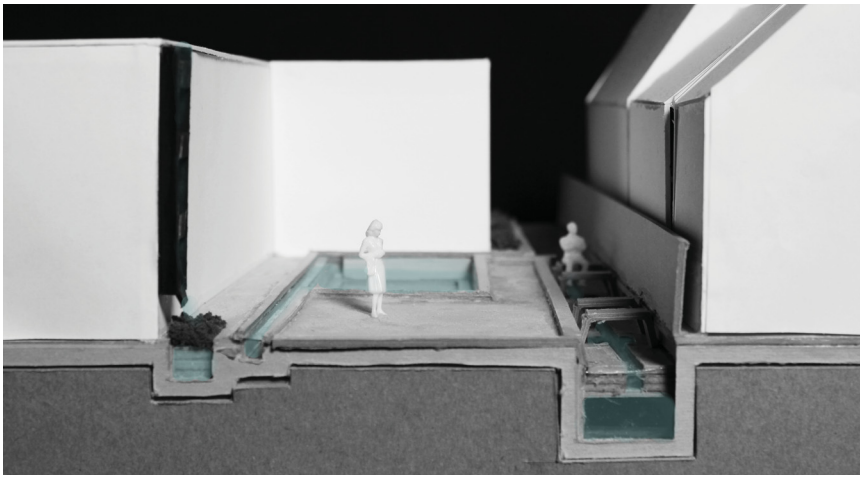




1:300 site model showing the proposed ponds and waterways, as well as their relations to the existing temples and buildings within the Wat Chakrawat compound.

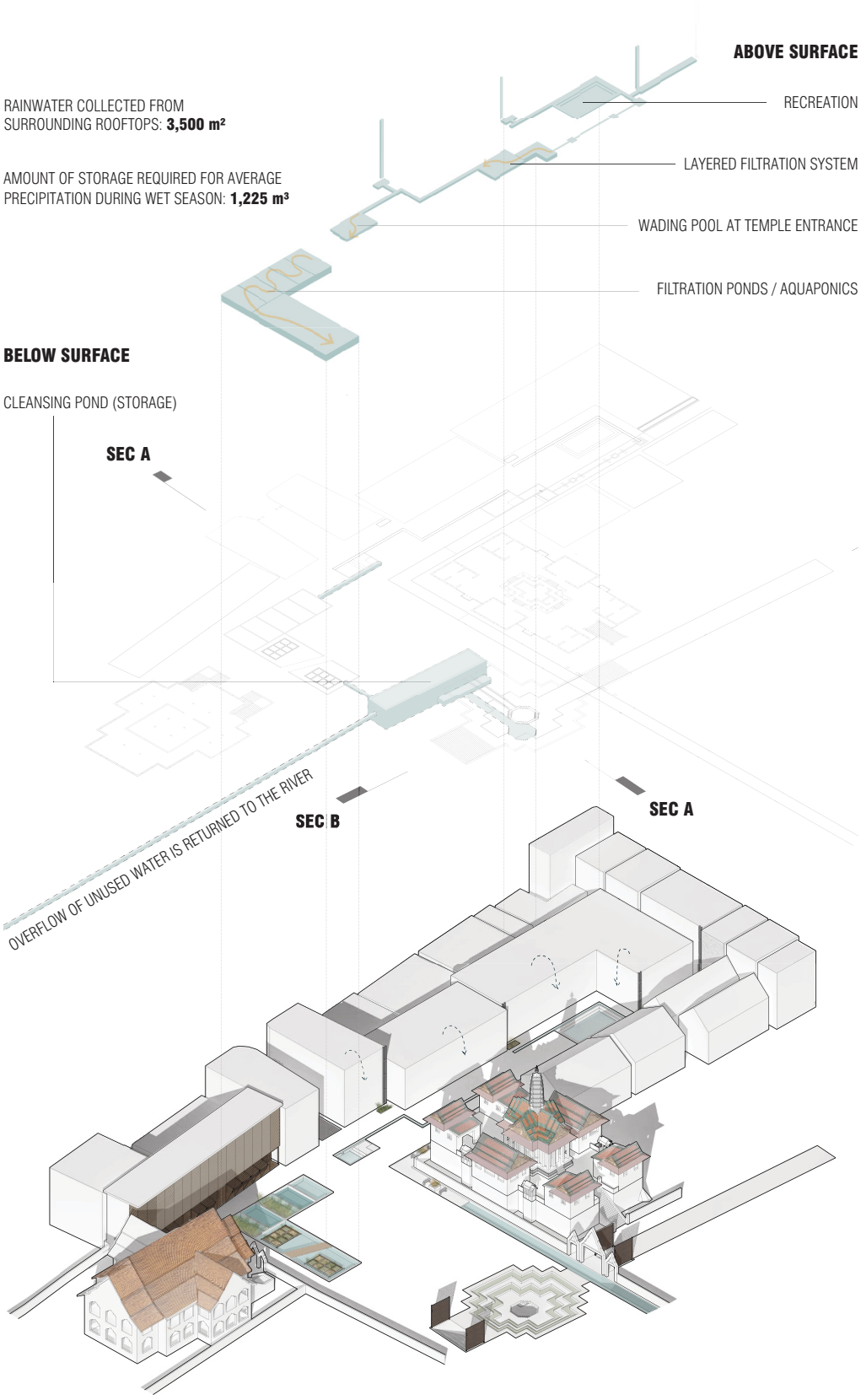
Programming the Profane

In the profane zone, rainwater is first collected from the roofs through downspouts and moved through water channels on the ground to a series of filtration / aquaponics ponds where various vegetation (such as duckweed), can be grown to help purify the water. The clean water is then stored for use in an underground basin. This process of filtration has been placed close to the existing Wat Chakrawat School located in the profane zone so that the waterways can meander around the school's courtyard to programmatically connect to and create spaces for both recreation and education—thus allowing both the students attending the school and other visitors of the temple to learn about the water filtration process as they move through the space and interact with the ponds and waterways.

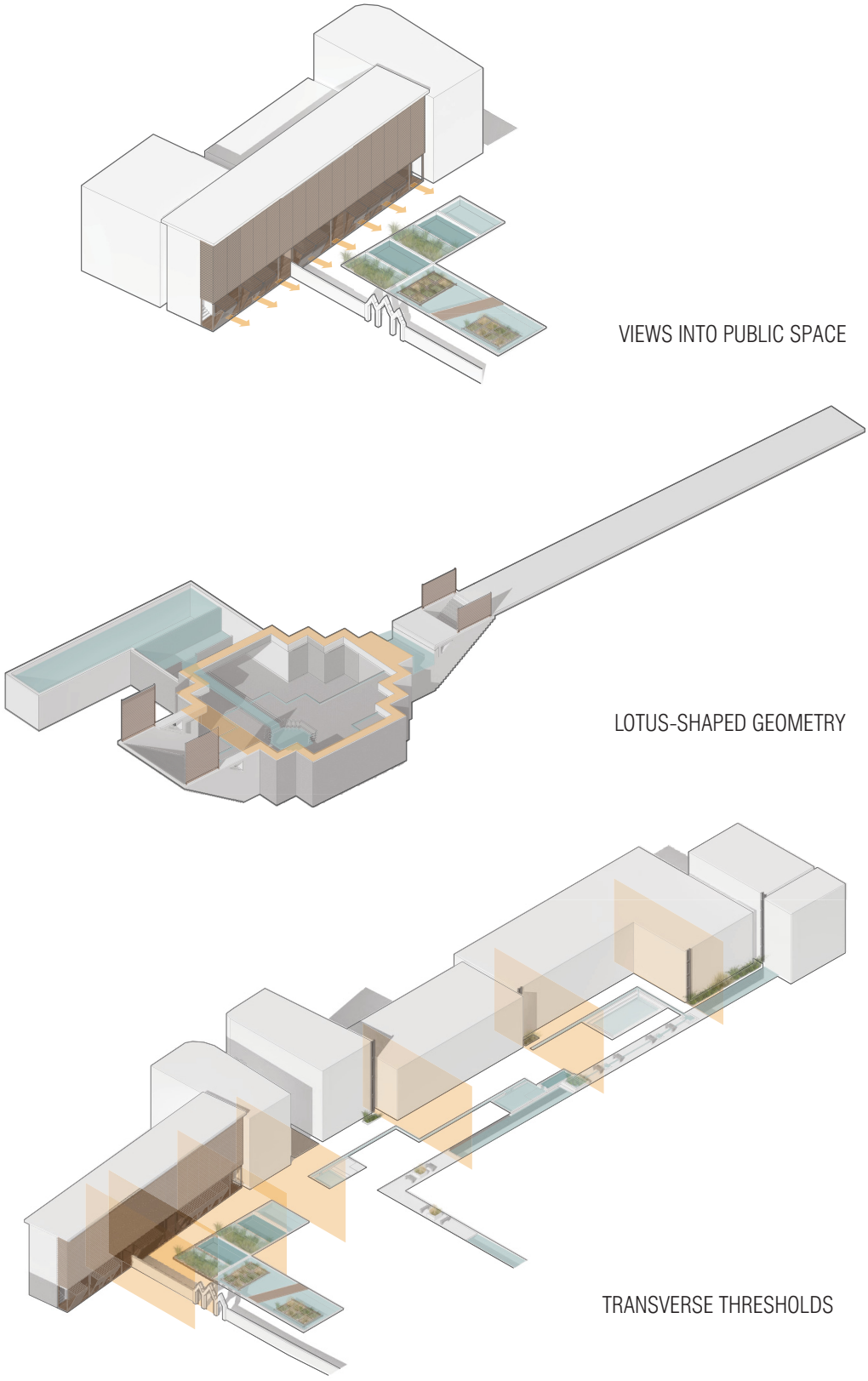


1:100 model demonstrating how rainwater is collected from the roofs through downspouts and moved through water channels on the ground through a series of filtration and recreation ponds.

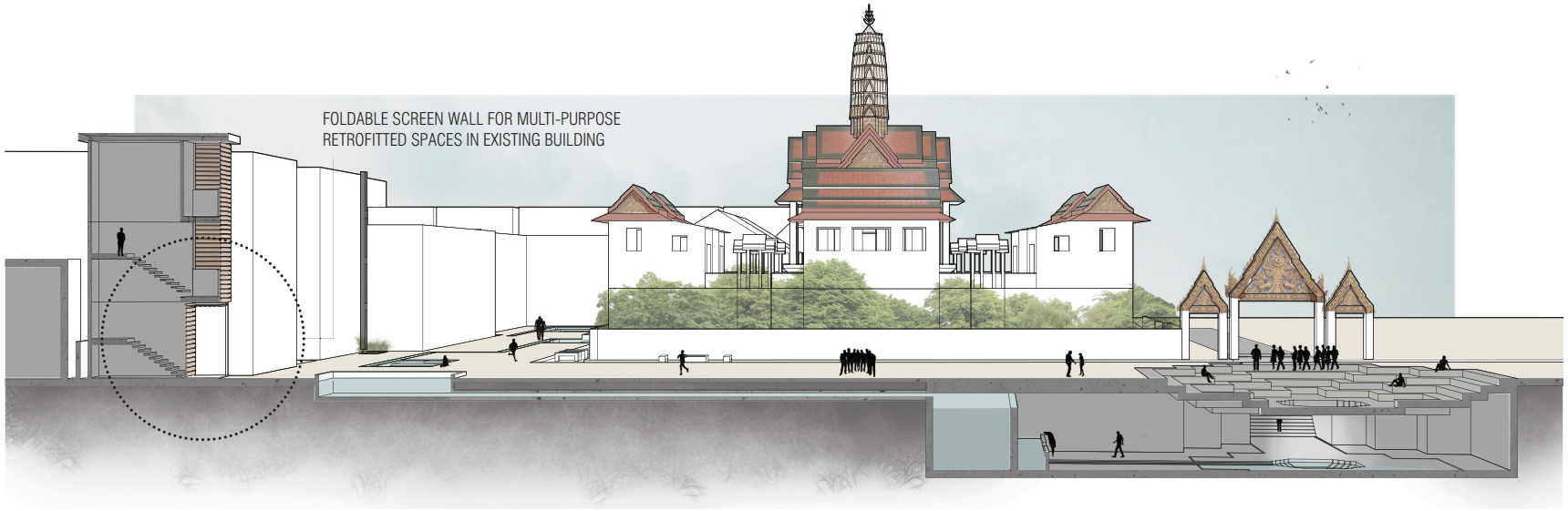
Architectural parts can also be attached to this system, building off earlier sacred strategies to inform how we could build into existing walls to frame and look into these areas. The idea of thresholds was important in determining how these waterways could define a change in space, especially as you move closer to the sacred from the profane. The stored water is kept for a cleansing pond, which visitors must descend through to wash and purify themselves before going into the temples. These spaces would change during the dry and wet season: in the school zone, recreational squares might become spaces for water leisure. In the cleansing pond, people may simply wash themselves using water in a small basin, or even dip their feet into the water to clean. But during the wet season, they may be forced to submerge their bodies in the water before they can enter the temples.



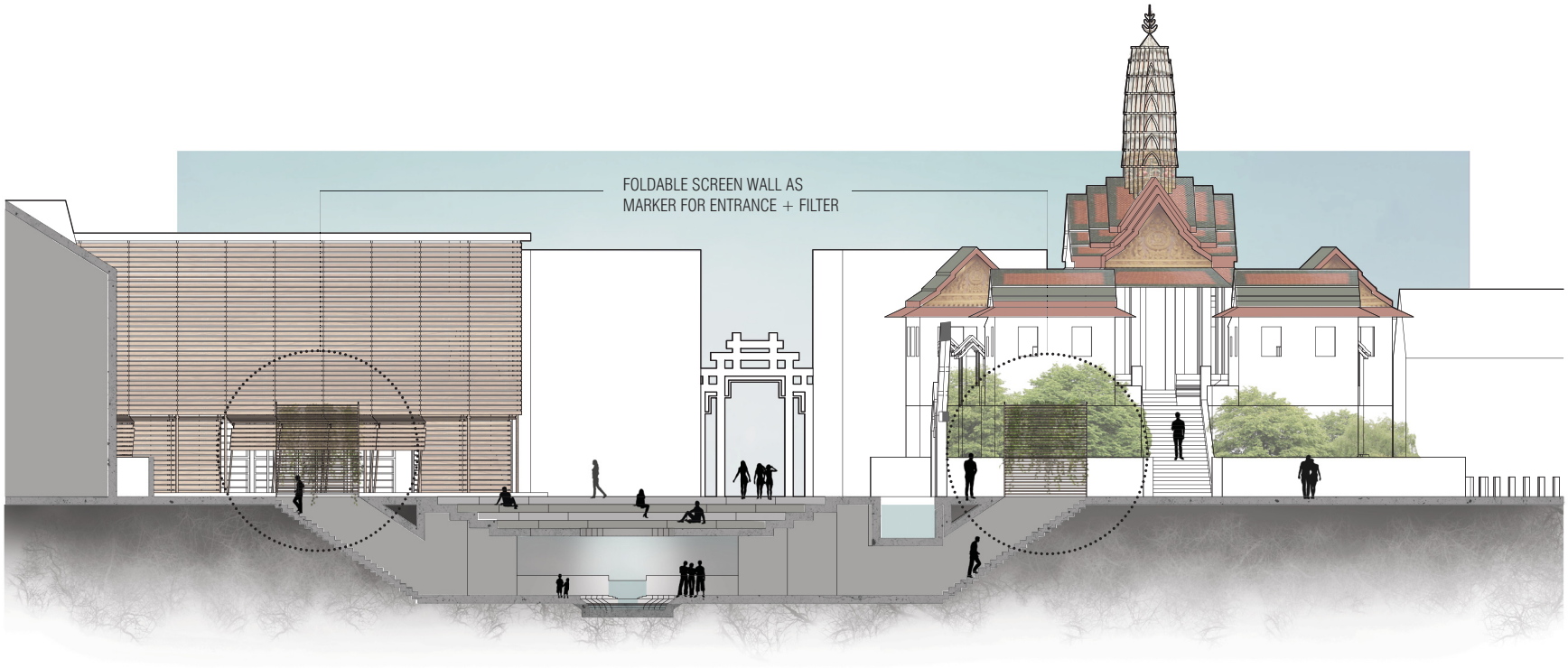
Layered axonometric drawing of the proposed water system for the profane zone, highlighting which ponds and waterways are located above / below the surface, as well as the amount of storage needed for average precipitation in the wet season that was used to determine pond dimensions.



Diagrams of the sacred strategies that have been integrated into the design of the profane zone.



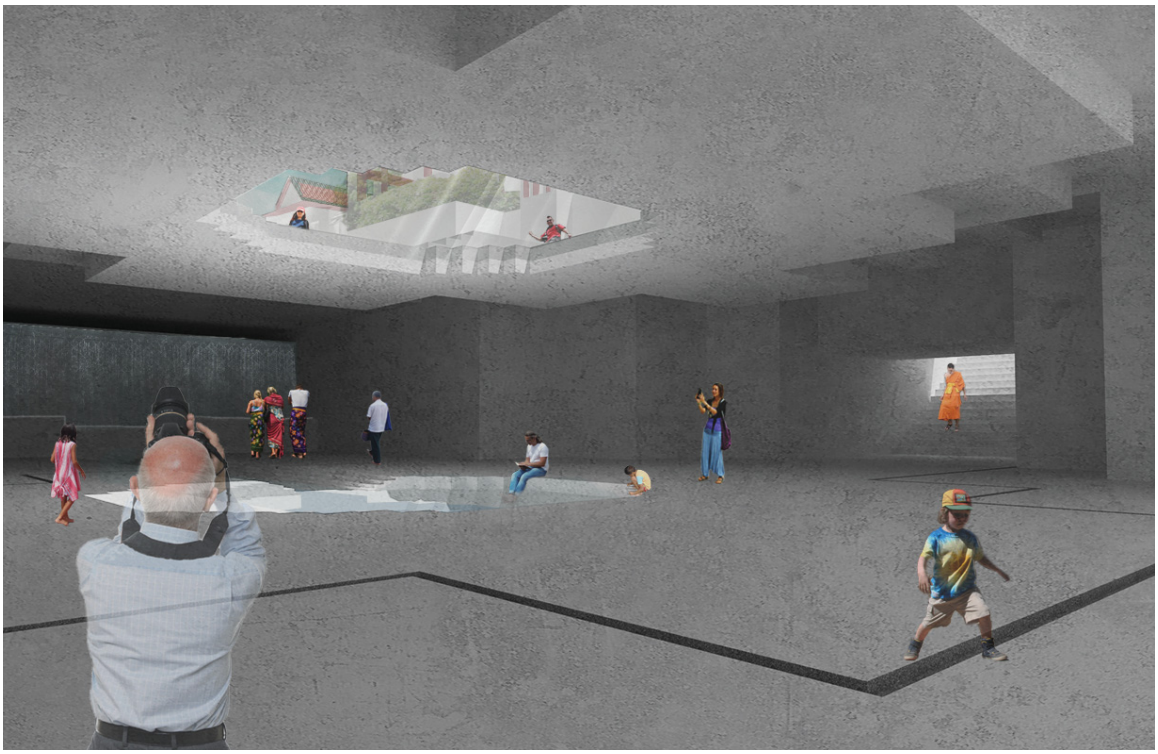
SEC A: Transverse section from filtration to cleansing (1:100).



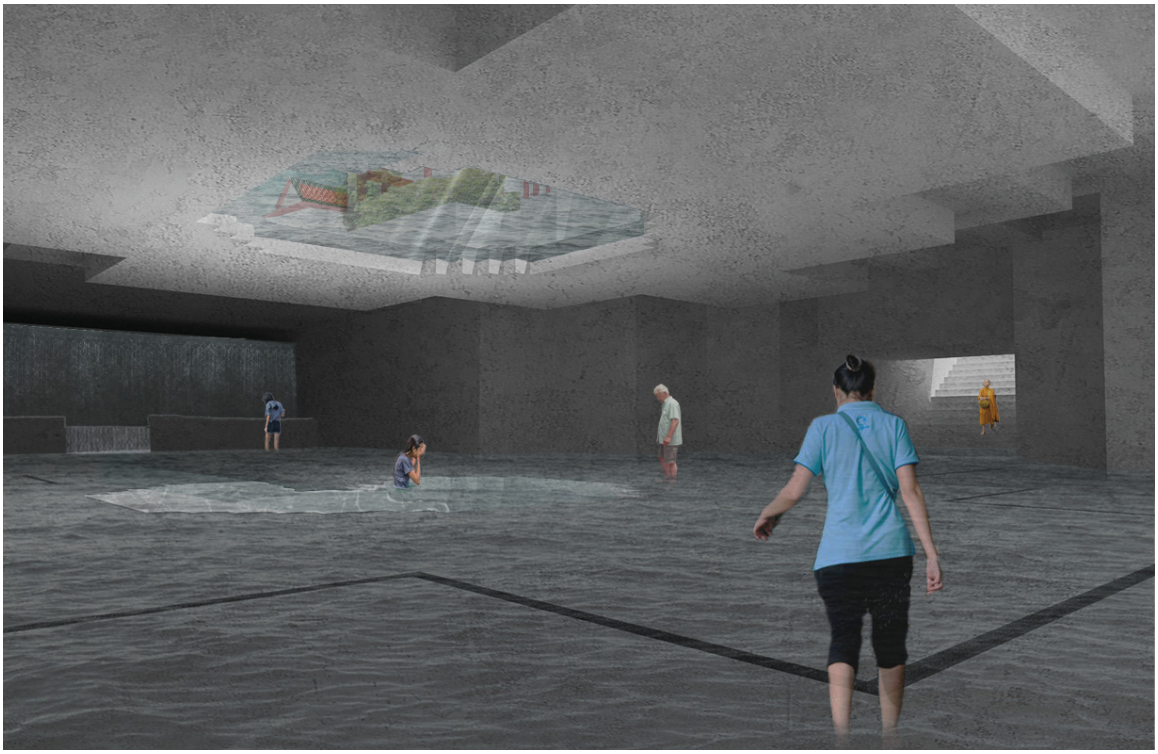
SEC B: Longitudinal section from cleansing to the sacred (1:100).

Rendering of the recreational and filtration ponds that meander through the Wat Chakrawat School courtyard (dry season).

Rendering of the recreational and filtration ponds transformed into spaces for water leisure during the wet season.



Rendering of the cleansing pond where the stored, filtered water can be used for washing your hands, feet, and head during the dry season.



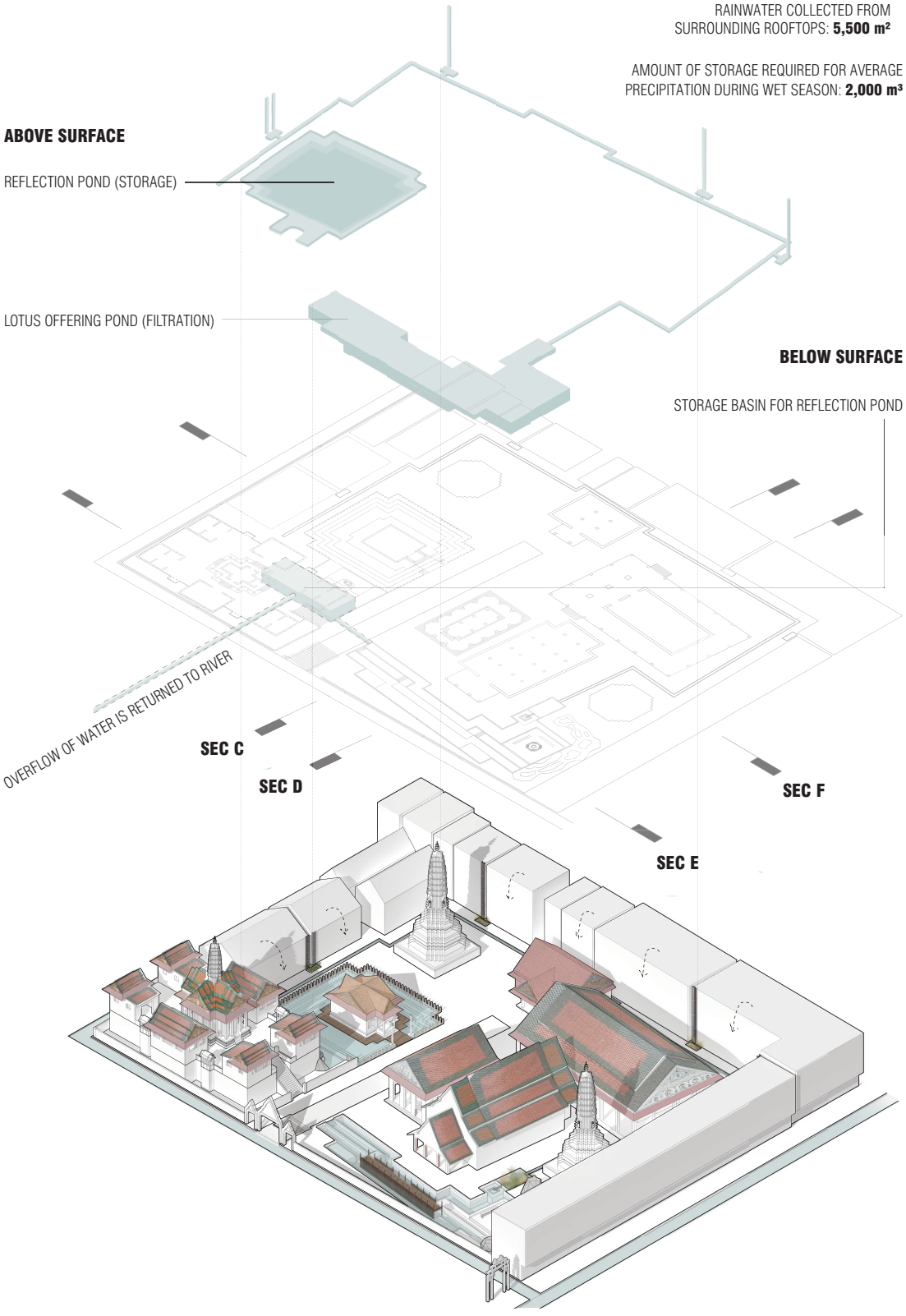
Rendering of the cleansing pond during the wet season, in which visitors must actually submerge part of themselves before entering the temple.

Reconnecting Rituals in the Sacred

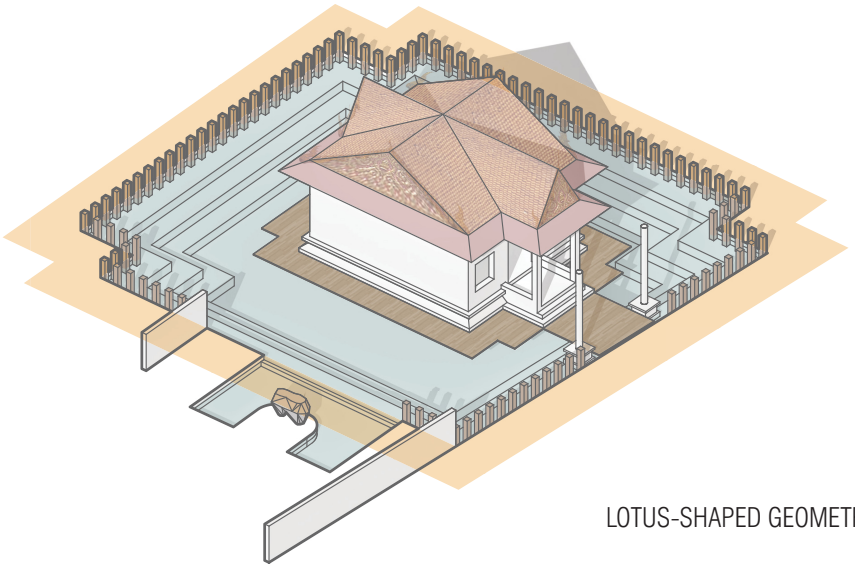
Moving into the sacred zone, the same water system is applied to collect water from the roofs through downspouts into reed beds for filtration; however, in this case, the waterways wrap around the temples to reinforce the water threshold between the profane and the sacred. Following its collection from surrounding buildings, water is then filtered through a lotus offering pond where lotus plants can be used for phytofiltration. This ties in closely with the sacred ritual of giving an offering when first you enter the temples—which, after physically cleansing oneself, is another symbolic act of leaving behind one's impurities before entering into the temple buildings. Many of the commercial spaces that have evolved around the temple allow visitors to purchase different flowers and objects that can be used as offerings within the temple. The development of the various programs surrounding the temple compound thus becomes closely tied to the act of sacred rituals. In a similar manner, water has been used in the design of the lotus offering pond to provide new opportunities for people to spiritually and culturally reconnect with the water.

Building off earlier design strategies, the lotus offering pond offers different experiences of descending down through the water and then rising up above it help to define the different thresholds in the sacred zone as one move towards and past the temple in the space. The end of the path is marked by a destination point that connects to an existing rock structure in the temple where people leave behind relics and pay respects to their deceased family members. A small offering basin has been provided for people to leave behind floating lotus-shaped candles that are often used as offerings in Thailand. A large Buddha relic is also located in the centre of the basin to allow visitors to pour water over Buddha and wash the statue as another act of purification and removing their sins and bad luck.

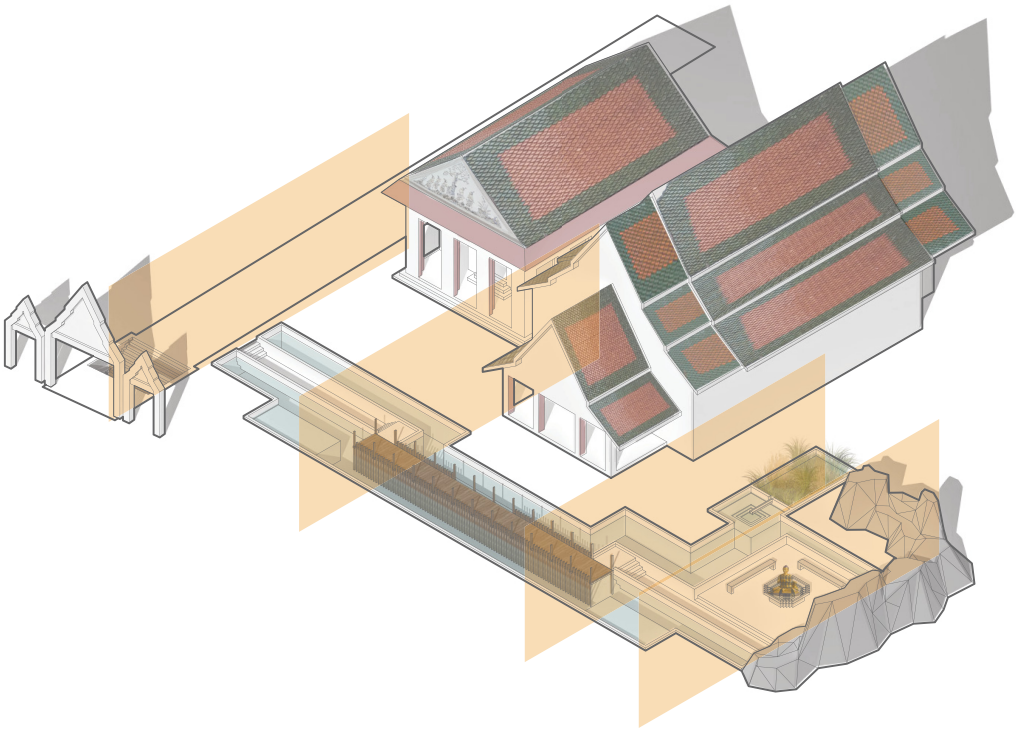
After the filtration process, water is then collected and stored in a reflection pond, which surrounds a small temple in the sacred zone and becomes an area that can be floodable during the wet season. It is also a space where people can personally connect to water in isolation as they pray and meditate. The temple structure has been adapted to be amphibious and floatable during the wet season to meet the specifications of these sacred rituals of prayer and meditation, as it allows people to physically feel the rise and fall of water in times of heavy rain. This in turn enables them to become more aware of their relationship to the water throughout their day-to-day lives.



Layered axonometric drawing of the proposed water system for the sacred zone, highlighting which ponds and waterways are located above / below the surface, as well as the amount of storage required for average precipitation in the wet season that was used to determine pond dimensions.

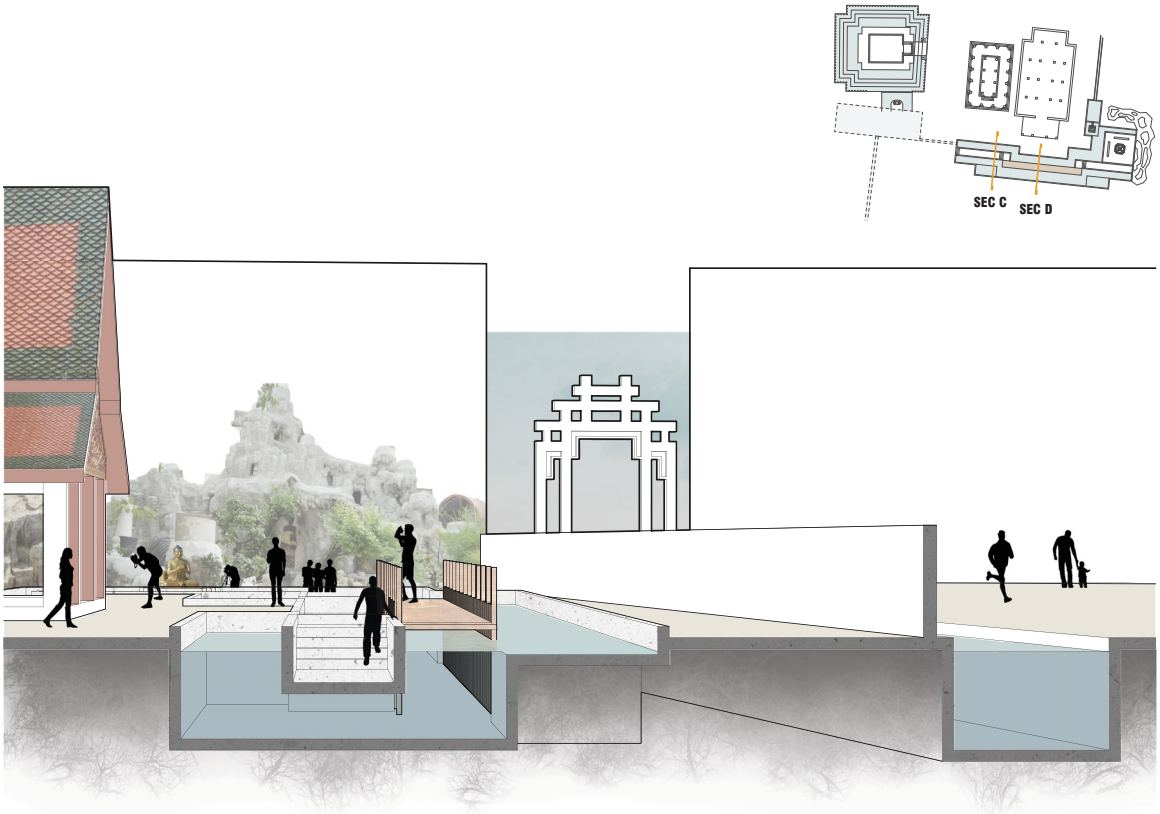


LOTUS-SHAPED GEOMETRY

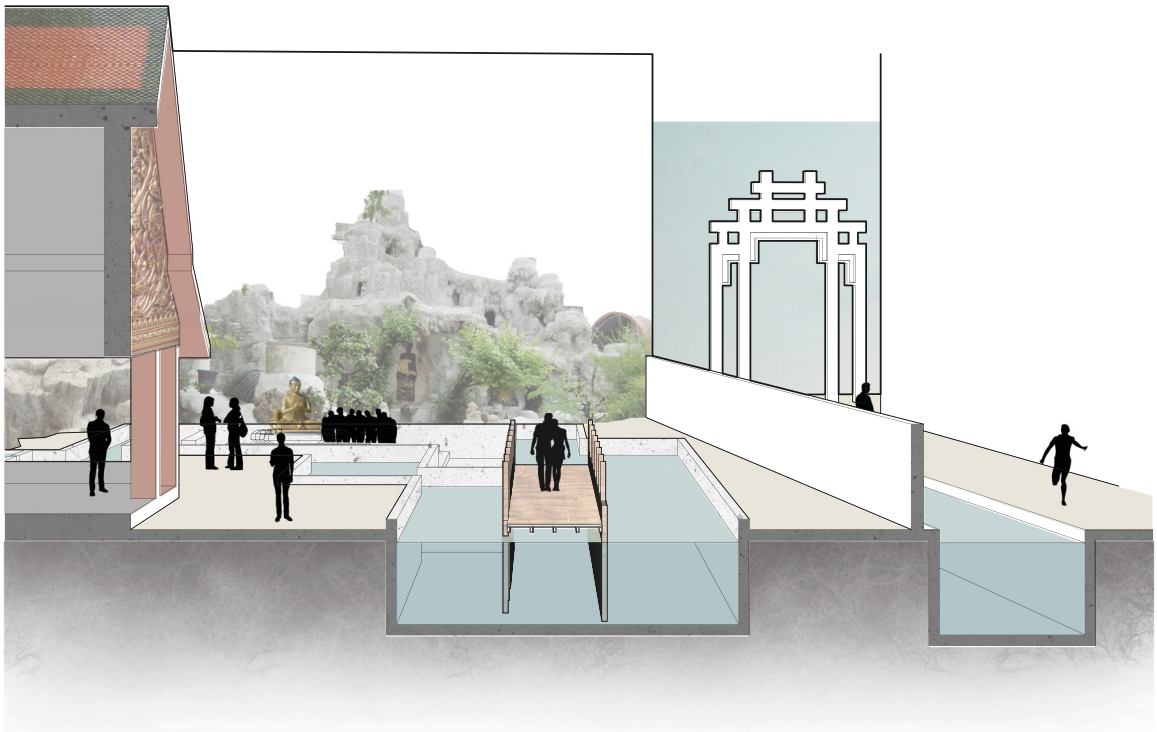


LONGITUDINAL THRESHOLDS

Diagrams of the sacred strategies that have been integrated into the design of the sacred zone.



SEC C: Section of the path at the lotus offering pond that descends down into the water before and after passing the temple (1:75).



SEC D: Section of the path at the lotus offering pond where users crossing over as they move across directly in front of the temple (1:75).

SEC E: Longitudinal section across the lotus offering pond (1:200).

SEC F: Longitudinal section through the reflection pond (1:200).

Rendering of the lotus offering pond where people can leave behind objects and relics upon entering the sacred zone (dry season).

Rendering demonstrating the raised water level in lotus offering pond during the wet season, which may partially flood some paths.

Rendering illustrating the lower water levels in the reflection pond during the dry season, in which the temple remains static on its foundation.

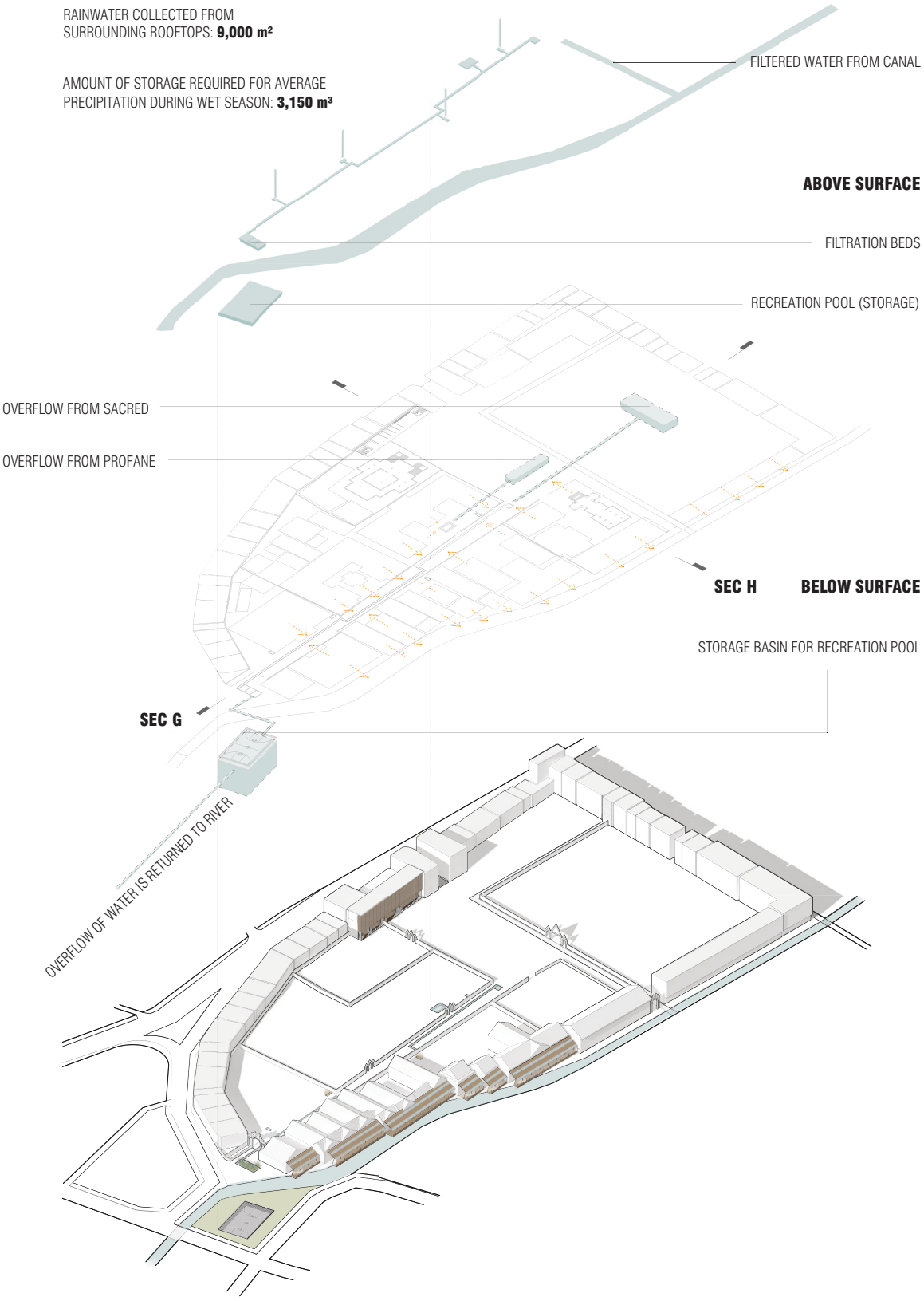
Rendering illustrating the lower water levels in the reflection pond during the dry season, in which the temple remains static on its foundation.

Informing Urban Thresholds

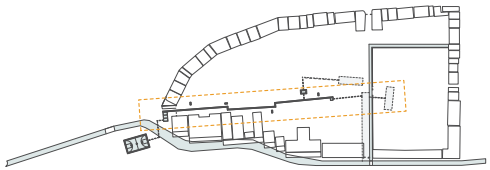
Any unused or overflow of water from both of the storage ponds in the profane and sacred zones can be channeled underground along the axis of the main pathway towards the new canal, which deposits back into the Chao Phraya River. Using the design strategy, the same system of filtration can be applied again but at a larger urban scale. There are also similar opportunities for the water to resurface so that people can interact with it as they move through the main corridor. After being filtered, the water is then stored in a basin located in the greenspace that expands upon the existing one outside of the temple compound, which can be used for a recreation pond. As in the Wat Chakrawat School courtyard, this pond can be used as a space for recreational sports and activities during the dry season and can fill up for water leisure during the wet season.

The urban enclosure also deals with the threshold between the wall enclosure and the new canal, where temporary market spaces are currently being built off the wall by vendors. This can become another architectural part that attaches to our new water system, in which a more formal space is provided for these vendors and markets to float on the water. The design of these market spaces is comprised of several architectural components that help to define thresholds and celebrate the interactions between people and the water. A kit-of-parts was developed as part of the design strategy to demonstrate how these architectural components could take on the new infrastructure—looking at the roof, the wall, the platform, and the idea of tethering as pieces that can be interchanged.

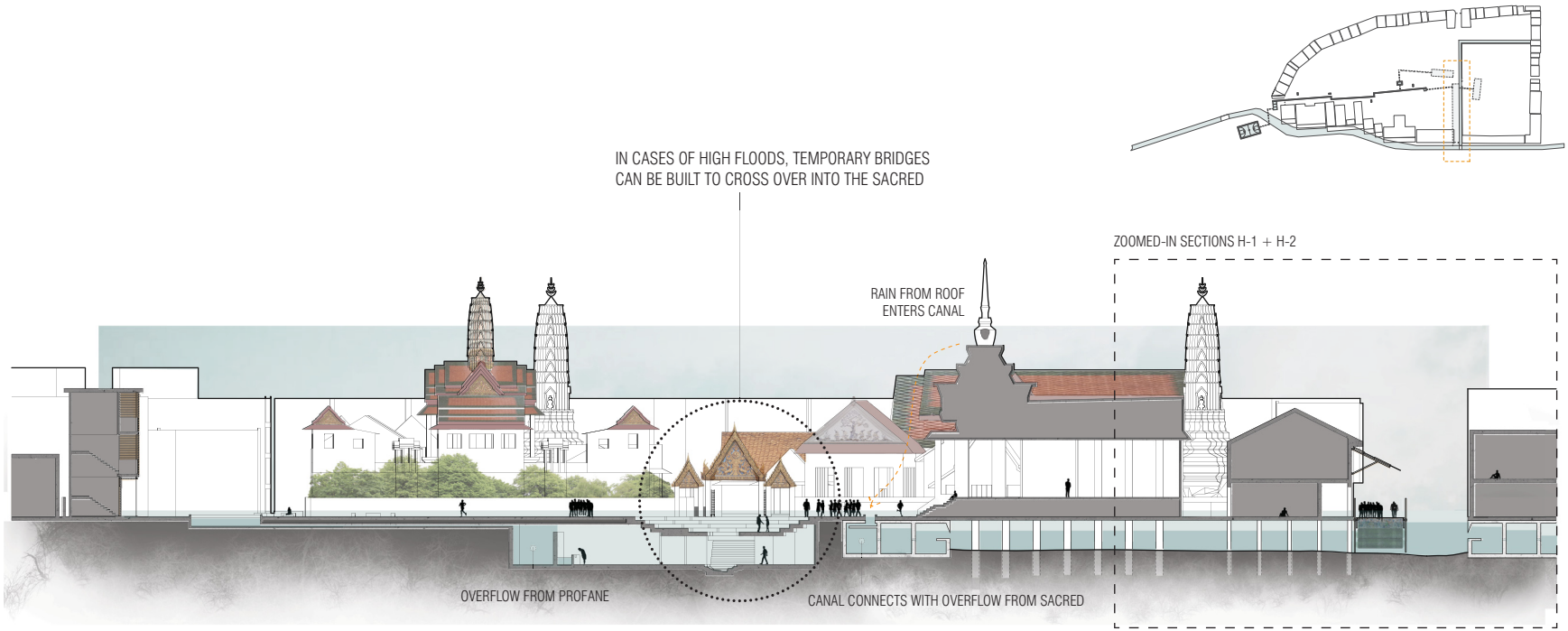
For example, the roof could be fixed high up on the wall enclosure with a moveable platform that rises and falls with the changing water levels during the dry and wet seasons, or it could be moveable so that it can be folded up and down to visually represent when a market stall is open or closed. A screen can also be swung up and down to create a wall that allows for vendors to set up first, or when the wall is down, it could hang into the water to allow for filtration by using a mesh where vegetation could be grown in-between the screens. Floating gabion baskets and pathways also provide different ways of filtering water and moving along the new canal. As such, the kit-of-parts informs how one can move over, through, or under water—strategies which have been integrated throughout the proposed design. By using this toolkit, there is a flexibility in how spaces can be programmed and used to create new thresholds that increase interactions between people and water.



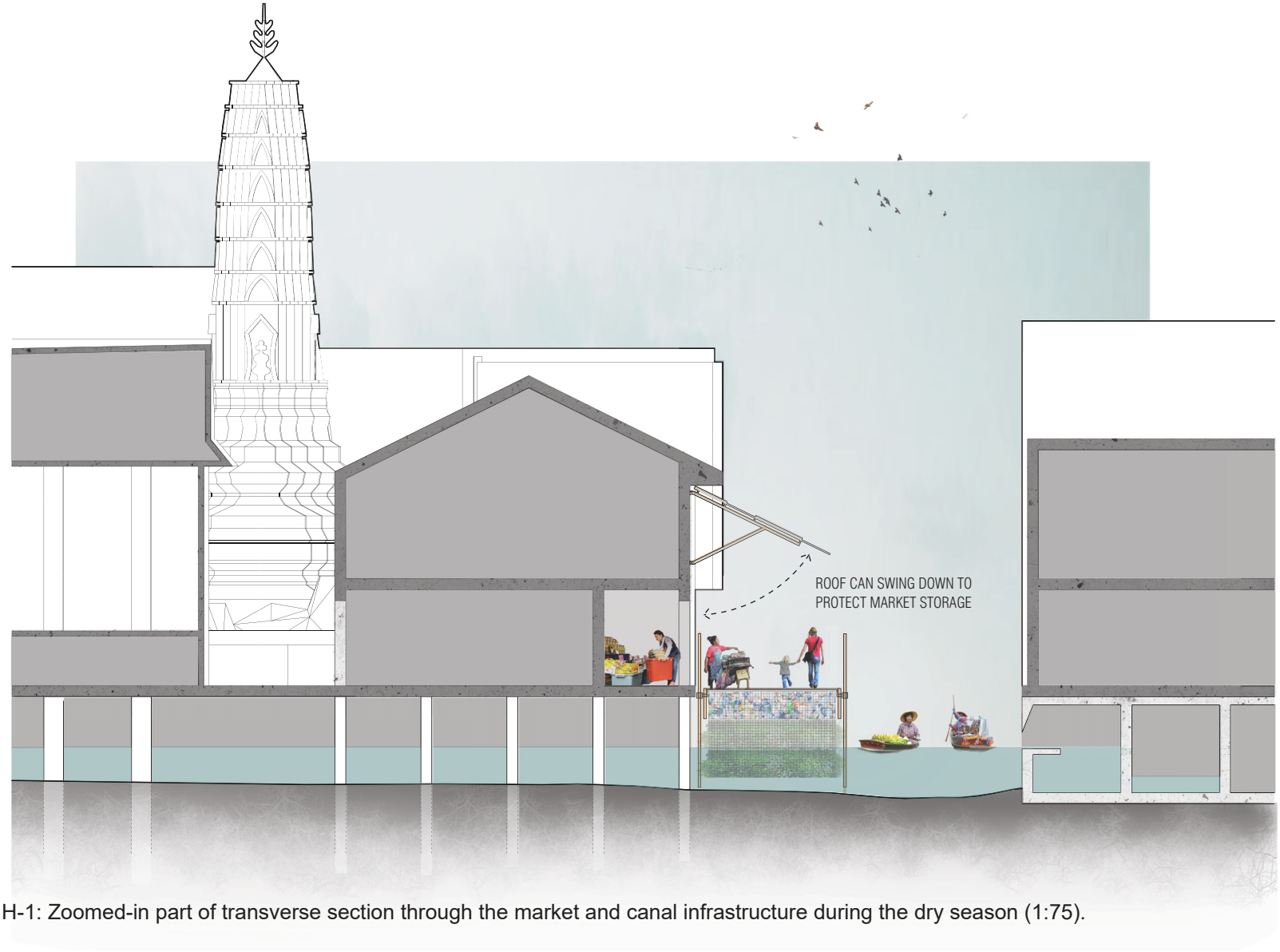
Layered axonometric drawing of the proposed water system for the urban enclosure, highlighting which ponds and waterways are located above / below the surface, as well as the amount of storage needed for average precipitation in the wet season that was used to determine pond dimensions.



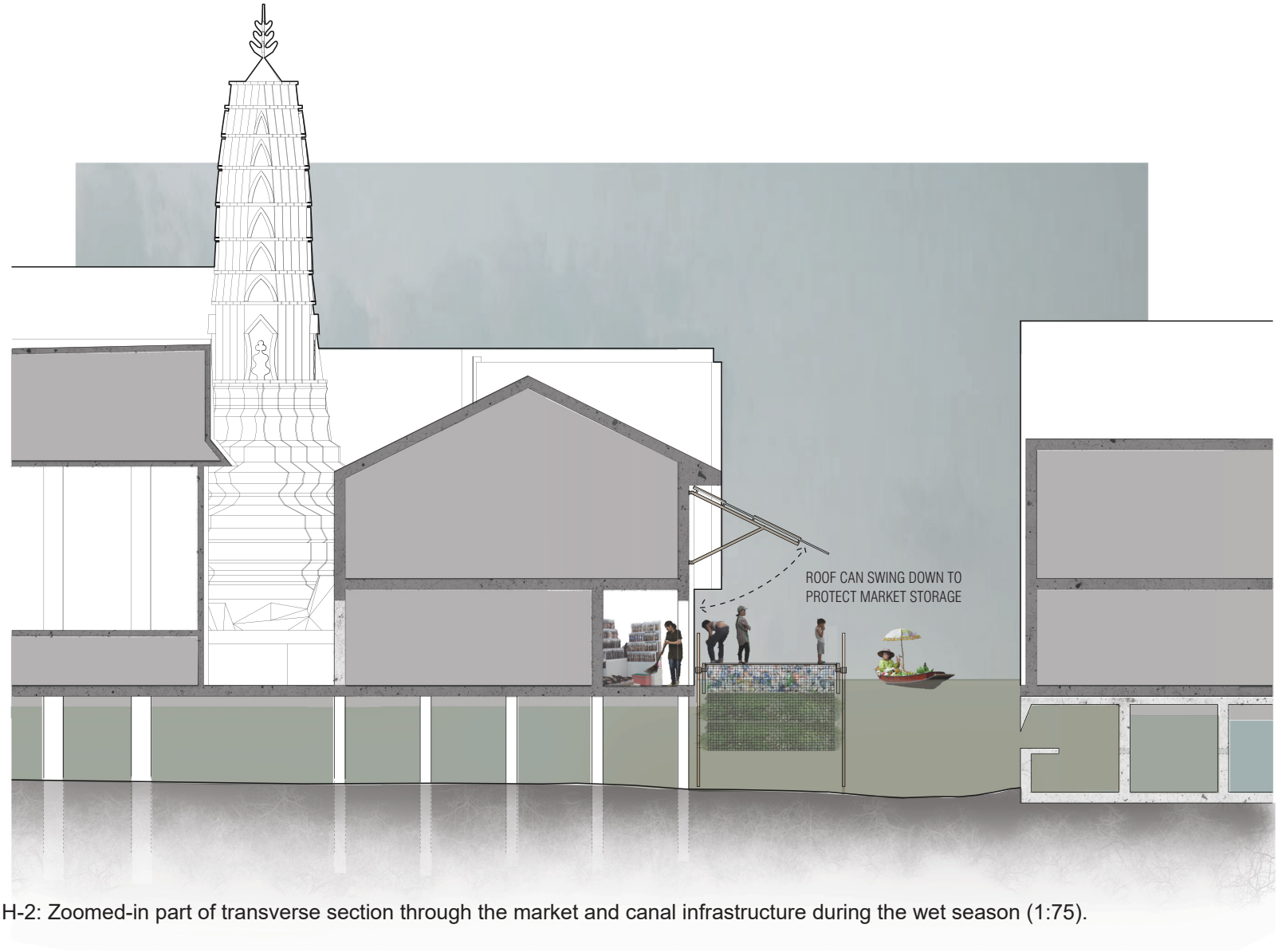
SEC G: Longitudinal section through the open space-access corridor and three main zones of the temple to the Chao Phraya River (1:400).



SEC H: Transverse section across the different water systems within Wat Chakrawat, demonstrating how the temple compound connects to the canal infrastructure during the wet season's periods of high precipitation levels and the worst-case scenario flood times (1:200).

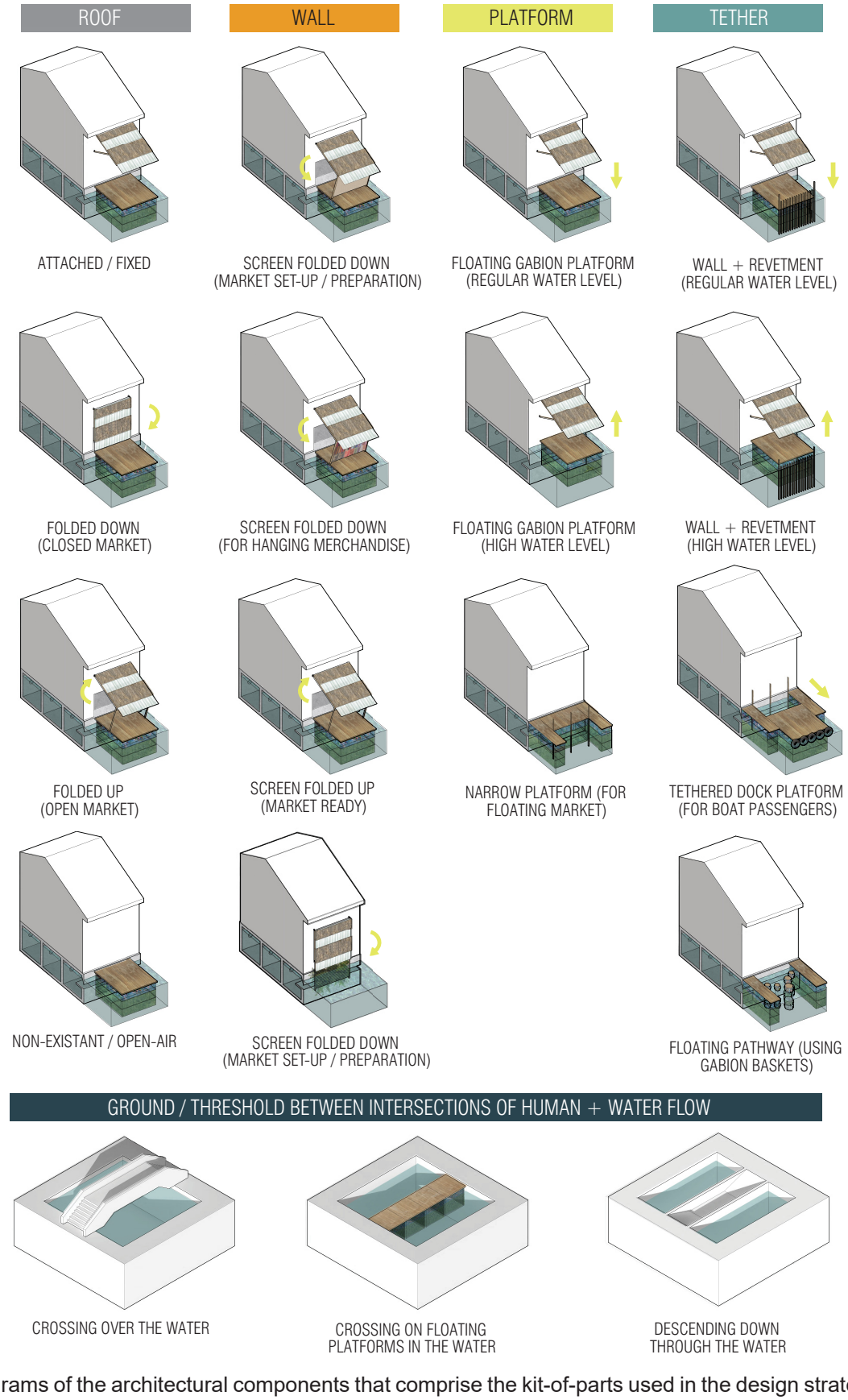


SEC H-1: Zoomed-in part of transverse section through the market and canal infrastructure during the dry season (1:75).

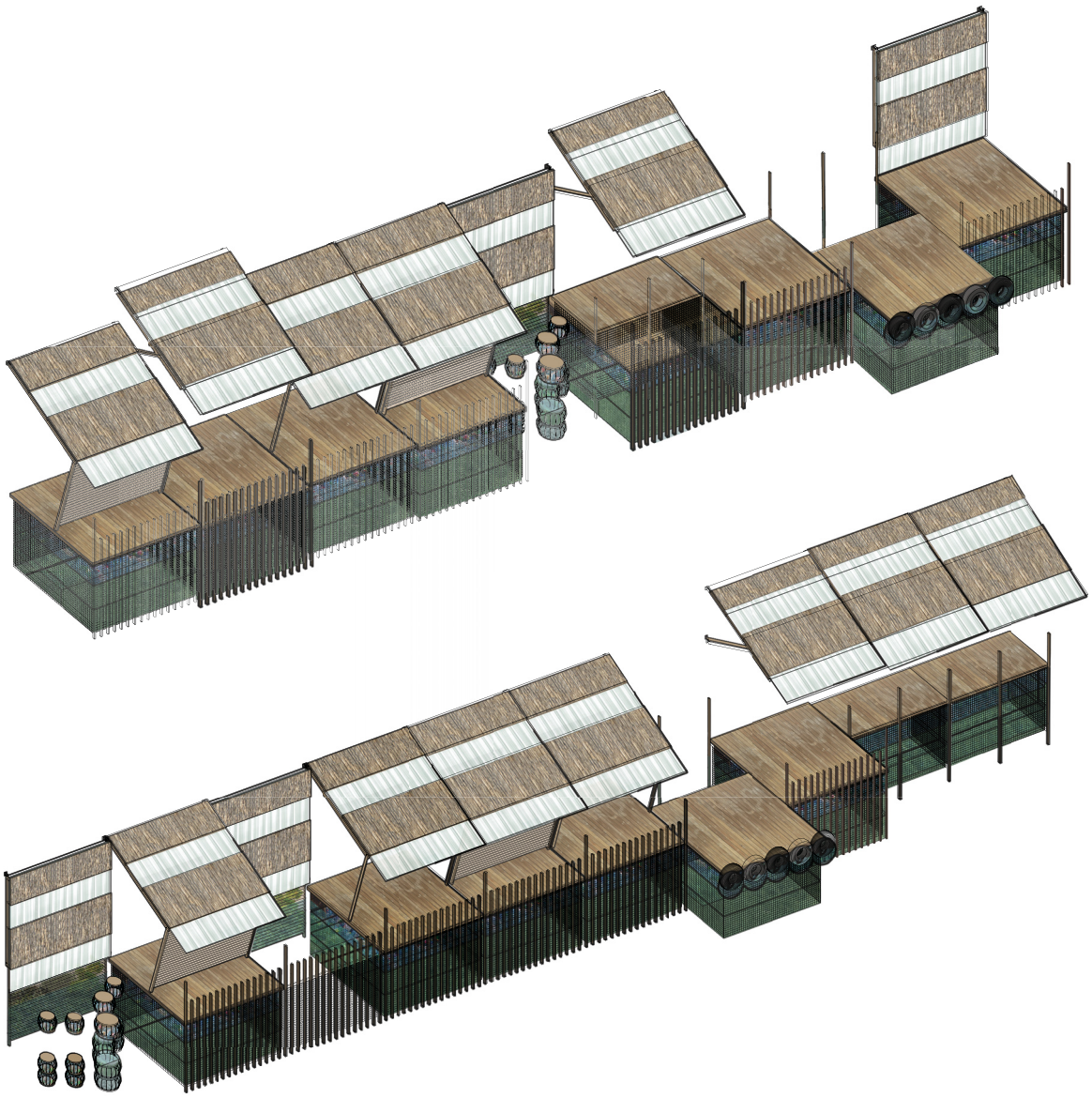


SEC H-2: Zoomed-in part of transverse section through the market and canal infrastructure during the wet season (1:75).

Photograph series demonstrating the moveable architectural components used in the kit-of-parts for the market addition, which can develop thresholds between the vendors and passersby, as well as the temple compound and the canal infrastructure.



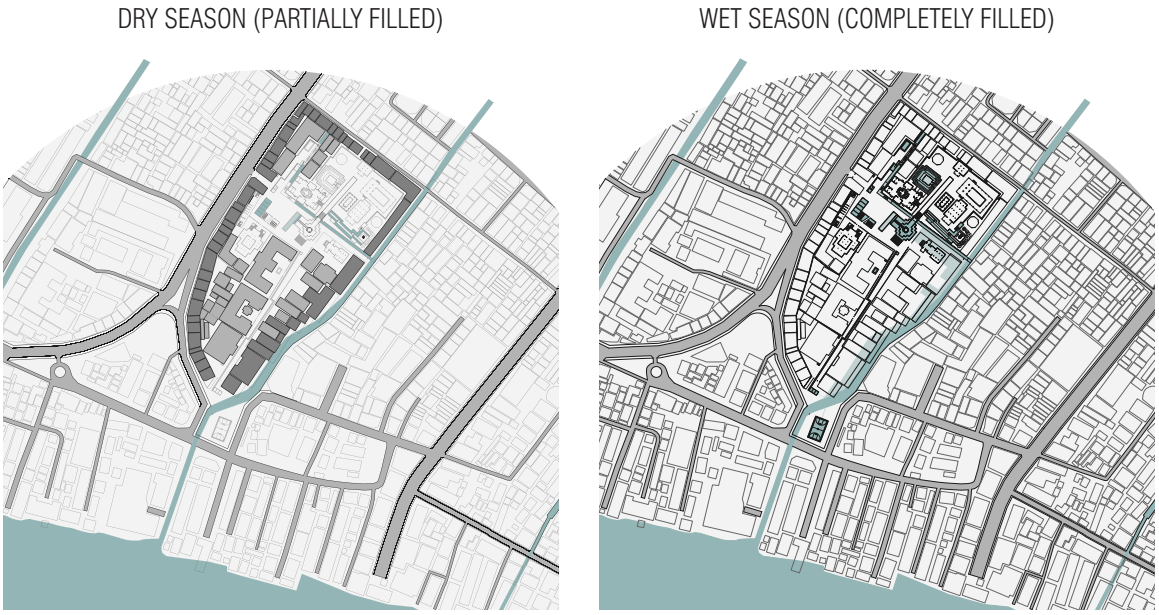
Diagrams of the architectural components that comprise the kit-of-parts used in the design strategy.



Diagrams of potential modular combinations for flexible programming using the kit-of-parts.

CHAPTER 6: CONCLUSION

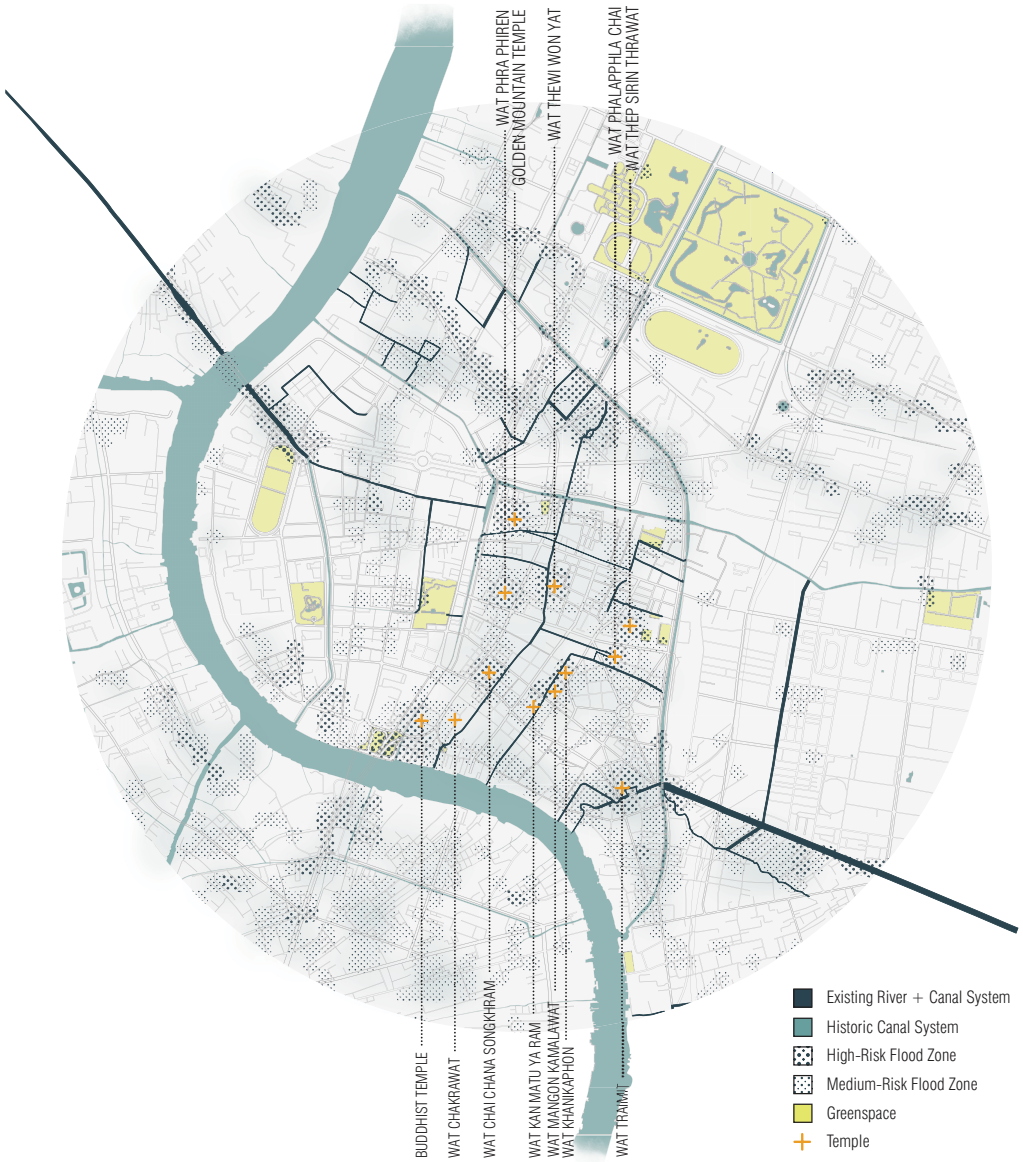
Due to the expected impact of climate change combined with Thailand's monsoon season, as well as the natural geography of its landscape which directs and holds water in the deltaic zones along the Chao Phraya River, urbanized areas like Bangkok must reconsider how its urban structure can better adapt to flooding. This thesis proposes a multi-layered scalar approach to capture, retain, and slowly release water during flood events through a system of: (1) resurfacing the historic canals, (2) connecting public space with blue-green infrastructure, and (3) retrofitting buildings and surfaces with threshold connections and flexible programming to celebrate the intersections between people and water.



Diagrammatic maps of how the design strategies work together to take on flood amounts within the city, with some ponds filled year-round and others filling up during the wet seasons.

By resurfacing the historic canals and increasing their capacity below buildings, water can be captured and retained both locally from surrounding urban areas and from the accumulated volume in the river basin as it moves from the Chao Phraya River towards the Gulf of Thailand. This thesis looks at one temple compound as a potential model that can then be deployed on other temple sites found along the canals throughout the city—integrating the larger urban canal system with the temple compounds to form areas that hold and release water during storm events.

This aggregation of the temple compounds along the canals therefore alleviates the accumulation of local precipitation and allows for overflow from the canals and the river during flood times. This strategy reconnects Bangkok's existing urban fabric with the historical structure of the canals and the symbolism embedded in the temple compounds—restoring the connectivity between the social, spiritual, and cultural aspects of water. This can then reinforce a specificity of culture and place along the Chao Phraya Delta.



Urban map illustrating the potential shift in Bangkok's high-risk zones from previous flood mapping (see map on page 37), following the application of the design strategy. Base drawing is adapted from the original ArcGIS data extrapolated from Sithiprom's "Urban Flood Hazard and Risk Resolution 100 Meter in Bangkok," 2016.

In deploying this project, it would therefore be important to work with local communities, landscape architects, and engineers to embed this technological knowledge socially. This ensures that the new infrastructural system is appreciated culturally and maintained locally. The engagement within and beyond the temple walls is critical to the success of this project. Other key considerations include the testing and economic costs of such a wide-scale urban project, which can be gradually implemented over time by establishing stages of phasing. Ultimately, by integrating this new infrastructural system with the temple typology, Thailand joins the discussion with other nations like the Netherlands and Denmark on how water can be dealt with in delta conditions and have cultural specificity.

MAINTAINING VITALITY OF THE CANAL
VENICE, ITALY

DAYLIGHTING THE CHEONGGYECHEON RIVER
SEOUL, SOUTH KOREA

WATER SQUARE - DE URBANISTEN
ROTTERDAM, NETHERLANDS

ENGHAVEPARKEN FLOODABLE PARK
COPENHAGEN, DENMARK

UJALA BAOLI - INDIAN STEPWELL
MANDU, INDIA

ERAM - PERSIAN GARDEN
SHIRAZ, IRAN

RECLAIMING POROSITY
BANGKOK, THAILAND

Precedents of strategies for living with water. Images adapted from Urban Future's "Removing Urban Highways – The Story of the Cheonggyecheon Stream in Seoul"; Wilkinson's "Water Square, in Rotterdam, The Netherlands by De Urbanisten"; Grozdanic's "Copenhagen's Enghaveparken Public Park is Designed to Be Flooded"; Lautman's "Indian Subterranean Stepwells"; and Mirahmadian's "Beautiful Persian Garden of Narenjestan Ghavam or Qavam with its Historic Pavilion and Engineered System of Canals and Fountains."

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