



Catch Rain where it falls

Exploring into the ancient water wisdom of Jaipur, Rajasthan, India

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Figure 1 Atmosphere of stepwells

Context.

Jaipur is located between 26°23'N to 27°51'N latitudes and 74°55'E to 76°50' E longitudes occupying an area of 11,151 sq. km, almost 3.3% of the State (JDA Master plan 2025). The region lies in the eastern part of the state having semi arid conditions and is flanked by the Aravali Hills on the northern and eastern sides with some isolated peaks, the elevation of which vary from 500-800m

As part of the hot and dry climate zone, the region experiences very hot summers with highest monthly mean of 40.3 oC during the months of April to June and mild winters during the months of December and January with monthly mean of 7.8 oC. The rainfall is considerably low, however this eastern part receives more rainfall as compared to the western part of the state. The average annual rainfall varies between 823.2mm to 540.6mm. 'The district is drained by several rivers viz., Banganga, Banas, Sabi and Shekhawati rivers and streams like: Bandi, Mashi, Dhund, Morel, Mendha, Gumti ka Nala, Madhobini, Sota etc' (Hydro-geological Atlas of Rajasthan- Jaipur District,2013)

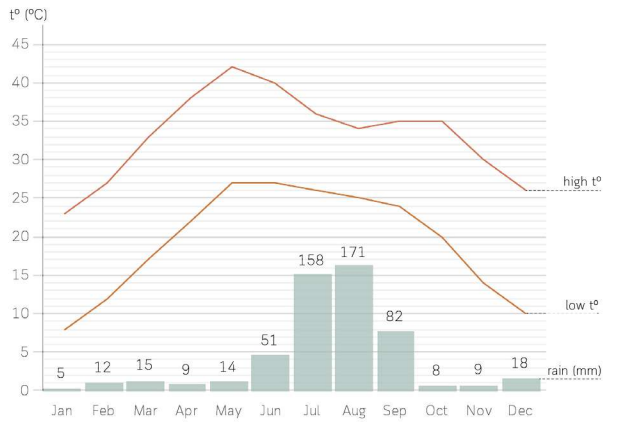


Figure 2 Climate Graph

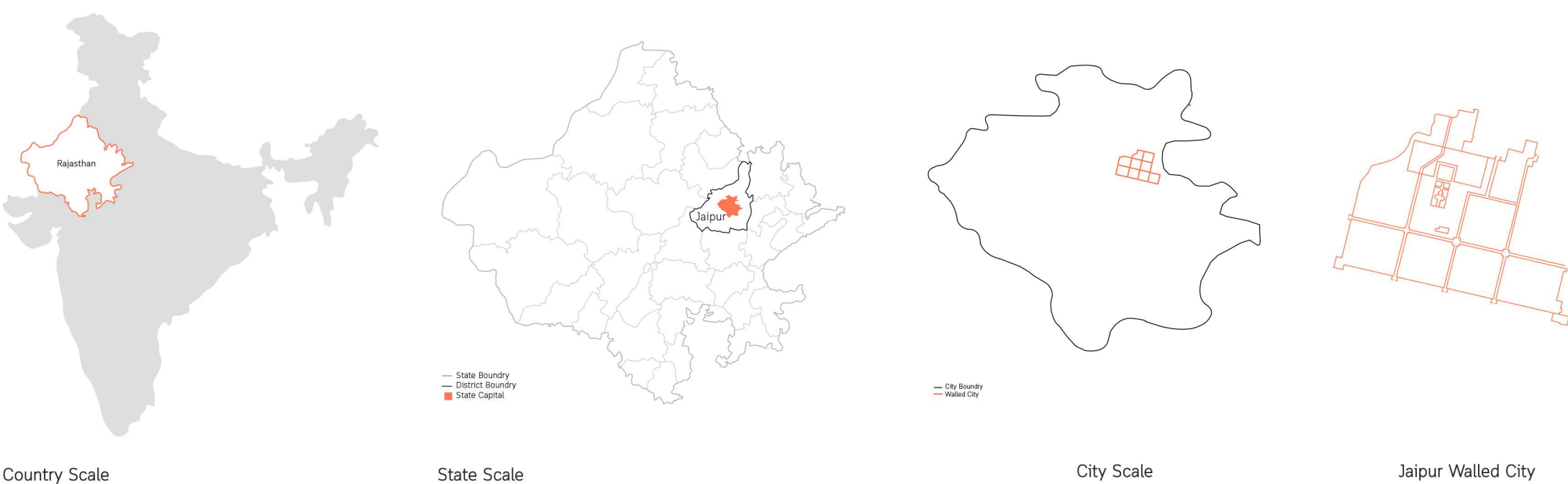


Figure 3 Location of the city

Diversity in Traditional Practices.

Due to the frequent shortage of water, the local inhabitants mastered the use their resources wisely. They succeeded in designing structures which helped them in efficiently use and conserve water. Some of these practices have been discussed and are now being used in villages across the state. The main principle behind these indigenous practices is ‘rainwater harvesting’ and is deeply rooted in the social fabric. These practices are eco-friendlier, inexpensive, contextual and base their logic on following natural processes, encourage community participation and allow for more equitable distribution of development benefits.

Structures like tanks, kunds, step-wells or baolis/ baoris, vavs, wells, ponds etc were built across the region. This further led to systems like johads, anicuts, check-dams, khadins, tankas, adlaz, jhalara, modhera, vapi, medhbandhi (earthen structure on fields to prevent water from flowing out were developed. Between them, these systems met the drinking water, irrigation, agricultural and other water-related needs of the people of the area even in years of lesser than usual rainfall. Most of these practices were being used until the central water system was laid out during the ‘colonial and modern period’.

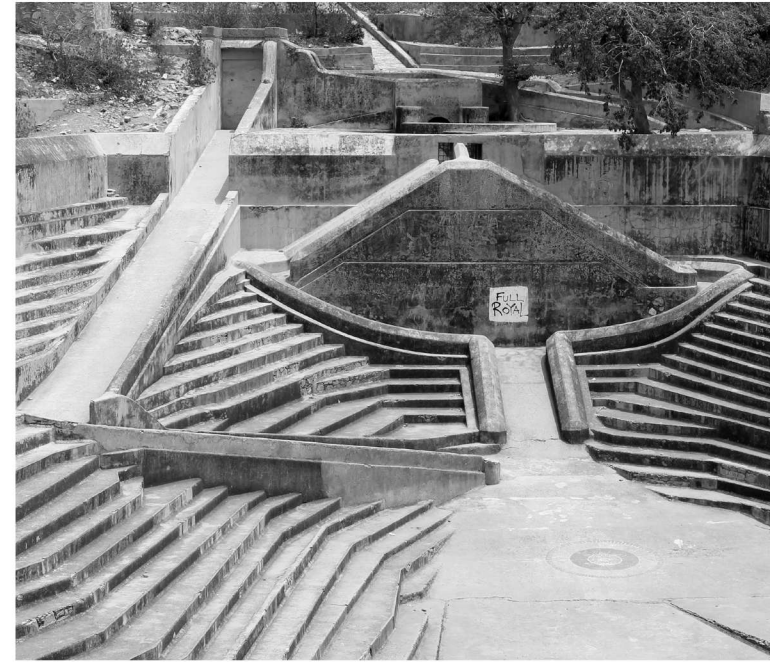


Figure 4 A Stepwell at the Nahargarh Fort (top left)

Figure 5 Water as part of the recreational landscape at Jaigarh Fort (top right)

Figure 6 Typical well in the peri urban areas of the city (bottom left)

Figure 7 A kund at the Badi Chaupar (now demolished) in the Walled City of Jaipur (bottom right)

Catchment Area & Planning of the City.

The history of Jaipur kingdom can be traced back to 1150 CE, but the present walled city was only planned as the new capital in 1727 when the ruler Sawai Jai Singh II, after who the city has been named, envisioned it as a commercial city and a business centre of thriving enterprises. With an area of 6.7 sq. km, it is one of the first planned city of northern India based on the principles of “Shilpa Shastra”, ‘Jaipur clearly represents a dramatic departure from extant medieval cities with its ordered, grid-like structure – broad streets, criss-crossing at right angles, earmarked sites for buildings, palaces, havelis, temples and gardens, neighborhoods designated for caste and occupation’(UNESCO, 2015).

During the planning of the city, special attention was given to the water supply system. With half of the city surrounded by the hills, the city took advantage of various rain catchment areas that were available for storage direct response to local geo-physical conditions. The ruler then, built 16 miles long canals from the nearby river streams and brought water to the city through aquaducts. As the city grew with increased demand for water, a dam across the river of Dhravyavati was constructed in 1844 along with a canal which runs east to west of the city, wide enough for 5-7 horsemen to ride abreast. This covered canal would then distribute the water through various channels and wells across the city and open at some places for direct access. However, after construction of the metalled roads and new pipe system of supply, the canal got buried within the markets and its deep walls got filled up.

Fortunately there has been a revival of interest in traditional water systems in recent years, both for theoretical and practical purposes, especially by development activists

(including organisations like the Center for Science and Environment (CSE), Alwar’s Tarun Bharat Sangh (TBS), etc. Issues emerging from the debate on environmental protection and community empowerment have resulted in a strong need to have a fresh look at these older and time tested practices and utilize their benefits for meeting the present day needs of rural and urban areas.

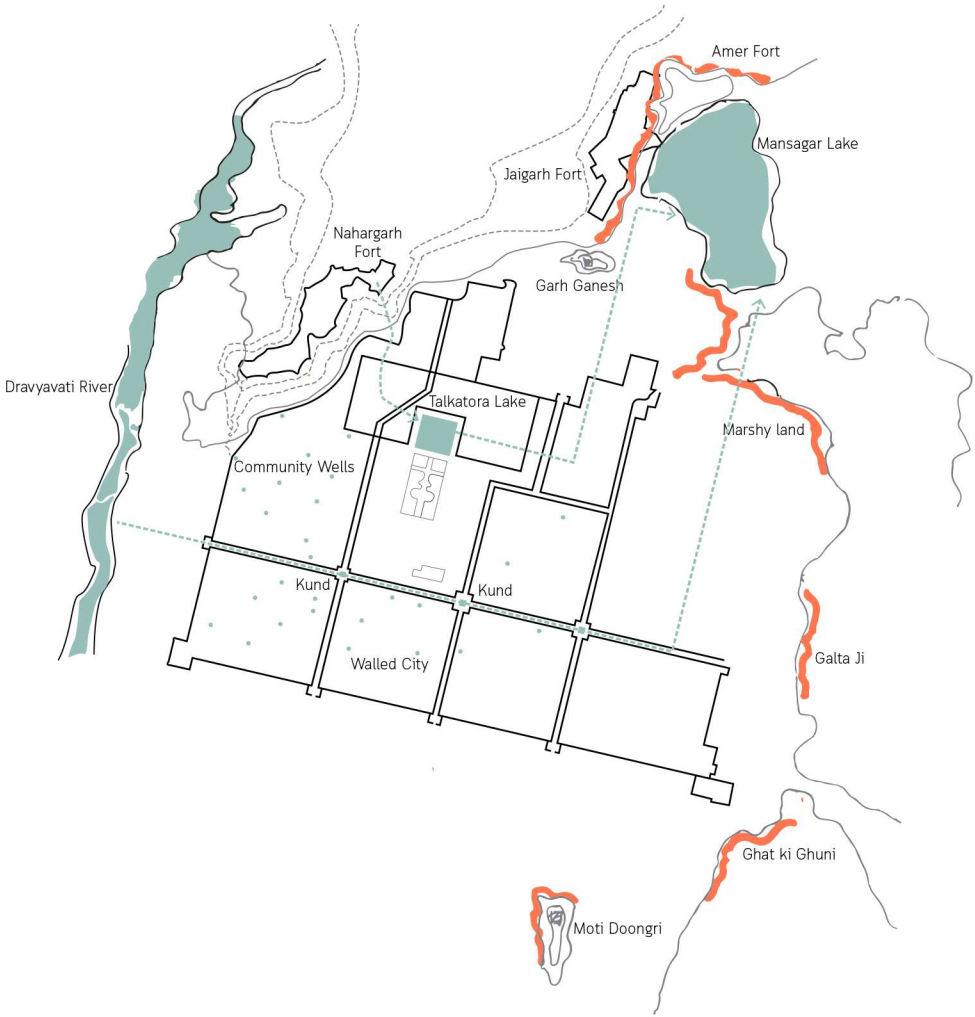
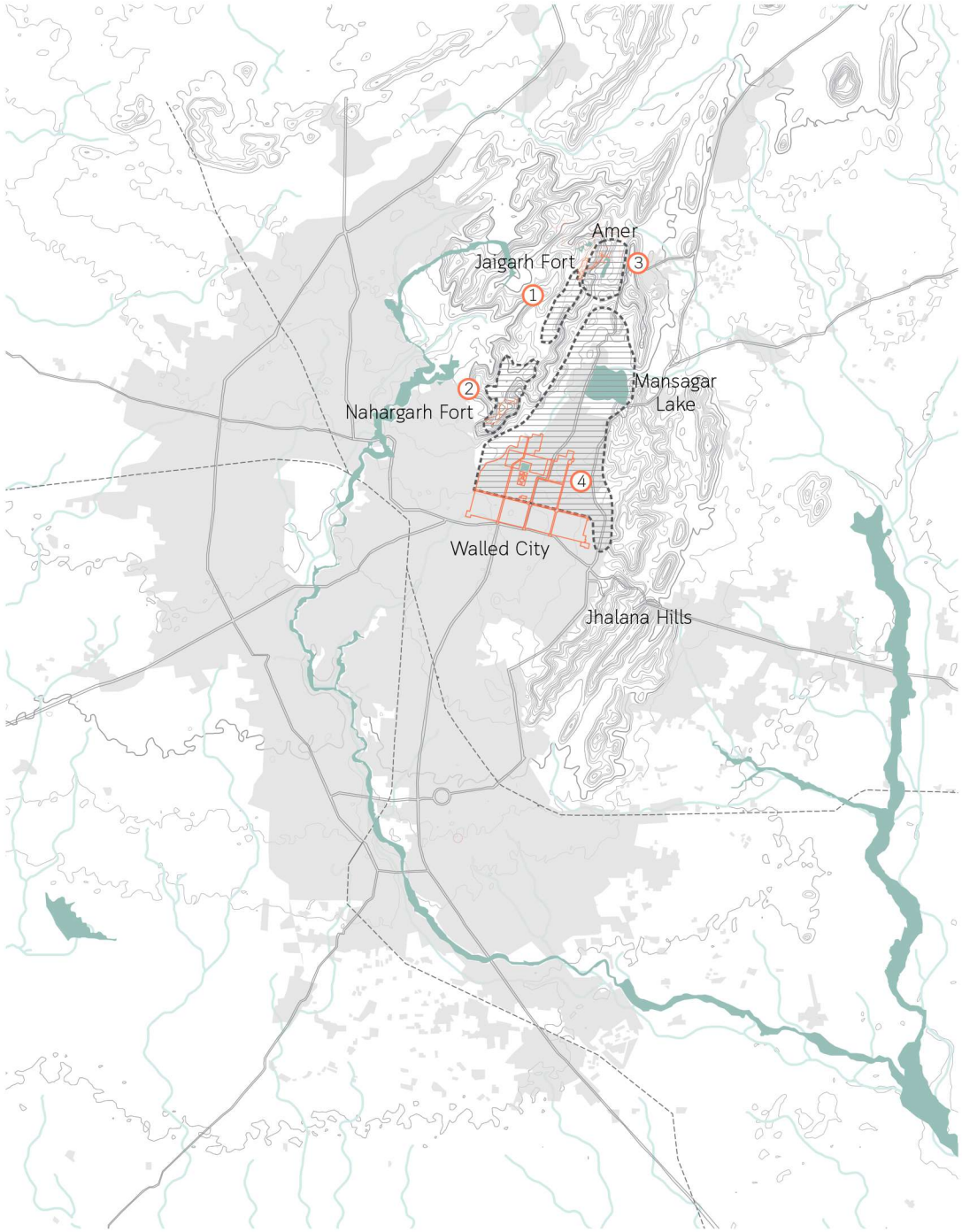


Figure 8 Planning of the Walled City (left)
Figure 9 Catchment Areas of the different systems in the city (right)

- Catchment Areas
- Settlement
- Rivers/ Water Bodies
- Railway lines
- National Highways
- Historic Areas
- Contours

0 1 2 3 4km



Jaigarh Water System.

Water Channels | Aqueduct | Tankas

Situated on the north of the city, 2000ft high on the spurs of the Aravalli range is the Jaigarh fort. Built in the 10th century, it functioned as a defensive fort to the ruler back then, besides serving to all basic requirements of a hill fort. However, the most interesting feature of the fort lies in its water system which was built later in the 18th century. The network starts from the south of the hills, with water channels forming 3 loops before entering the fort walls. The loops have been designed according to the topography in such a manner that rainwater falling in these areas is collected through these channels and directed towards the fort.



Figure 10 Inside the underground water tank (top left)
Figure 11 Water channel entering the fort area (top right)
Figure 12 Water collecting reservoir in loop 3 (bottom left)
Figure 13 Open reservoir within the fort (bottom right)

The first loop is located 3.5km from the fort. The hillock is outlined with water ducts about a kilometre in length, forming an elliptical circle. From here, the water passes through an aqueduct raised on 5 bastions and 39 arches, which carries the water from one hill to another in order to avoid sudden dips between hills. After a distance of 330m, the channels divide into two, forming a second loop. After a distance of 500m, they join, immediately to separate again and form an irregular third loop. Small cisterns have been provided at junctions for easy flow. As the third loop ends, the ducts meet again and are directed towards the east before it enters the fort. All along this route, the channels change direction with sharp angles to ensure sedimentation of debris from runoff. The last duct which enters the fort is 1.83m wide and 330m long.

From here, the water falls into a rectangular opening provided in the floor which takes the water inside the fort through a subterranean channel. The first catchment area allows the debris to settle. Once filled, the water is directed towards the next reservoir through a channel inclining upwards to 25°. By opening a sluice gate, the clean water travels through underground channels to the central tank of the fort.

Once the water crosses the second gate for the fort, the channel leads to a water cistern with 2 sluiced openings. With one the water gets directed to a large underground water tank having a capacity to hold 60,00,000 gallons of water. The ceiling of the tank rests in 80 arched pillars. The second opening leads to an open tank used for bathing,

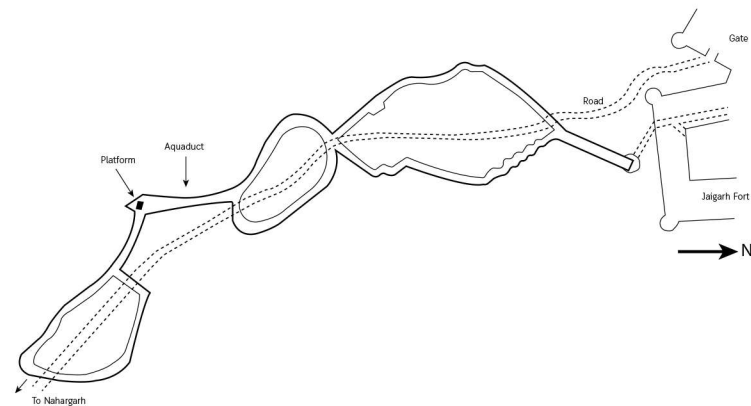
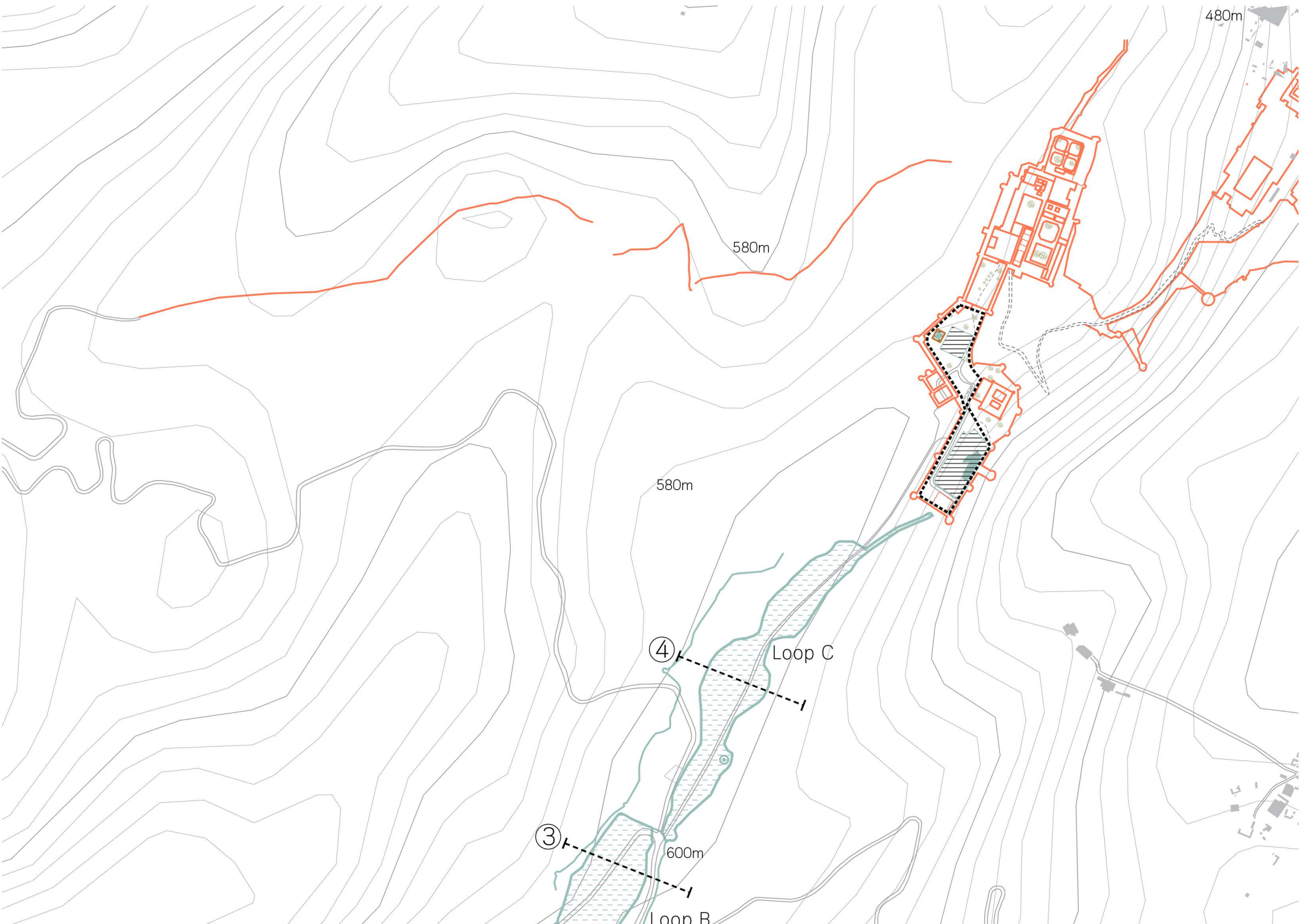


Figure 14 Conceptual diagram showing depicting the loops of the system



provided with a flight of steps leading down to the water. Adjoining the open tank towards the south is a third covered underground tank with nine holes on its ceiling to draw water for domestic and drinking purposes. This tank was meant only for clean water.

The advantages of constructing underground tanks is to ensure minimum evaporation, avoid pollution and lastly, ensure natural cooling of water. Although some channels and viaducts have dilapidated over the years with no maintenance, this ineffective functioning of the whole system. But some water is still collected and caters to the needs of the tourists and inhabitants of the fort even now.

LOOP SYSTEM

Water collected considering the average rainfall in Jaipur
650mm/year averagely
Runoff coefficient 0.5

LOOP 1
Surface - 67,300 m²
Capacity - 43,745 m³ (43,745,000 lit)

LOOP 2
Surface - 24,500 m²
Capacity - 15,925 m³ (15,925,000 lit)

LOOP 3
Surface - 38,300 m²
Capacity - 24,895 m³ (24,895,000 lit)

TOTAL CATCHMENT
Surface - 1,30,100 m²
Capacity - 84,565 m³ (84,565,000 lit)

- Fort Area
- Contours
- Water Channels/ Walls
- Road
- Pedestrian Pathway
- Loop/ Catchment areas
- Water Bodies
- Section Lines

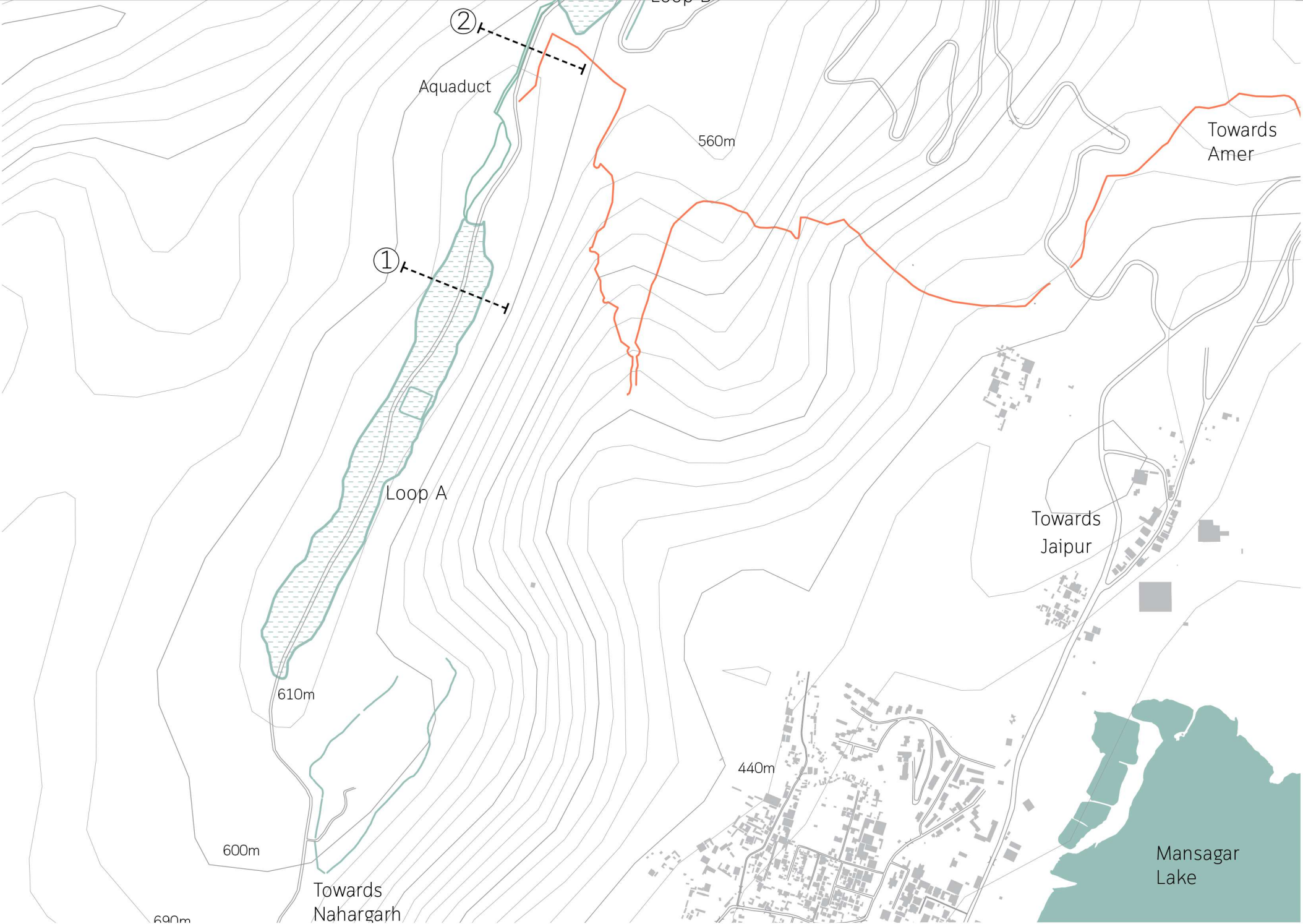
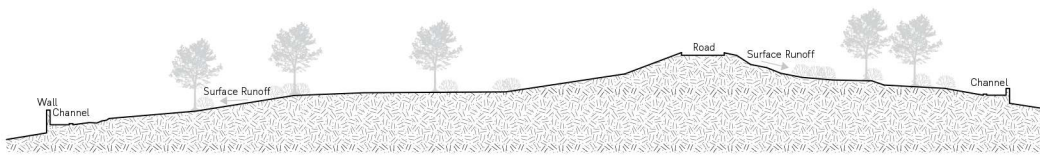
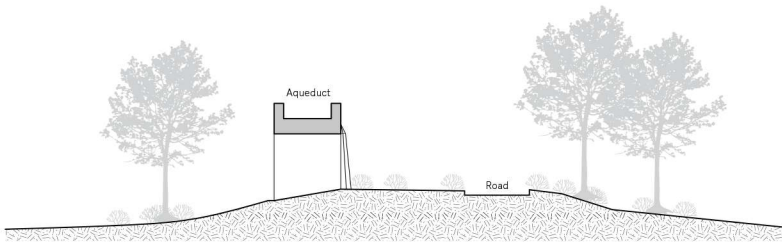


Figure 15 Catchment Network of the system

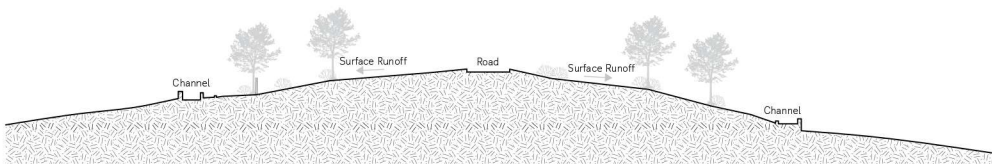
Section 1



Section 2



Section 3



Section 4

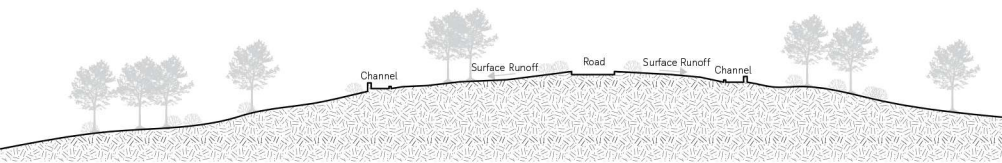
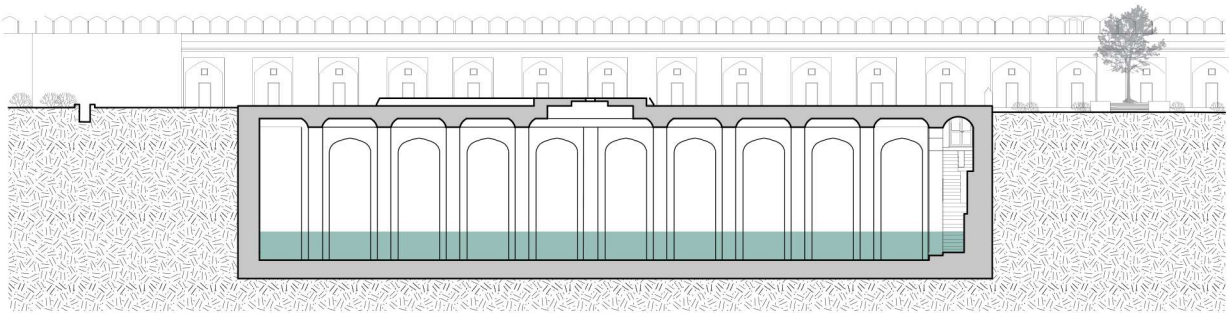
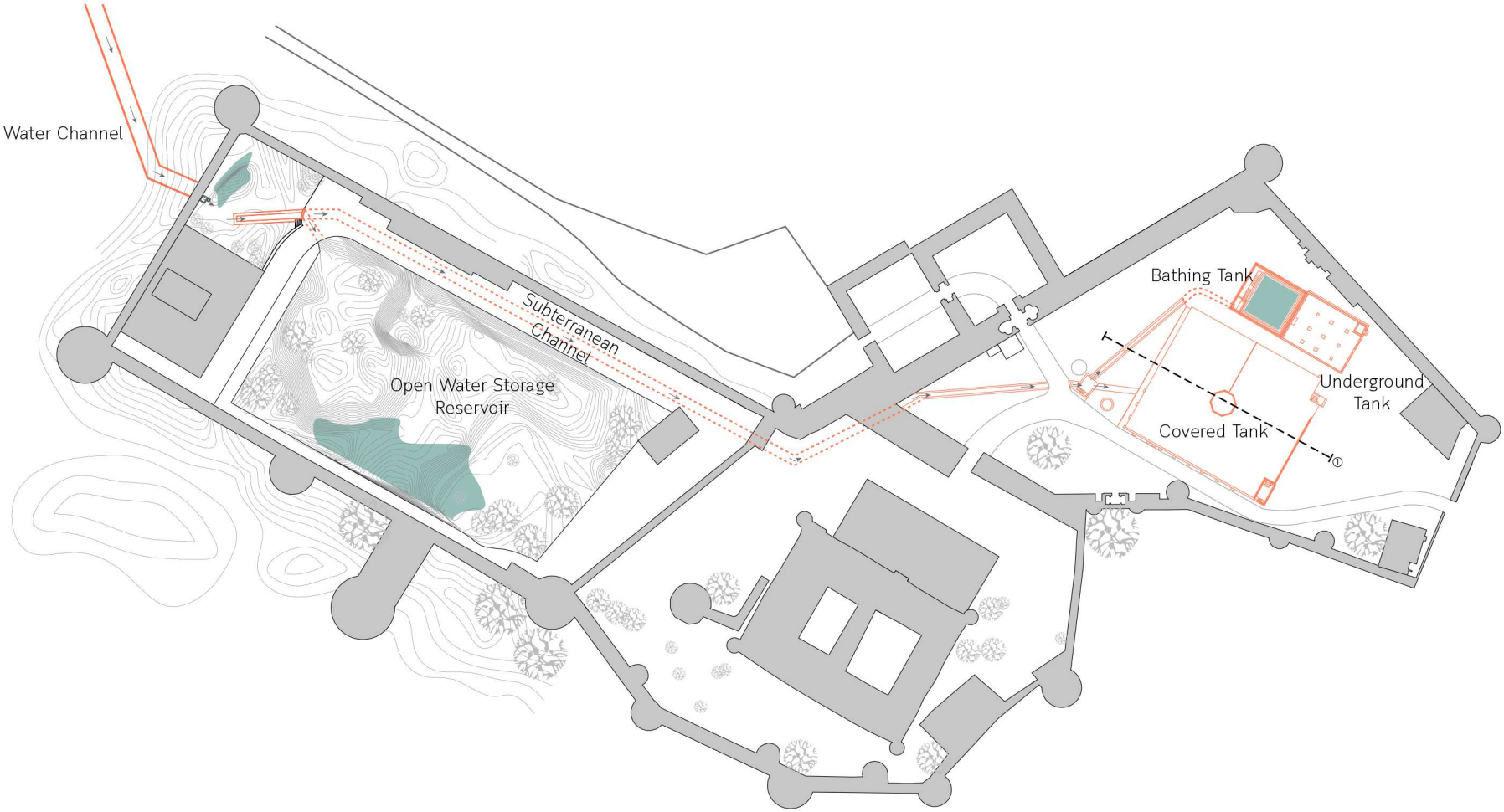


Figure 16 Sections through the loops (left)
Figure 17 Water network within the fort (top right)
Figure 18 Section of the underground tank (bottom right)



- Fort Area
- Contours
- Water Channels/System
- Road
- Pedestrian Pathway
- Loop/ Catchment areas
- Water Bodies
- Section Lines

Nahargarh Water System.

Water Channels | Aqueducts | Stepwells | Kund

Located at some distance from the Fort of Jaigarh in the hillocks of Aravalli overlooking the city, is another fort, popularly known as 'Nahargarh Fort' or 'Tiger Fort'. Built largely by Sawai Jai Sign II in 1734, shortly after founding of the walled city, it functioned majorly as a residential royal fort, with a maze of courtyards and cambers for 9 queens. Apart from providing the basic facilities, the fort has a self sufficient elaborate water system with catchment areas that extend about 6kms of its surroundings.

The main idea behind the networked system if to collect, control flow, purify and store maximum water. Similar to the Jaigarh fort, this system forms 5 catchment loops that spread organically across the hill, connected through small channels and aqueducts to bring water to the fort. The catchment beds have been designed keeping in mind the gradient and undulating surfaces. The runoff from these beds are collected and directed through a long drain that enters the fort to bifurcate at a distribution point with a cistern to switch flow.



Figure 19 Water channel carrying water to the firt (top left)
Figure 20 Stepwell 1 at Nahargarh Fort (top right)
Figure 21 Aqueduct connecting catchments to water channels (bottom left)
Figure 22 Stepwell 2 at Nahargarh Fort (bottom right)

Water collected considering the average rainfall in Jaipur
650mm/year averagely
Runoff coefficient 0.5

Catchment A
Surface - 22,200 m2 Capacity- 14,430m3 (14,430,000 lit)

Catchment Area B
Surface - 10,900 m2 Capacity- 7,085m3 (7,085,000 lit)

Catchment Area C
Surface - 32,300 m2 Capacity- 20,995m3 (20,995,000 lit)

Catchment Area D
Surface - 3,000 m2 Capacity- 1950m3 (1,950,000 lit)

Catchment Area E
Surface - 29,000 m2 Capacity- 18,850m3 (18,850,000 lit)

Total Catchment Area
Surface - 97,400m2 Capacity- 63,310m3 (63,310,000lit)

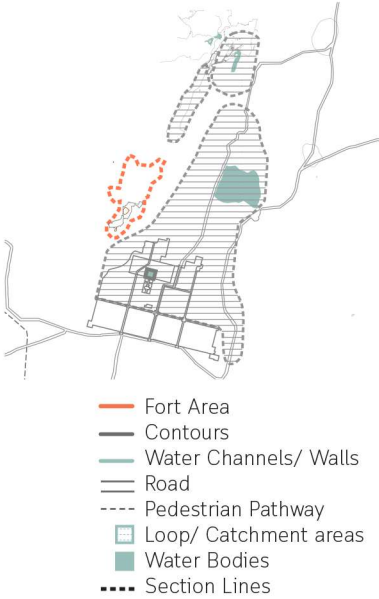
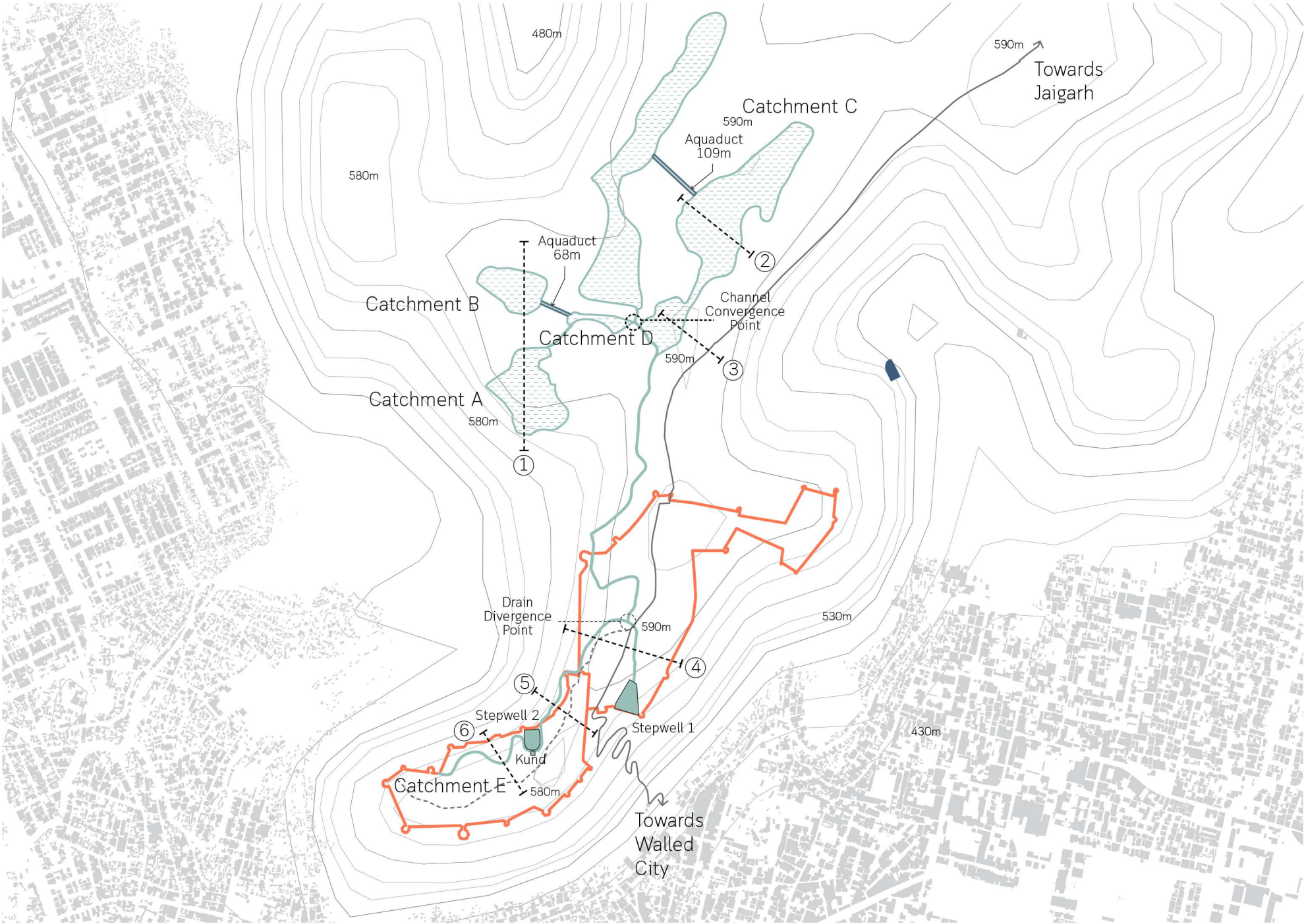


Figure 23 Network of water catchments and distribution system



Unlike Jaigarh, the Nahargarh fort has two large stepwells (Baolis) and a Kund (tank). The water from the distribution point flows in two directions, towards the stepwells. While Stepwell 1 was used by the common men and animals for bathing and recreation, Stepwell 2 was for the royal family. The catchment area E which lies within the fort, collects runoff within the fort area and directs it to the kund. Both the kund and stepwell 2 have an interconnected network to ensure maximum storage and adequate distribution of water for various purposes.

Stepwell 1

Length - 70m
 Breadth - 50m
 Depth - 12m
 Capacity - 42,000 m³ (42,000,000 litres)

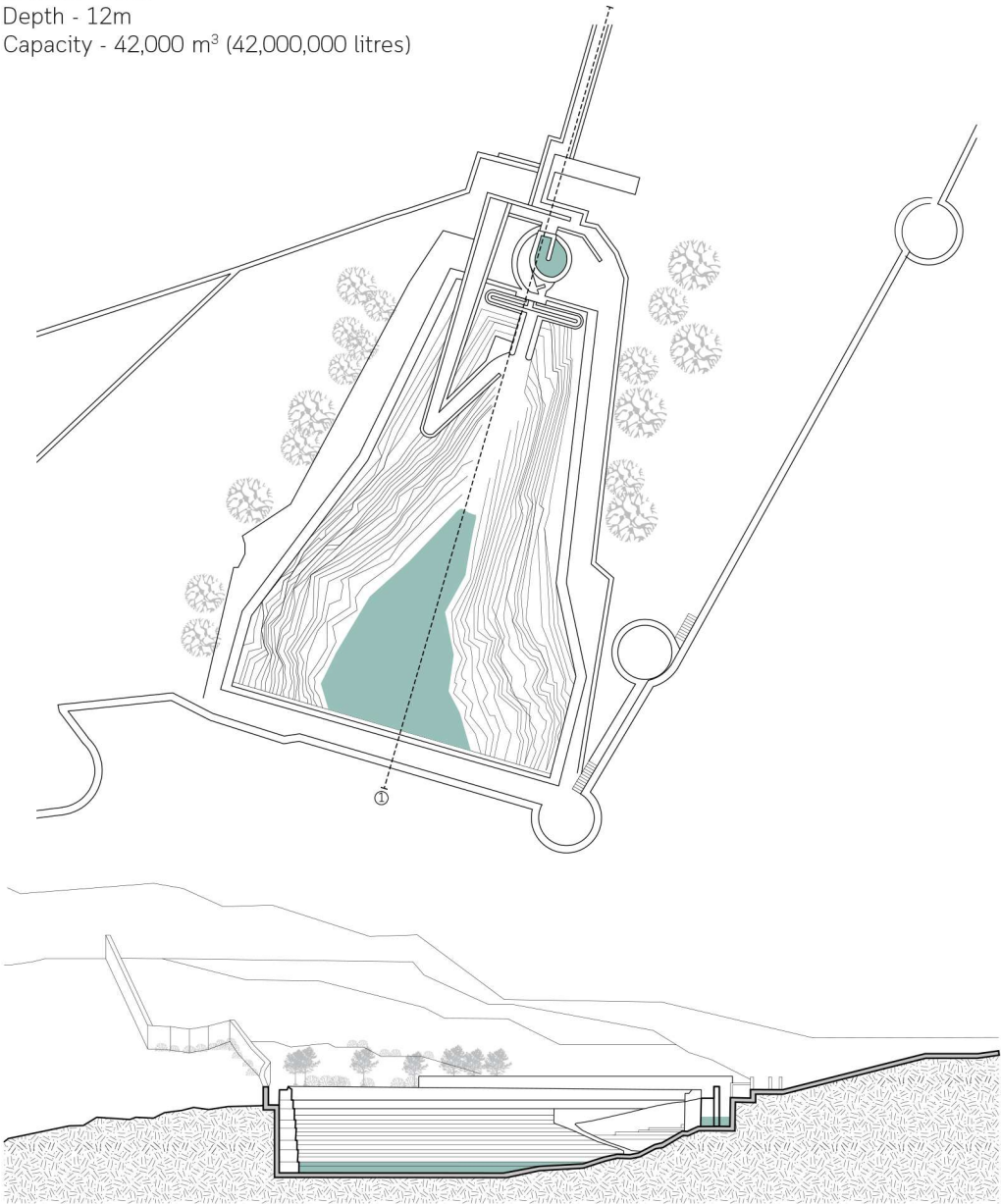
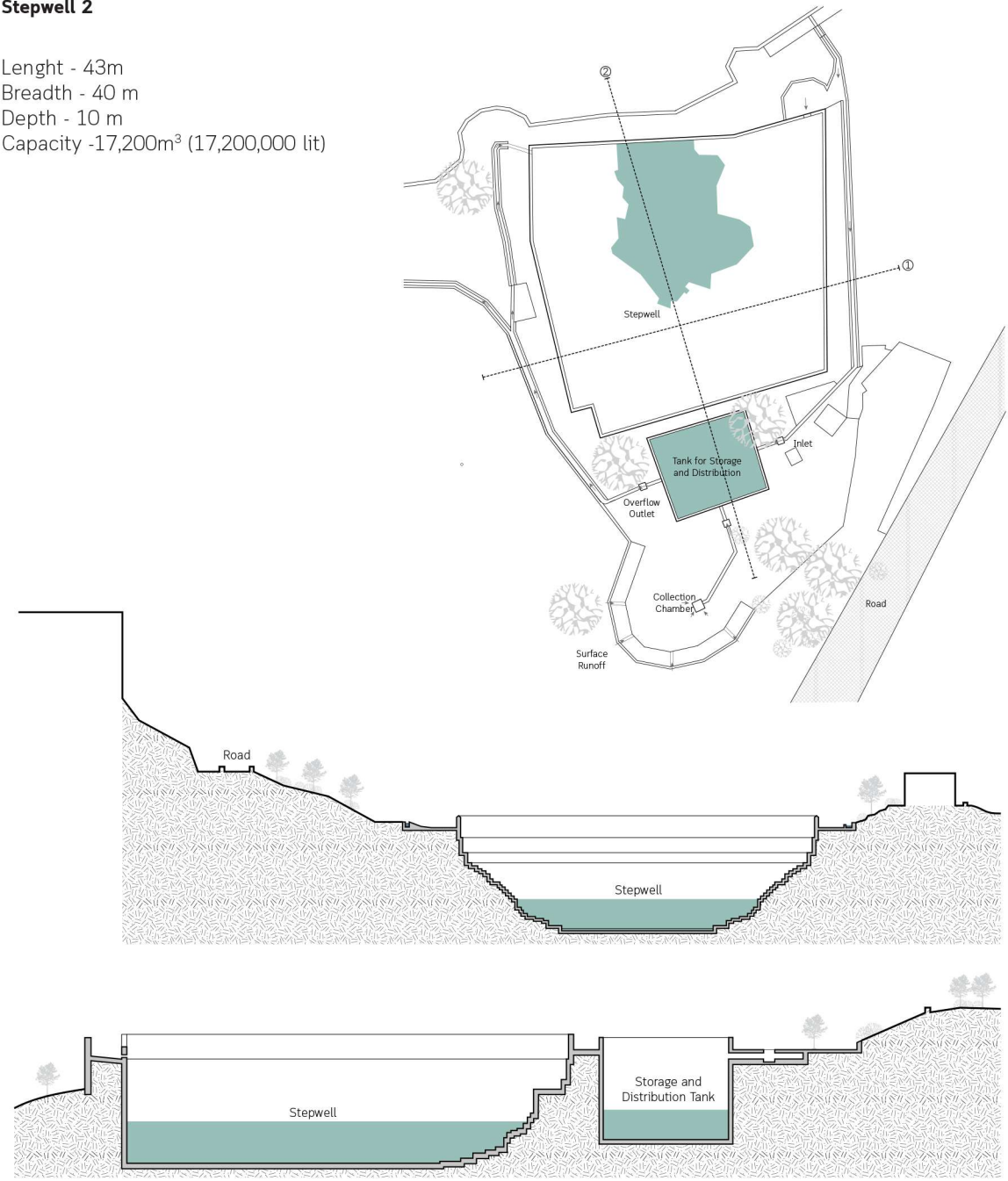


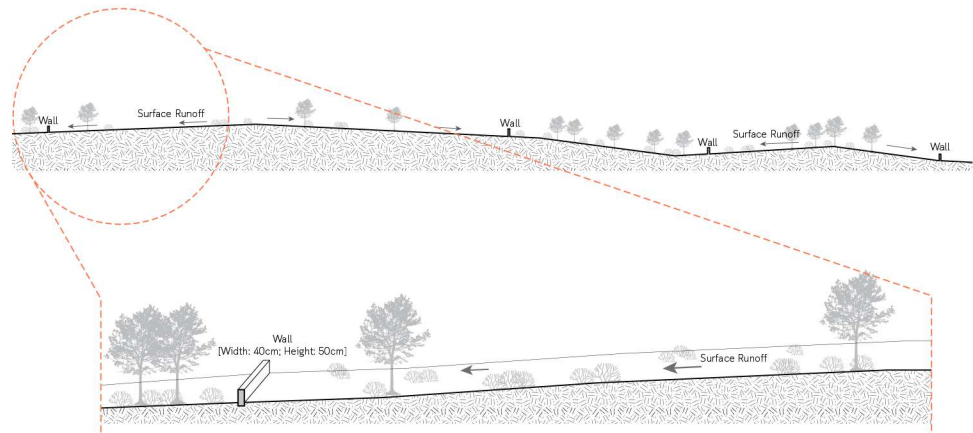
Figure 25 Plan and Section of Stepwell 1 (left)
Figure 26 Plan and Section of Stepwell 2 (right)

Stepwell 2

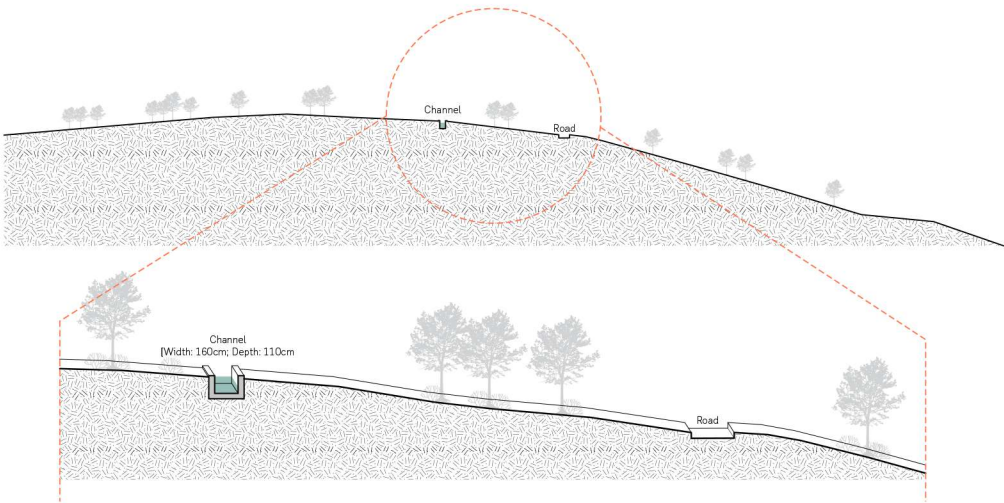
Length - 43m
 Breadth - 40 m
 Depth - 10 m
 Capacity - 17,200m³ (17,200,000 lit)



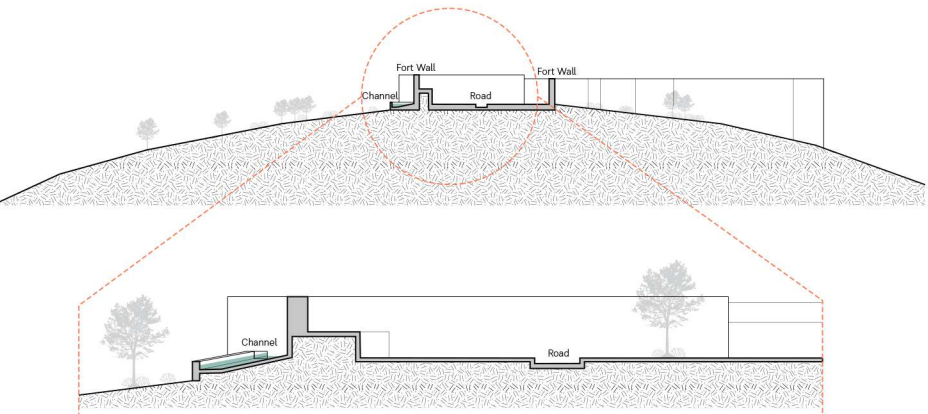
Section 1



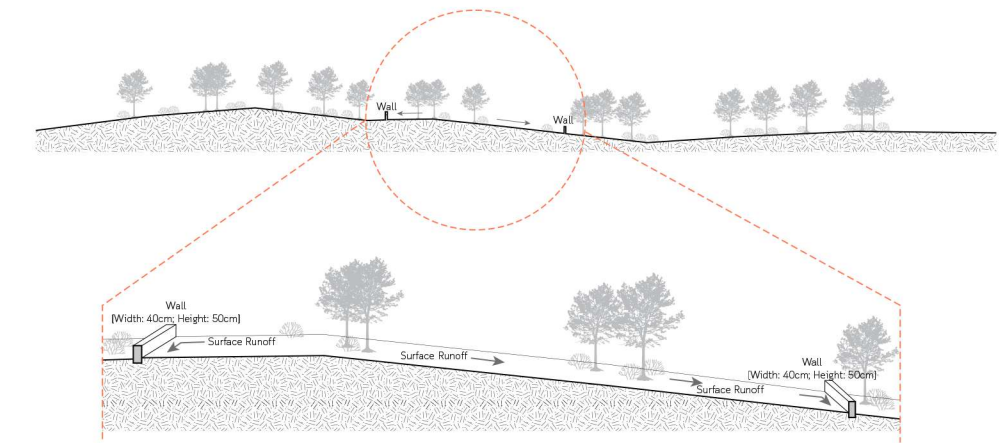
Section 3



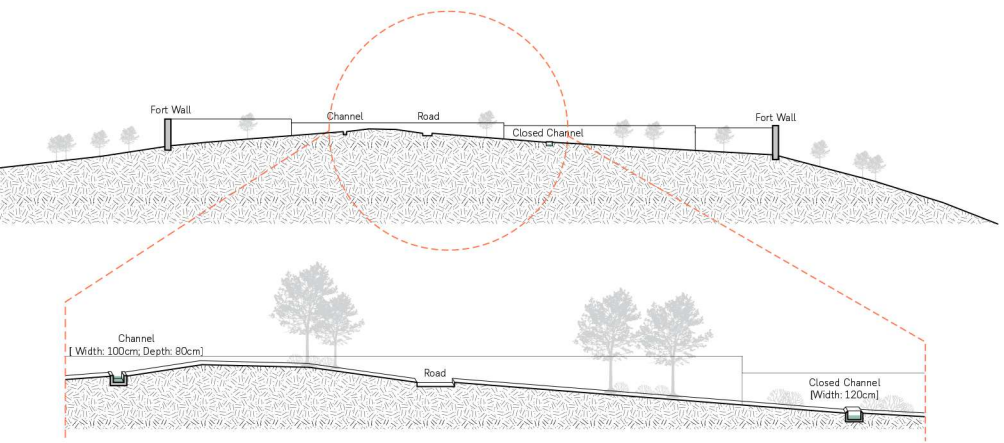
Section 5



Section 2



Section 4



Section 6

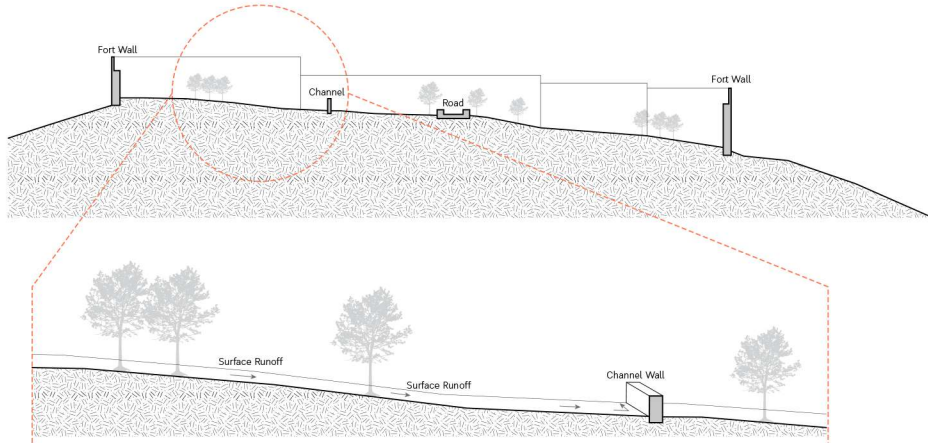
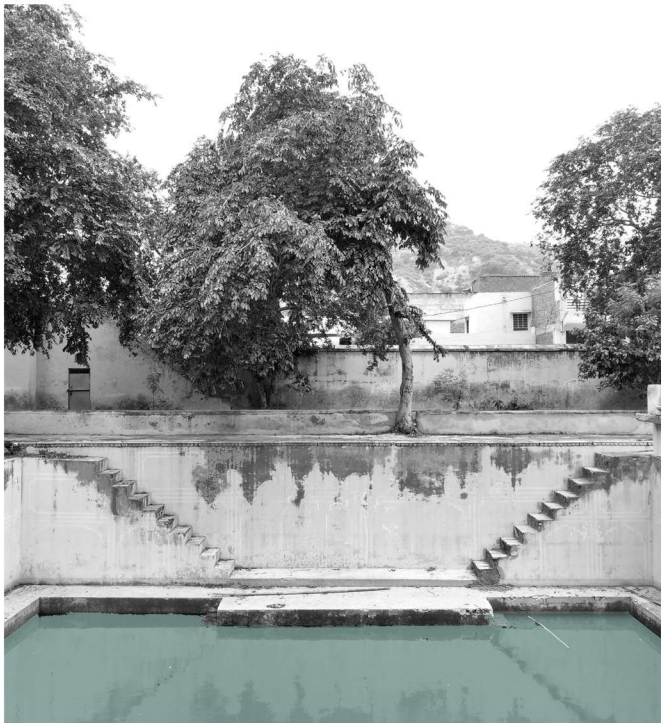
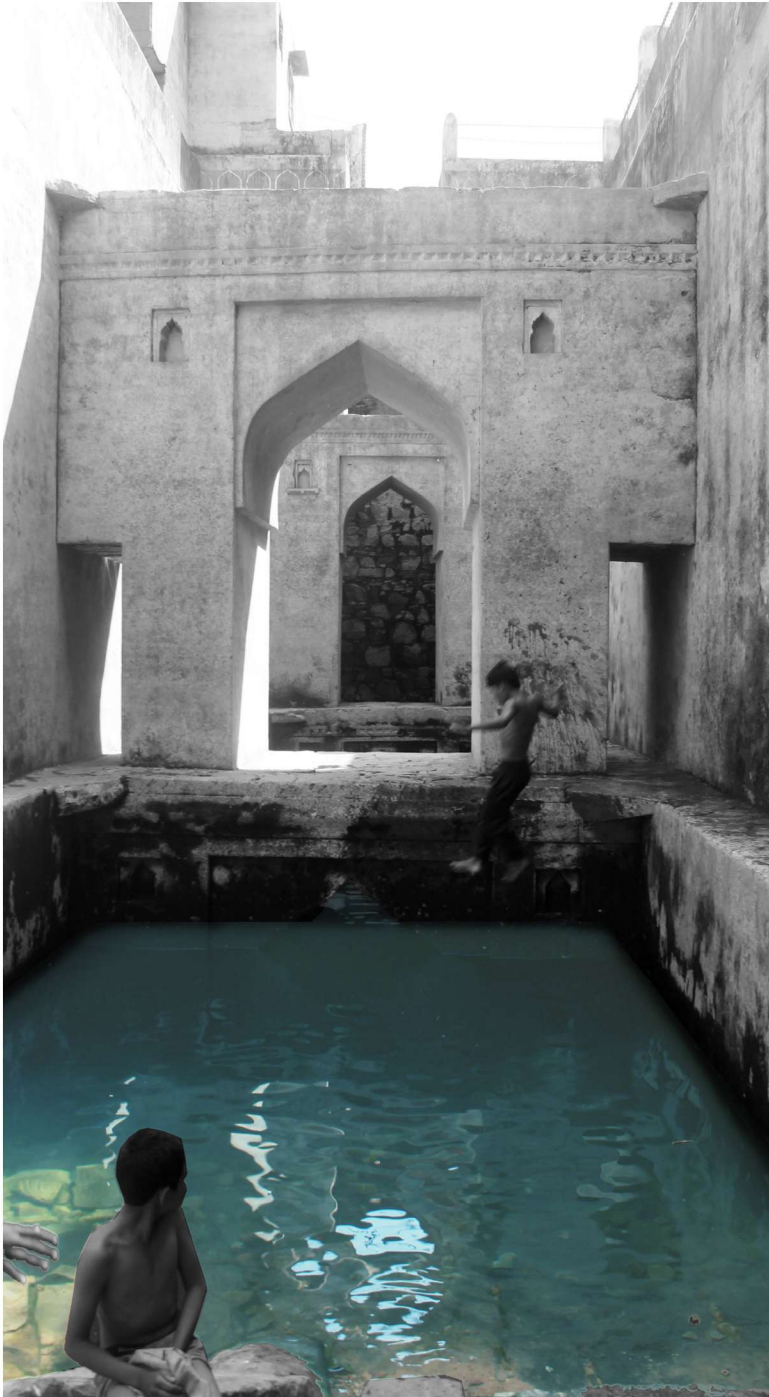


Figure 24 Sections across catchment areas

Stepwells of Amber.

Water has a special significance in Hindu mythology, believed to be as a boundary between heaven and earth. For centuries, stepwells and stepped ponds, also known as Bavdis, Bawadis, Baolis or Vavs, have not just played a significant role in functioning as traditional water systems, serving the community through generations but also as hotspots of social, cultural and touristic interactions. 'While various water structures such as tanks, cisterns, paved stairways along rivers (ghats) and cylindrical wells are found elsewhere in India, stepwells and stepped ponds are indigenous to semi-arid regions of Gujarat and Rajasthan'(Livingston & Beach, 2002)

Figure 27 Typology 2- Cheela Bawadi (left)
Figure 28 Typology 1- Atreya Bawadi (top middle)
Figure 29 Typology 3- Sarai Bawadi (top right)
Figure 30 Typology 4- Bengali Baba ki Bawadi (bottom middle)
Figure 31 Typology 5- Parshuram Dwar ki Bawadi (bottom right)



Location of Stepwells.

Largely built between the 7th and mid-19th century, these structures are usually from three to nine stories deep, forming a passage into the terrain escaping the heat, thus also becoming community spaces and invested with religious meanings. In Rajasthan, these can majorly be found along the belt of the Aravalli Hills between the Thar desert and Delhi. Fed either by rain water harvesting or natural springs, these stepwells were majorly used for bathing and washing purposes. However, 'some of the Bawadis were built to cater to specific building or complexes viz, temples and gardens, some were used by the commoners residing within the settlement of Amber, while others were part of highway infrastructures, where trespassers used these bawadis'(Drona, 2015). Some structures contain semi open arcades and chambers which were often used by those travelling on foot. The central idea is fairly simple. 'An excavation lined with stone allows the water level inside the cavity to fluctuate freely with the surrounding water table.'(Livingston & Beach, 2002). Thus, during monsoons, the descend to water is less and the well fills up and reaches higher steps meanwhile also recharging the water table and even during dry periods, water is always available through the water table.

The architecture of these bawadis varies by type and location and when they were built. According to Unesco, 'the stepwell's construction reflected a mastery of this complex technique and great beauty of detail and proportions' (UNESCO, 2014). However, these structures gradually lead to decline during the British Rule as they feared the unsanitary conditions of these drinking and bathing spots, thus replaced them with centralized water pipes and pumps. There are approximately 50 stepwells in the city of Jaipur which have been identified, but only a few have been mapped and conserved to some extent. A concentration of them can be seen around the town of Amber. In order to satisfy the needs of the people then, the town had a well-functioning water system of its own which included stepwells which were built within the settlement and along transportation routes. While these structures comprise of India's major building tradition, however they are also the most neglected one. Most of them have either dried up due to overuse or inadequate recharge through rain or contain water which is polluted owing to lack of maintenance and ignorance of the government. According to studies by Drona, there are five typologies of these stepwells which will be discussed.

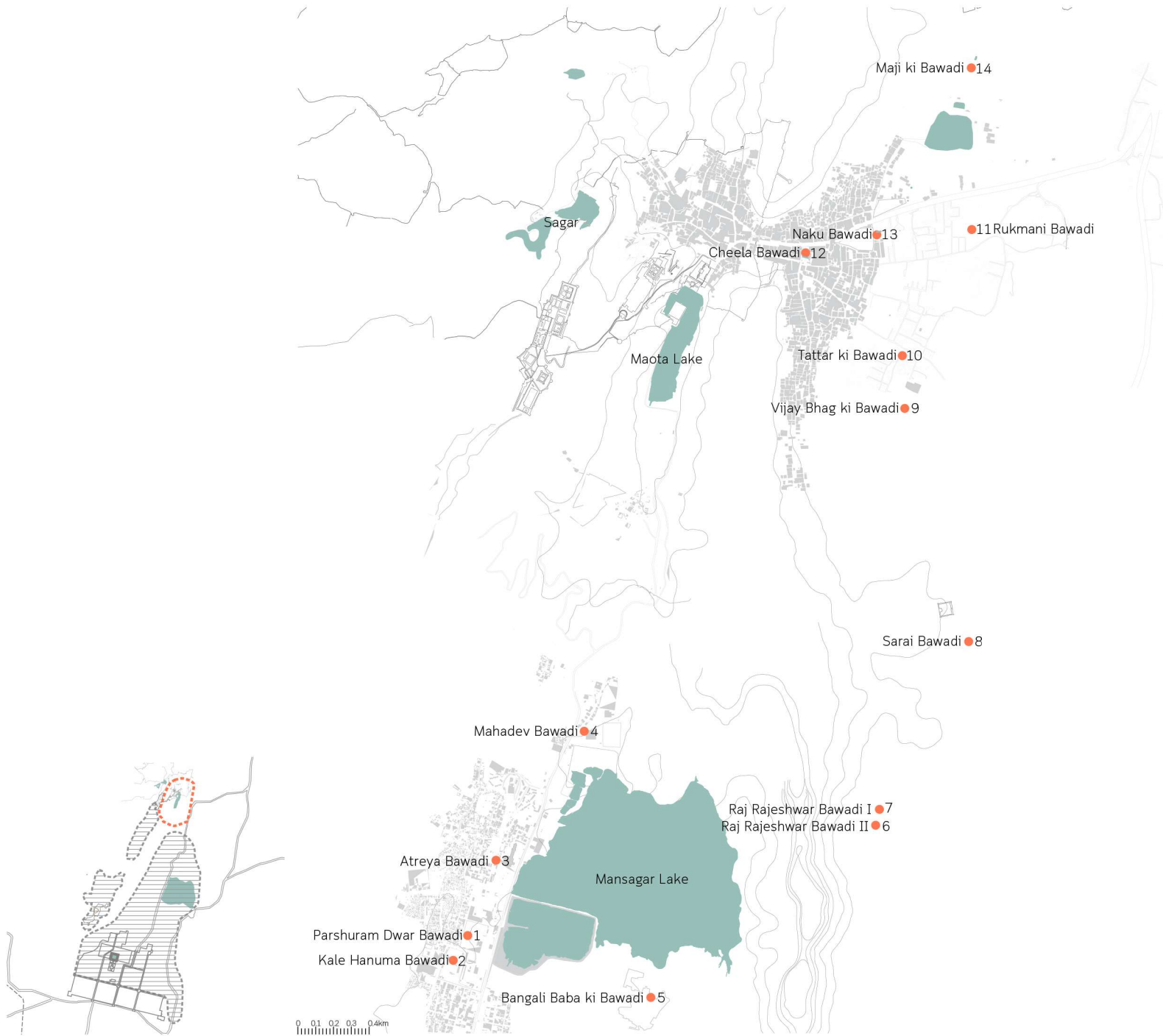


Figure 32 Locations of Stepwells in the city

TPOLOGY 1

These stepwells have direct access to the water storage reservoir through a series of steps which lead to the water. There is no presence of a well and water is through a natural spring. There are 3 stepwells of such type which have been identified in Amber.

TPOLOGY 2

This typology has steps on one side which lead down to a reservoir connected to a well. During the periods of monsoons, the rise in well water reaches the reservoir through openings in the wall which separates the well from the stepwell. There are 4 stepwells of this type.

TPOLOGY 3

Similar to typology two, but has an added layer of single semi open rooms or arcades which run along the walls of the stepwells. Four such structures are present in Amber.

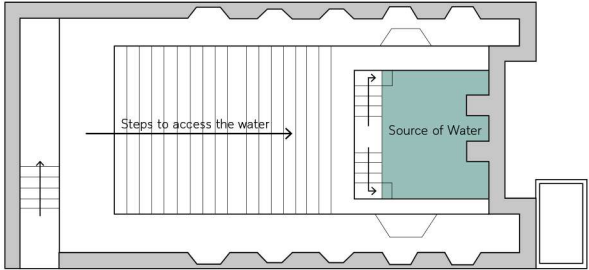
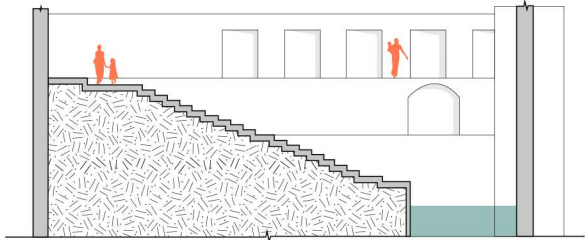
TPOLOGY 4

With access steps on one side, surrounded by arcades or habitable rooms on other, these structures are mostly found near temples and two of them have been identified.

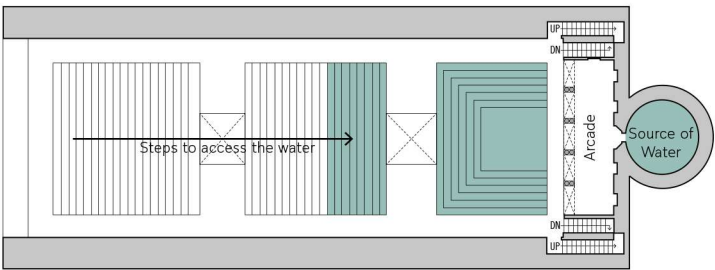
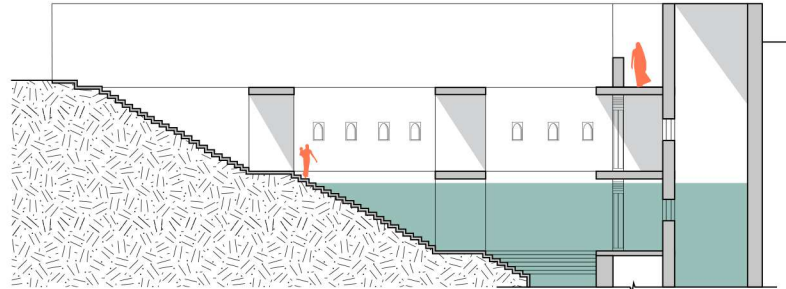
TPOLOGY 5

This type has steps on all four sides which lead down to the water storage. There is no presence of a well and water is fed from natural spring. The form is essentially square for this type, forming a symmetrical elevation on all sides. There is only one of this type.

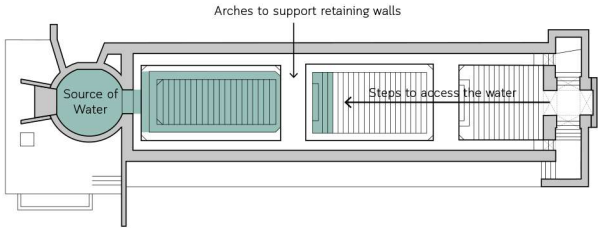
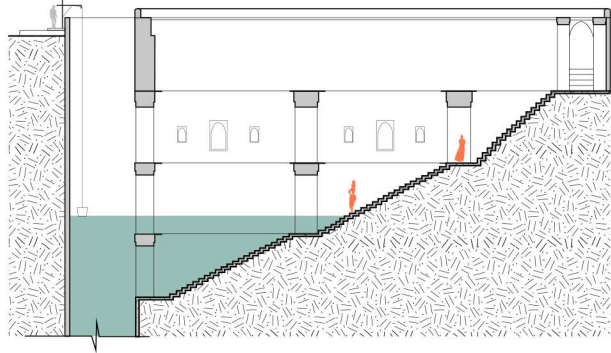
Typology 1



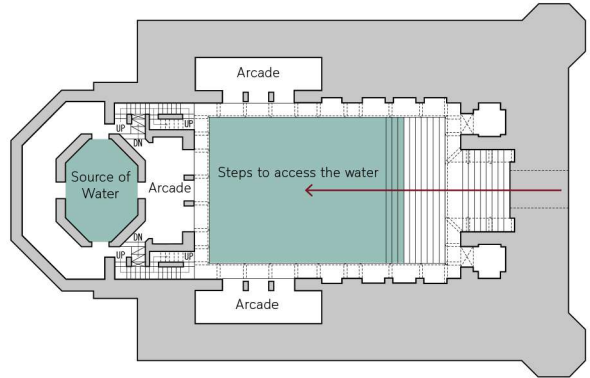
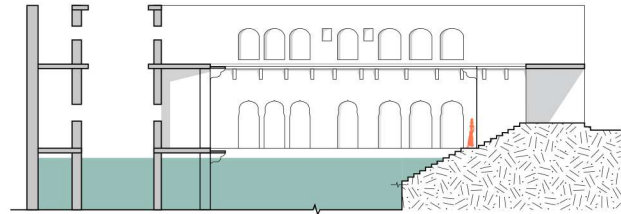
Typology 2



Typology 3



Typology 4



Typology 5

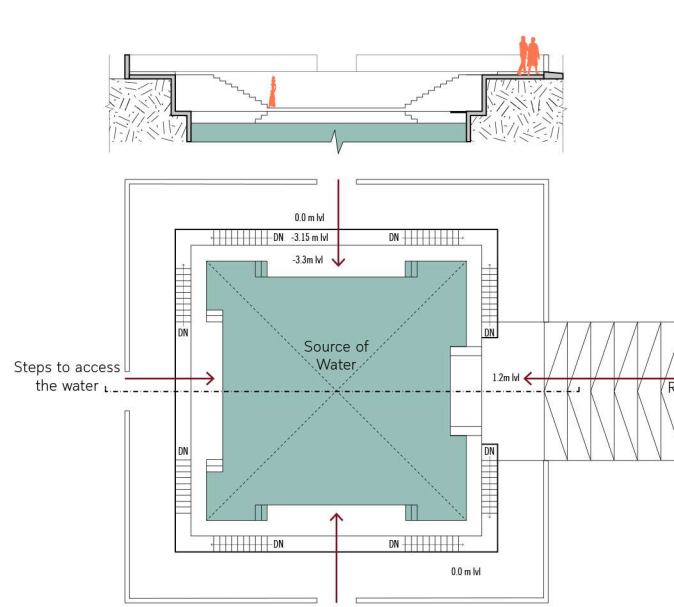


Figure 33 Typologies of Stepwells/ Bavadis

Public Wells in the Walled City.

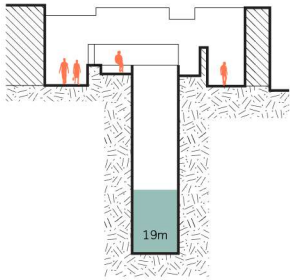
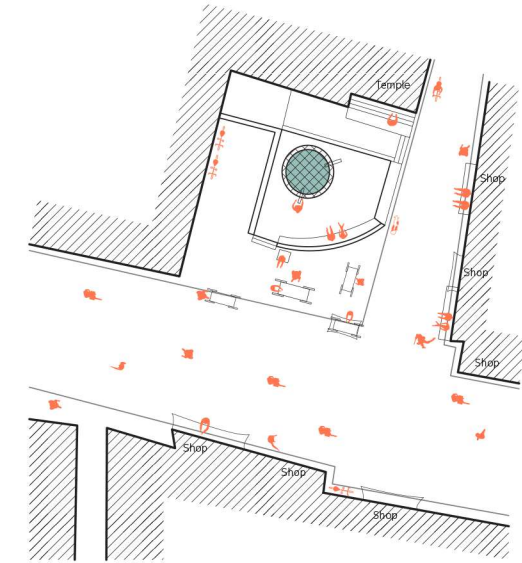
The walled city of Jaipur was planned to support a population of 150,000 people over an area of 1658 acres (or 6.7 square km). To cater to the water needs of the people, there are approximately 820 wells located within neighbourhoods in the walled city. The oldest ones date back to the 18th century, however most were used from 1872 onwards once the city started growing.

The water from these wells were used for bathing, recreation, religious, cleaning and sometimes even for drinking. Each well is attached to a temple, located in a public square, thus serving as a social space for the inhabitants. The depth varies from 7-21m. While some access water from deep aquifers, others were filled through the water channels. Over the years with increase in demand, most of these wells dried out or became unusable due to water pollution. However, very few are still active and pumped using borewells.

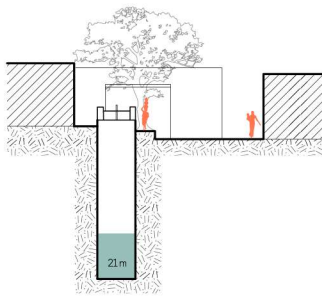
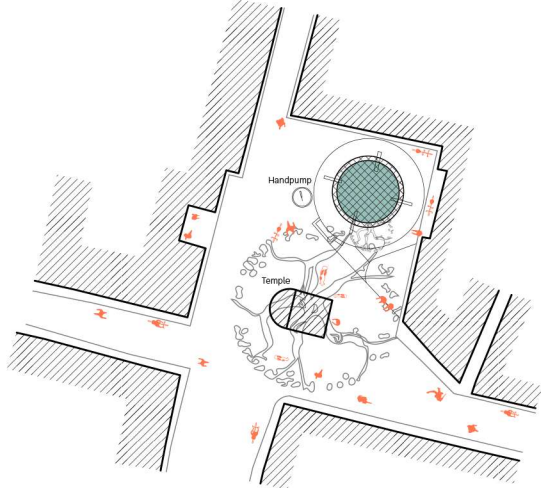


Figure 34 A well in a residential street adjoining a temple (above)
Figure 35 Spatial Analysis of a Commercial Street with well (top left)
Figure 36 Spatial Analysis of a Residential Street with well (bottom left)
Figure 37 Location of Wells in the walled city of Jaipur (right)

Commercial Street



Residential Street



Conclusion.

The purpose of this research is to study the place of water from a historical perspective and analyse the potential in the water cycle for the sustainable future of urban water management for the city of Jaipur. Although there are several other traditional practices which exist in the region of Rajasthan, this study focuses on the ones which exist in the urban realm of Jaipur, a city created from scratch amidst its hilly terrain at the edge of the desert area. Being in a semi-arid zone, the frequency of water shortages and droughts is high. However, 'Ancient civilizations grasped the complex reciprocities of natural systems and created an infrastructure that was modelled on, and worked in tandem with, those reciprocities' (Brown & Stigge, 2017). And so, the region continued to thrive, also as the most densely populated desert area. With the main principle and collective effort of 'rainwater harvesting', the inhabitants built Tankas, Johads, Khadins, Stepwells, Kunds, Tobas, etc., and these practices are deeply rooted in the social fabric. Even though over the years, these systems have gradually declined, nevertheless, these structures, often with very intrinsic details and imposing architecture continue to persist in the city's landscape.

Landscape values: Water plays a significant role in the history of Indian civilization, starting from the Indus Valley to the British. With every imperialization came elaborated water systems, not just as part of infrastructural systems but also religious and recreational activities. The water systems presented in the book are also deeply embedded in the cultural realm. The landscape of the forts has gardens with water as the main feature, thus serving to recreational activities for the royal family.

Strategic values: These traditional water harvesting systems have been existing for centuries, evolved over the years using old age wisdom and knowledge of the terrain. As can be observed, the water channels are carefully aligned according to the topography of the city, following the natural gradient of the hills and transporting water through gravity.

Values of sustainability: The main materials used for the construction of these systems is stone and lime, both locally available materials of the region. Due to the presence of calcium, the lime plaster filters the water while the stone masonry keeps the structures cool during intense heat.

Ethnographic and identity values: 'The communities being closely knit had a strong culture of providing voluntary labour and material contributions for building these facilities for the common good'(J. Hussan, 2014). In an interview with 'The Economist' Rajendra Singh, popularly known as the 'Waterman of India' claims that 'He prefers the notion of "communitisation"—getting local communities to deal with water shortages by building and maintaining their own water tanks and other structures, usually giving their labour free. Nor is rainwater harvesting just for rural areas, it can also be used in big cities and in other countries'("The water man: An ancient practice revived," 2003). These systems not only encourage public participation in the development process, but also provides an identity to communities.

Therefore, there is a strong need to revive these practices for ensuring socio technical resilience in semi arid cities and cater to a more sustainable efficient urban water management system.

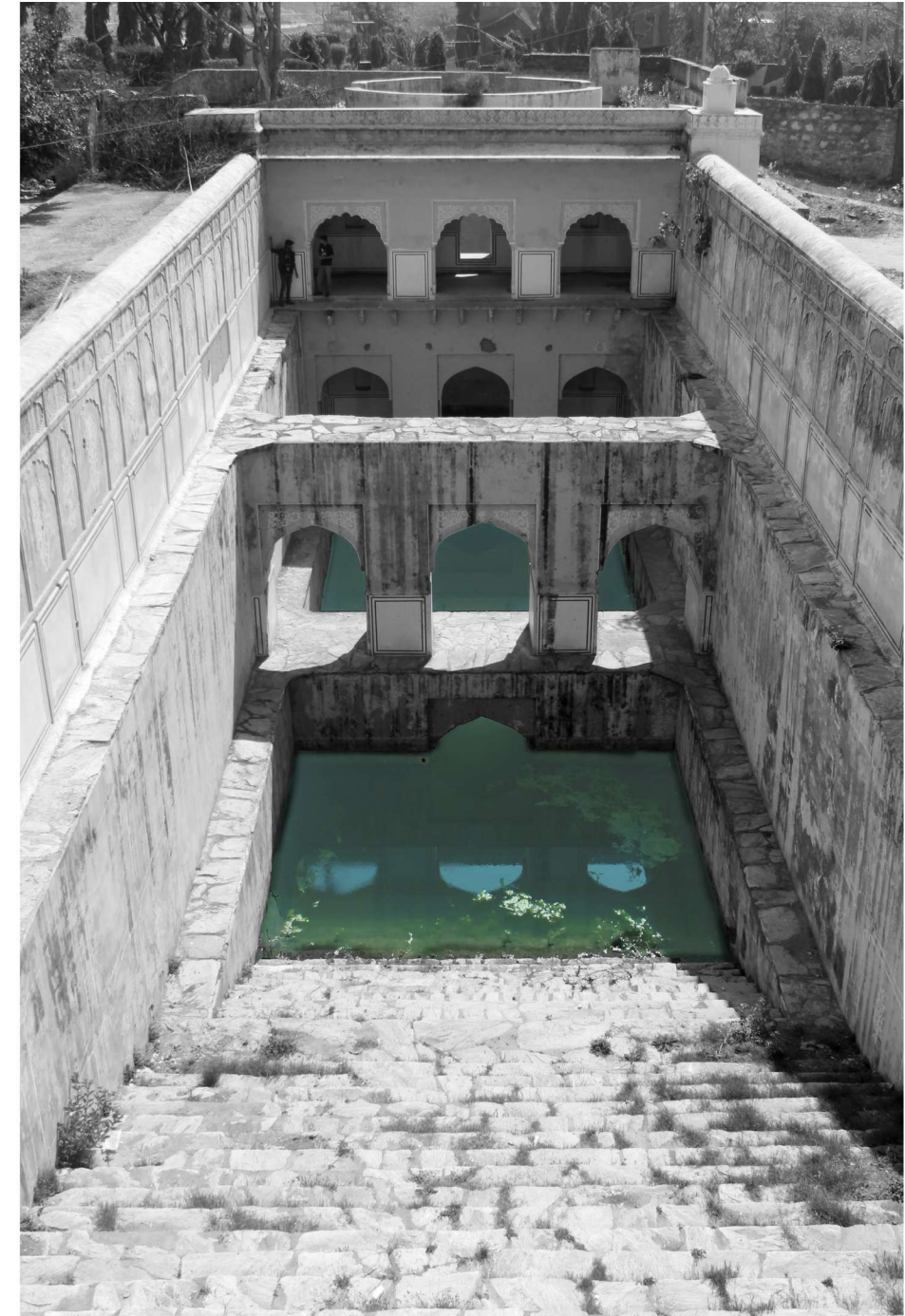


Figure 38 Tattar ki Bawadi, Amber