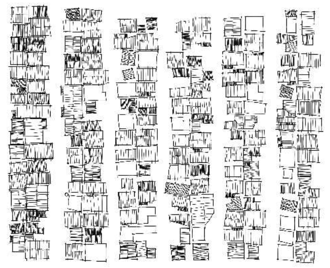


CHAPTER 05

TECHNICAL DEVELOPMENT

Figure 5.1. Plastic View dwelling structure (Author 2021)

5.1
INTENTION

The technical development of the dissertation encompasses the refinement of the structural language, material choices, systems and environmental strategies. The technical exploration comes as an extension and enrichment of the iterative design process and thus derives its intentions and conceptual approach from those of the design explorations in chapter two. As expressed in chapter one, the broader intention is to improve the resilience of Plastic View whilst anticipating the upgrading and expansion of the settlement. The design development process briefly discussed the themes of adaptability and multifunctionality, in its approach to architecture as an anchor, a catalyst and a connector. These themes, however, become the primary factor in the technical development of the dissertation.

The intention of the technical resolution is to provide an intervention that is wholly appropriate for the informal context of Plastic View. This brings integral factors of construction and maintenance costs, and the ease of maintenance and repurposing. To respond to these factors, the pattern language of Plastic View is reflected on and critiqued. The design iterations used the patterns to inform the scale and socio-spatial organisation of the intervention, whereas the technical development, and the factors of construction and maintenance, will be informed by the patterns at smaller scales of thresholds, private spaces and construction.

5.2
TECHNICAL CONCEPT

The technical concept draws from the established theoretical basis of the “safe-to-fail” mentality of Ahern (2011) and the open building systems thinking of Habraken (1987; 1988), as well as aspects of the design concept discussed in chapter 2. As a result, the technical concept expresses an interest in structural adaptability and transformative participation for settlement upgrading.

Structural adaptability

As anticipated in chapter 2, the expansion of Plastic View would bring about shifts in the spatial requirements and desires of the community. An efficient design fails to consider the dynamic role architecture needs to fulfil in the evolving context of an informal settlement, where an adaptable architecture is resilient in that it can continuously respond to its shifting needs. The structure thus requires two conditions; firstly, a fixed support that defines parameters and limitations of the structure, and secondly, a flexible infill that works within and extends from the support to suit the users’ needs.

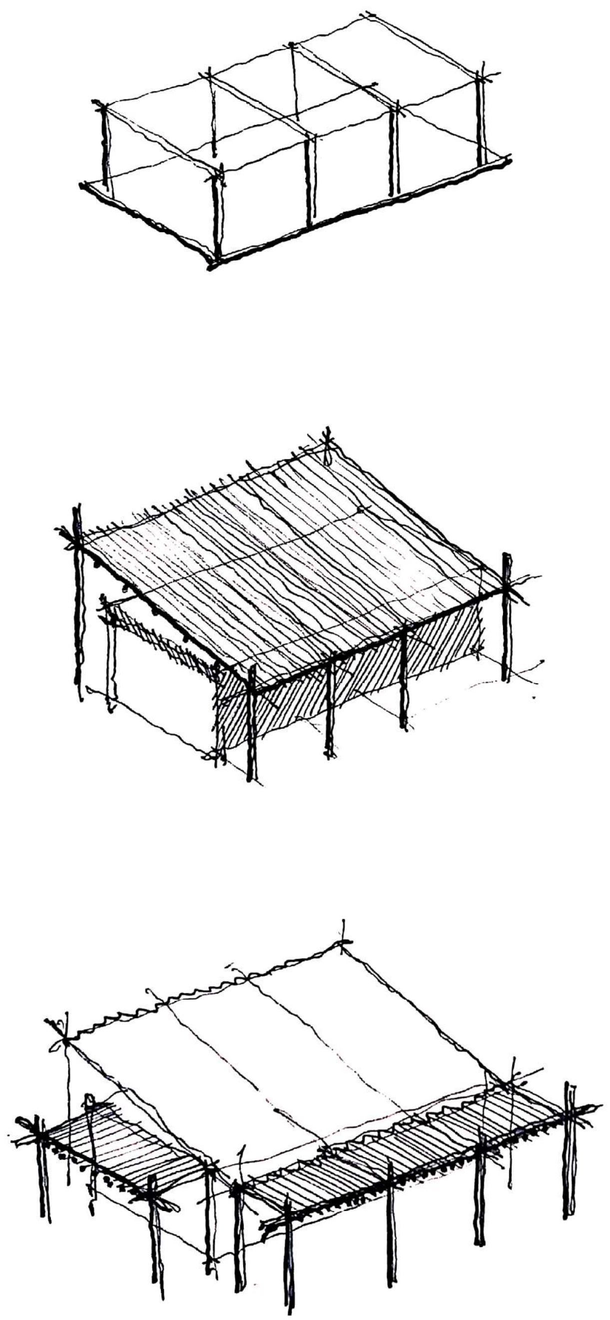


Figure 5.2. Structural adaptability sketch (Author 2021)

Transformative participation

The concept also considers architecture's potential to create an open dialogue of construction knowledge presented through structural articulation. Suppose architecture is communicated with transparency and rationality. In that case, it has a greater potential for the non-expert - or resident in the context of Plastic View - to actively engage with and understand the construction process (Till 2005:4). This knowledge can then be carried forward with the incremental upgrading of existing dwellings and the construction of future dwellings in the settlement. In this sense, architecture becomes an instructive tool for sustainability, safety and crisis mitigation in an environment that otherwise exists outside of regulation standards (Jones 2017:130).

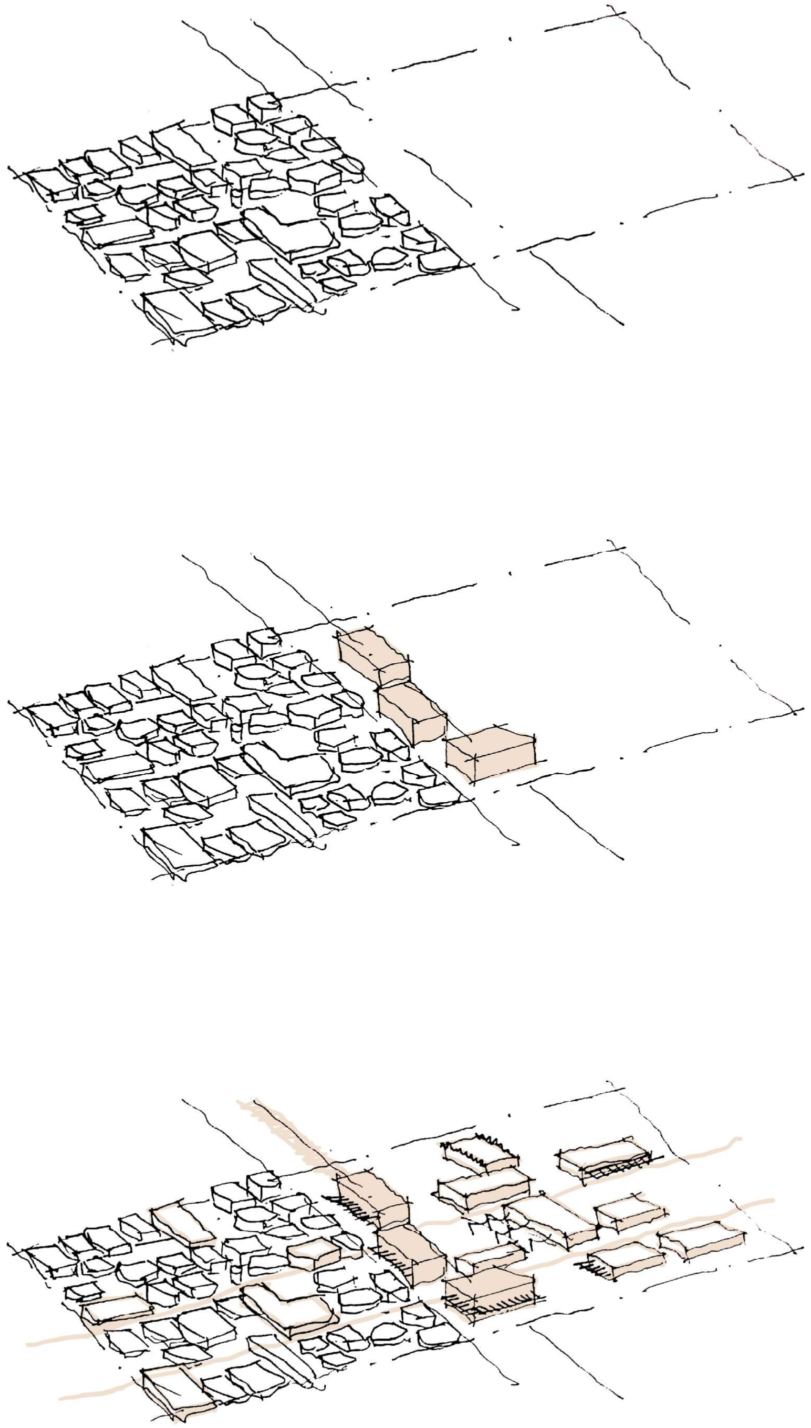


Figure 5.3. Transformative participation sketch (Author 2021)

5.3 TECHNICAL INFORMANTS

As discussed in chapter two, the spatial patterns within Plastic View informed the early design explorations, specifically in the development scale, functional requirements and third spaces. The technical development continues this intention, with a reflection on the tectonic and material patterns within Plastic View that reflect the lifestyle and identity of its community (Dawes & Ostwald 2017:3). The local construction knowledge acts as an informant for the technical language of the intervention. Continuing the layered format of observing the patterns, the layers at smaller scales; thresholds and private spaces, will be discussed. The analysis of construction patterns pertaining to methods and materials are incorporated into these two layers.

Thresholds

The thresholds between the street and the dwelling in Plastic View are calculated articulations of movement between public and private spaces. A large portion of activity and ritual occurs within these thresholds, including cooking, cleaning, trade, and socialising. With many of the dwellings in the settlement having spaza shops facing onto the street, thresholds are coordinated to attract residents to the shops. Overhangs are constructed with eucalyptus pole supports, creating shaded areas along otherwise exposed streets. The same frames are used for fixing signage and hanging goods from, defining the thresholds as points of business and trade. Seating is added, and with it comes social gathering.

Facades become extensions of the thresholds into dwellings, between the semi-private spaces under overhangs and the privacy of homes. Residents have become inventive in creating openings in facades for shops to operate out of, with doors being rotated and fixed in the walls to become bottom hung storefronts. The impermanent nature of the construction methods in Plastic View have allowed continuous adaptation and replacement of facades, and the continuous upgrading of dwellings to brick structures does not disrupt this quality. Brick facades can be highly flexible elements within structures when adaptive planning is made for supporting and distributing loads through various systems.

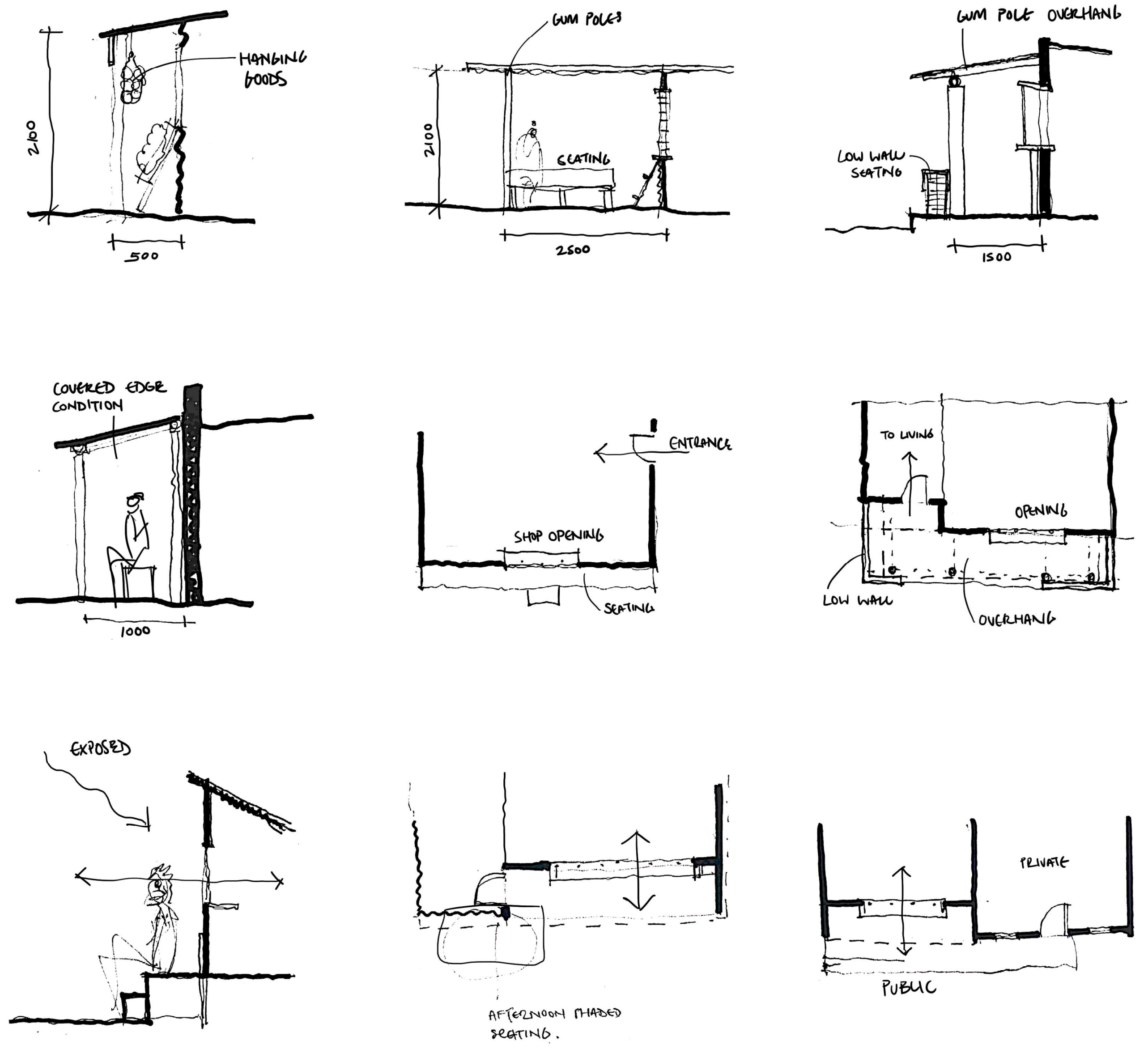


Figure 5.4. Threshold sketches (Author 2021)

As the dwellings in Plastic View are upgraded, the use of IBR and S-rib corrugated roof sheeting becomes more commonplace in the settlement. The versatile material, used with both eucalyptus pole frames and brick structures, is favoured for its durability and availability from hardware stores and second-hand sources such as construction companies. Its presence in the settlement suggests the local knowledge capacity for its installation and maintenance that can translate to its use in the proposed development.

Figure 5.5. Shop opening (Author 2021)

Figure 5.6. Dwelling roof structure (Author 2021)

Private spaces

Internal spaces are further illustrations of the incremental adaptation observed in informal settlements. In this sense, the dwellings should be analysed through the lens of Habraken (1988:12), consisting of supporting frames that are upgraded less frequently and infill partitions and fixtures that are upgraded more regularly as resources become readily available. As mentioned, the flexibility of brick suits the adaptive planning required in informal dwellings, particularly when one anticipates the continuous reorganisation of internal spaces. The conducted interviews (29 March - 31 March) showed that homeowners reconfigure rooms within their dwellings by reconstructing the internal walls. Bedrooms may be converted into shops or storage spaces, or divided into two so that one half can be rented out. The reconfigurations are expressions of the adaptive capacity that must be sustained in the formal structures to suit the changing needs within Plastic View.

Storage spaces are valued features of dwellings within Plastic View, especially with the recent upgrades that are being made. As mentioned in chapter two, residents are unlikely to attain enough construction materials on any one occasion to begin upgrades. Materials are thus collected incrementally and stored behind, within or adjacent to dwellings. As the intention is to allow the adaptation of structures, residents will require storage space for the incremental collection process.

Whilst the residents of Plastic View express a diverse understanding of construction knowledge, financial and infrastructural constraints heavily dictate the construction methods and material choices. The formal nature of the architectural intervention allows the implementation of new or revised construction methods and materials that can encourage alternative desires and an evolved identity (Dawes & Ostwald 2017:5). The technical resolution draws inspiration from the informal architecture, to preserve its qualities of adaptability and contextual suitability, whilst creating formal opportunities otherwise unachievable in the existing development of Plastic View.

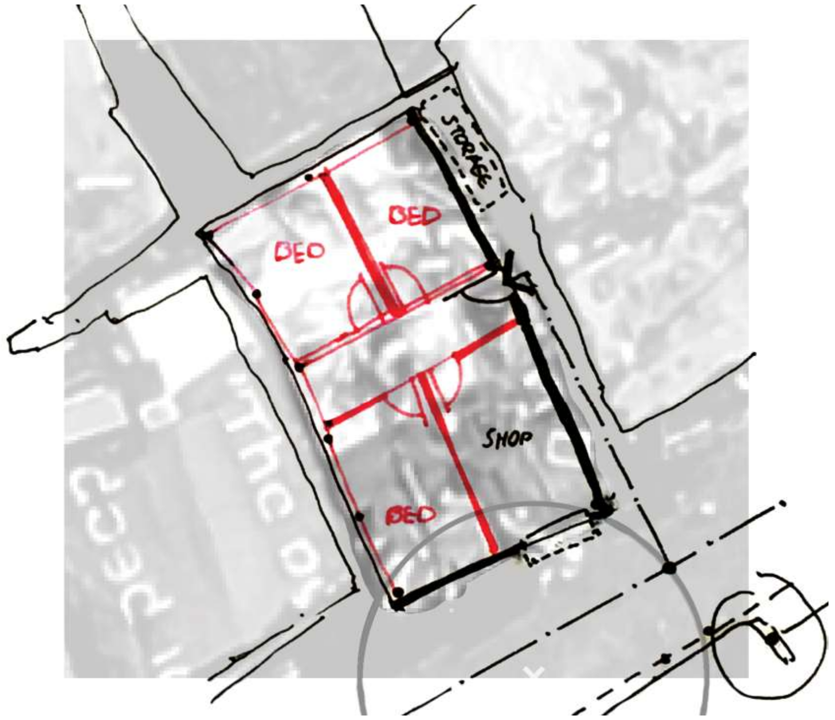


Figure 5.7. Internal spaces plan (MPIP 2021)

Figure 5.8. Material storage space (Author 2021)

5.4
PRECEDENT STUDY

Project: Bitterpan Wilderness Camp
Architect: Crafford & Crafford Architects
Location: Kgalagadi Transfrontier Park
Northern Cape
South Africa
Completion: Not dated

The self-catering lodge accommodation, designed by Crafford & Crafford Architects, is located in the Northern Cape portion of the Kgalagadi Transfrontier Park. The project consists of a series of cabins connected by an elevated walkway overlooking a waterhole (SANParks n.d.). With timber being the dominant material used in the construction of the cabins, a structural pole frame was designed to support the floors, walls and pitched roofs. However, it is the manner in which the pole elements are joined that makes this project notable. The horizontal and vertical elements consistently overlap from the point where they join, as opposed to joining at the ends. Not only does this structurally allow for overhangs of the roofs and balcony extensions, but it also creates an architectural language that celebrates the frame of the cabins rather than, for example, the facade treatment or fenestration. The double pole columns become repeated dominant elements that visually define the architecture whilst still supporting the structure itself.

These design decisions can be beneficial within the context of Plastic View and the scope of the concept regarding transformative participation. As discussed, the intention is to create an open dialogue of construction knowledge in the intervention. The articulation of the structural components in the precedent shows an effective method of establishing this dialogue that, in the context of Plastic View, can guide residents towards continuing with such methods as they upgrade their dwellings.

Figure 5.9. Camp cabins (Fisher 2001)

Figure 5.10. Roof detail (Fisher 2001)

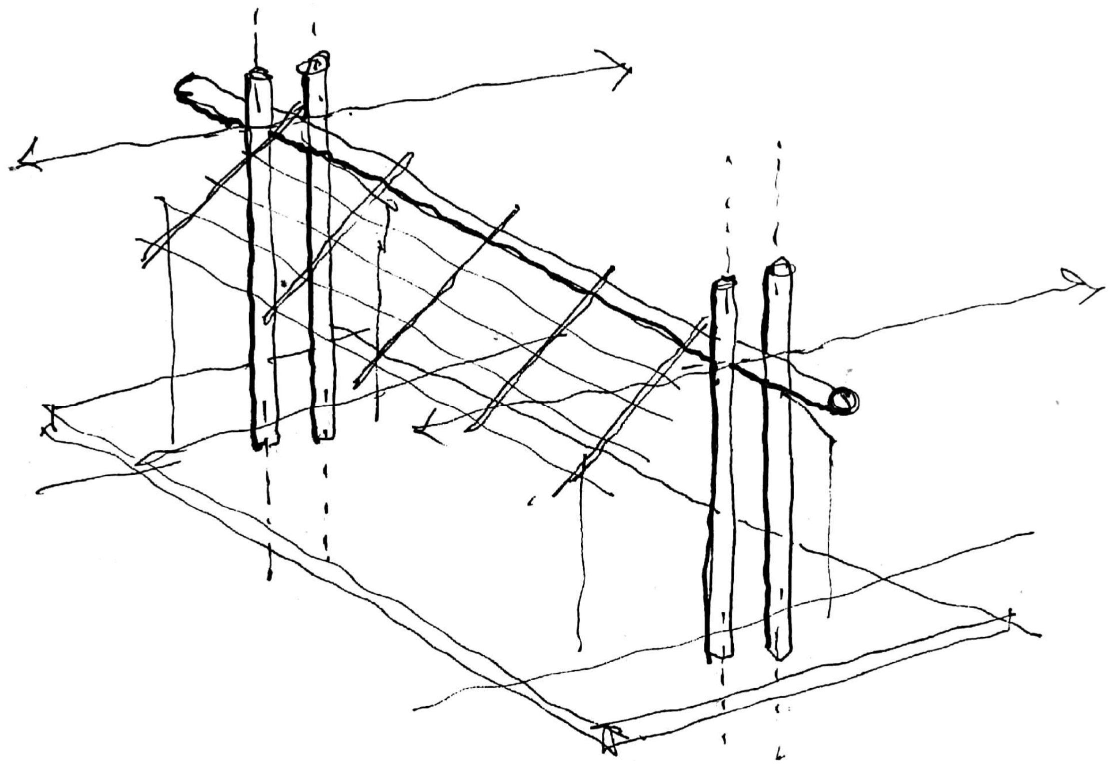


Figure 5.11. Cabin structure sketch (Author 2021)

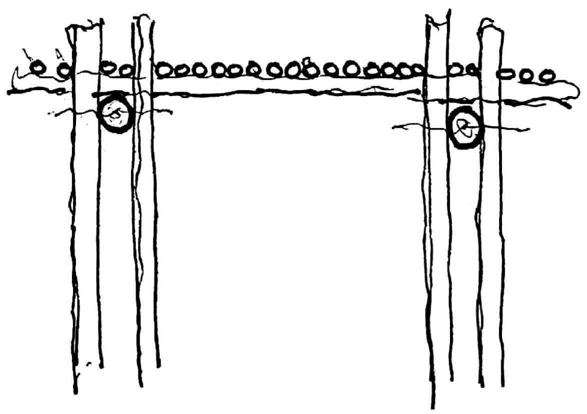


Figure 5.12. Cabin structure sketch (Author 2021)

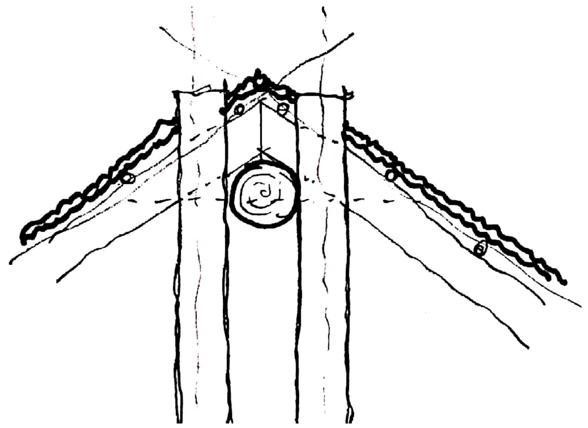


Figure 5.13. Cabin structure sketch (Author 2021)

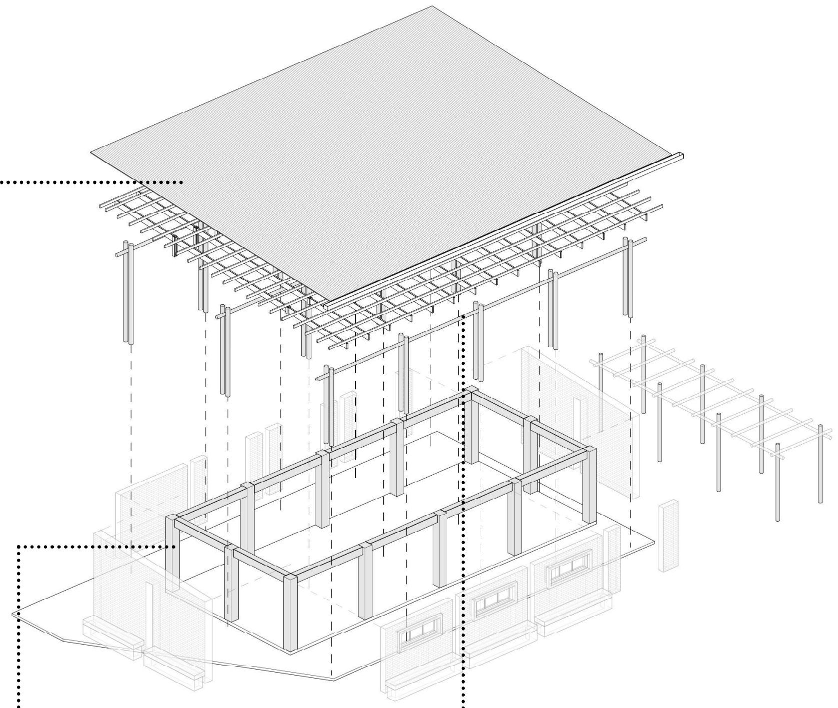
5.5 SYSTEMS

Structure

The structural language consists of three systems that connect and develop from one another but can be interpreted and understood as separate entities. The language stems from an understanding of Kamalipour and Dovey's patterns of increments of change within informal settlements (2020:3).

Primary structure

The primary structure consists of the fixed elements provided through formal intervention by the architect. The load-bearing elements, which make up the frame, include brick masonry columns, precast concrete beams and cast in situ concrete floor slabs. The local construction knowledge and limited water supply informed the choice to limit casting in situ concrete and instead construct brickwork columns and adopt precast beams that can be transported to the site on trucks. Whilst casting is required for raft foundation ground floor slabs, the use of precast rib and block systems for the first-floor slabs reduces the amount of concrete casting required. The roof systems are included in the primary structure, consisting of lightweight corrugated steel sheeting, supported by a combination of SA pine rafters and eucalyptus pole horizontal and vertical members. The eucalyptus poles read visually as being detached from the other load-bearing elements, lending to the dialogue of construction knowledge transferral. The system allows for low-profile pitches and wide overhangs in response to the local climatic conditions.



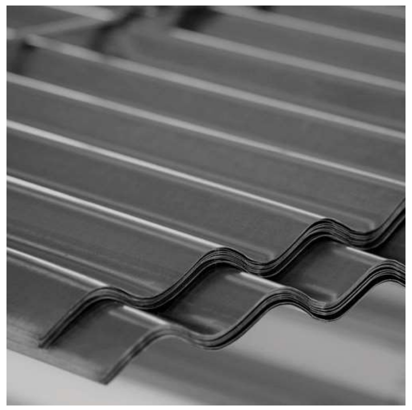


Figure 5.14. (Top) Primary structure axonometric (Author 2021)
Figure 5.15. (Left) Corrugated roof sheeting (Clotan Steel n.d.)
Figure 5.16. (Middle) Old cape blend face brick (Corobrik n.d.)
Figure 5.17. (Right) Eucalyptus poles (The Pole Yard n.d.)

Secondary structure

The secondary structure relates to the informal enclosure of the load-bearing frames (Kamalipour & Dovey 2020:4). It is the initial layer of spatial appropriation in the intervention by means of wall infills. The dissertation proposes that these walls be constructed with the in situ manufactured plastic bricks because, as discussed, bricks can allow a quality of flexibility, replacement and inclusion of various openings. Whilst the secondary structure is designed as part of the dissertation; it is understood that residents may opt for more affordable, less durable materials like timber and plastic sheeting initially. The load-bearing primary structure, however, allows incremental replacement of the impermanent walls to more permanent options suggested in the design.

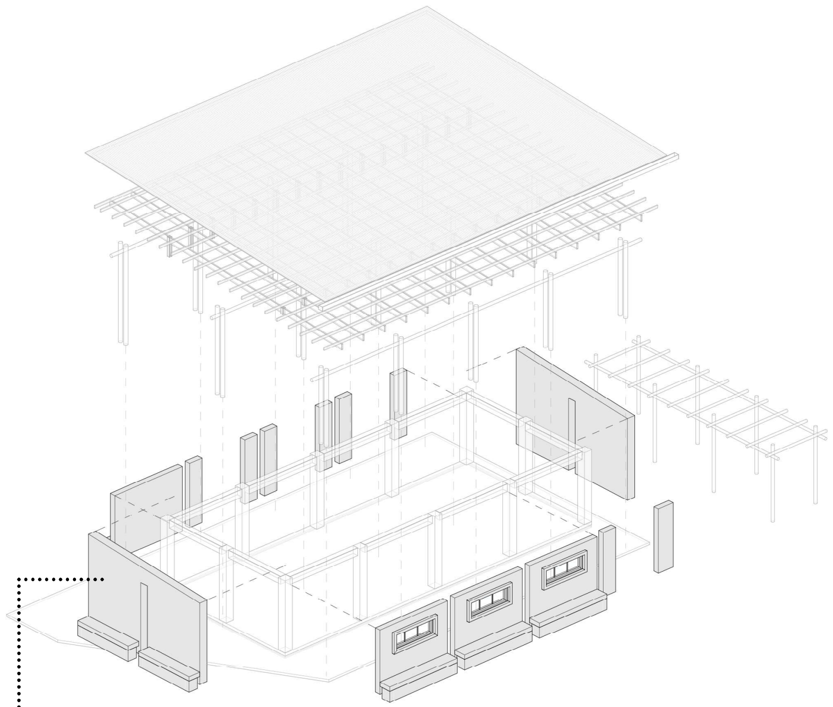


Figure 5.18. Secondary structure axonometric (Author 2021)

Figure 5.19. Plastic bricks (Ramtsilo 2018)

Tertiary structure

The tertiary structure completes the process of place-making that the primary and secondary structures initiate through various processes of attachment and extension. Recognising the favoured use of threshold spaces for social gathering and domestic routines, it consists of elements that enable residents to create shading devices, porch extensions and additional nuanced layers of appropriation in public and semi-public areas. As with the secondary structure, the dissertation presents suggestions and guidelines of how one can appropriate the spaces, whilst acknowledging the creative power is shifted to the hands of the community. The speculations of how these elements may alter and vary over time will thus be presented in conjunction with the design resolution.

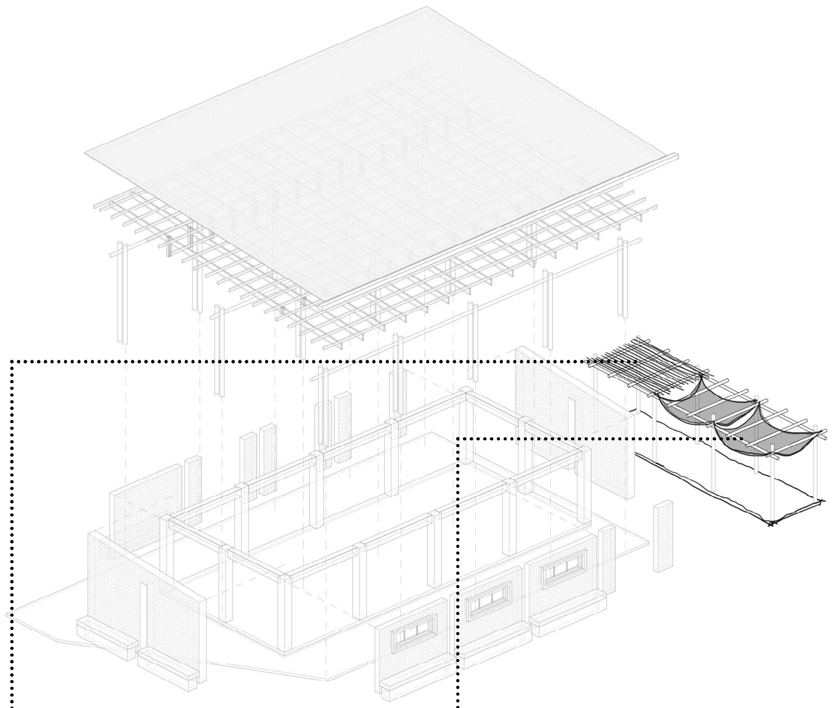


Figure 5.20. Tertiary structure axonometric (Author 2021)
Figure 5.21. (Right) Eucalyptus laths (Northern Poles n.d.)
Figure 5.22. (Left) Shade cloth (Mitre n.d.)

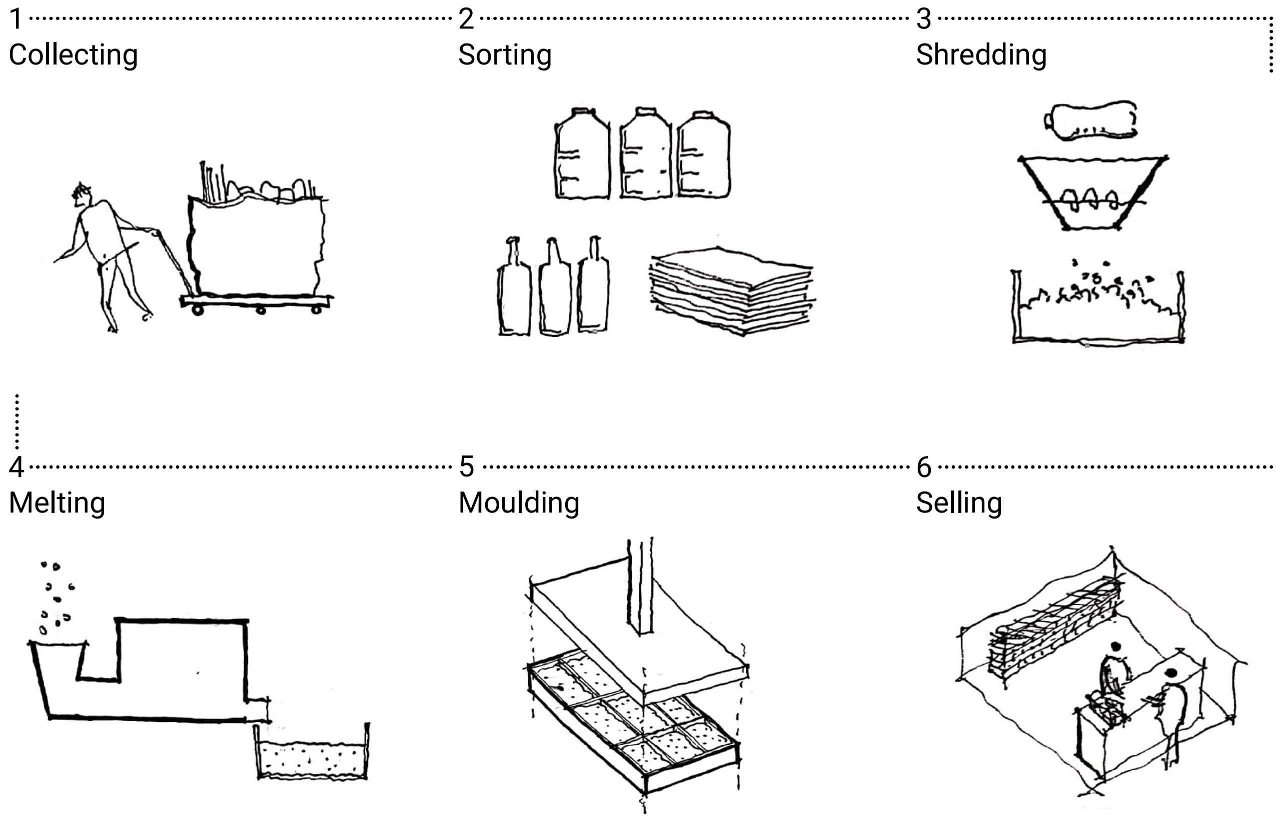


Figure 5.23. Brick manufacturing process (Author 2021)

Brick manufacturing

The process of manufacturing plastic bricks in the factory is considered part of a greater network of waste management within Plastic View. The process relies on the settlement's waste pickers (trolley pushers), who currently collect and sell plastics in bulk to recycling stations, to instead sell the waste directly to the plastic brick factory. According to research conducted by Trask (2013:92), in one week, a single waste picker can collect an average of 299 kilograms of polyethylene terephthalate (PET water and cold drink bottles) and high-density polyethylene (HDPE milk bottles, containers etc.). Considering that the required machinery has a daily output capacity of 800 bricks, which translates to approximately 500 kilograms of Plastic, a network of ten waste pickers can provide enough plastic for a five-day week of brick manufacturing. This process would yield approximately 4000 bricks per week which equates to 16000 bricks per month.

A 6 square metre double skin brick structure, similar in scale to the living units in the design, requires approximately 7400 bricks for construction. This means that the factory alone, as a source for construction materials, can contribute resources towards the infill walls of two living units per month. It must be noted that the plastic brick factory is not intended to replace but rather supplement the existing brick sourcing process in Plastic View, increasing the redundancy, and with it the resilience, of the settlement upgrading operation. Not only is it contributing to the upgrading operation, but also the local informal economy and the mitigation of pollution.

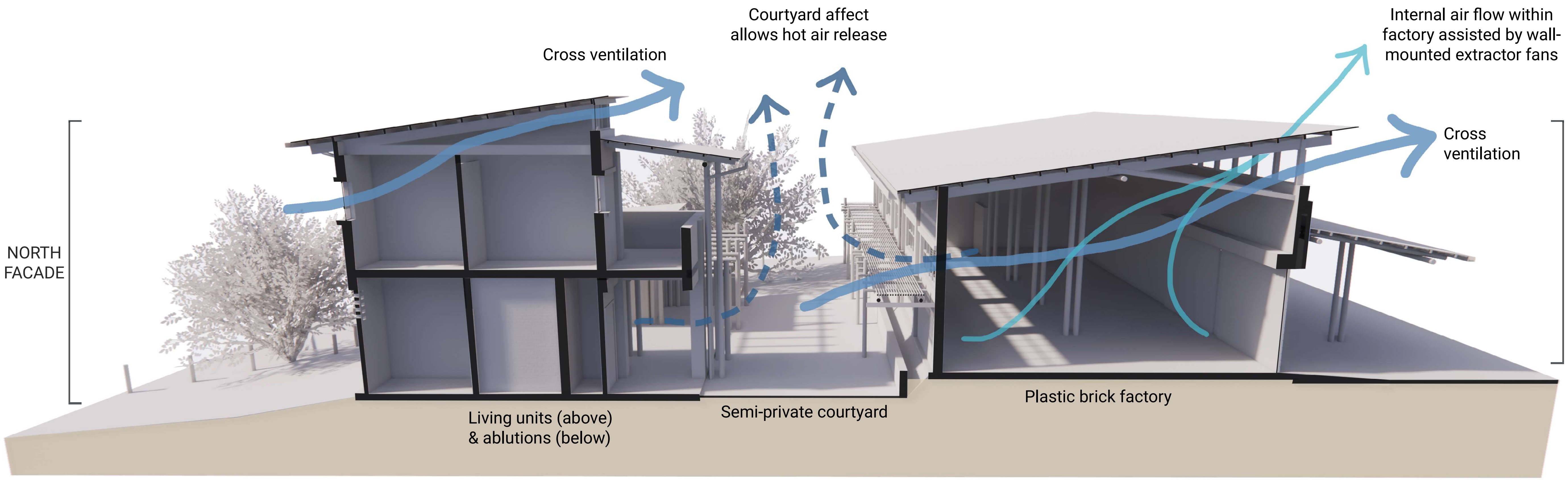


Figure 5.24. Passive solutions section (Author 2021)

Environmental strategies

The technical refinement of the dissertation also responds to the climatic conditions of the context through active and passive environmental strategies, including building orientation, daylighting, and natural ventilation. As it stands in Pretoria, Plastic View falls under climatic zone 2 as a temperate interior climate (SANS 204 2011:30), with hot to very hot summers and mild to cool winters (Muller 2013:105).

Daylighting

Designing for optimal daylighting is imperative in reducing the need for electrical lighting, limiting glare and maintaining a desirable heat gain (Muller 2013:109). To do so, the proposed design maximises north-facing walls and glazing with it whilst minimising east and west glazing (Muller 2013:105). This was possible in the case of all structures barring those that faced directly onto the existing street, in which alternate strategies were implemented. Shading elements were designed for north-facing windows, either through the overhangs of the roofs above or with additional brise soleil devices where overhangs were not sufficient.

Passive ventilation

Cooling strategies are integrated into the design by means of passive ventilation through structures. The pitched roofs common throughout the design allow for optimised cross ventilation through lower openings allowing natural airflow in and clerestory openings allowing airflow out again. In the waste management hub, the courtyard around which the structures are positioned allows hot air to move from interior spaces out to the courtyard, where it can escape upwards. In the plastic brick factory, wall-mounted extractor fans are fitted to assist in removing hot air, dust and residual fumes from the manufacturing process. The more exposed live/work units along the high street have vegetation planted along its north-eastern facades to shield them from the harsh morning sun and cool the air as it passes through.

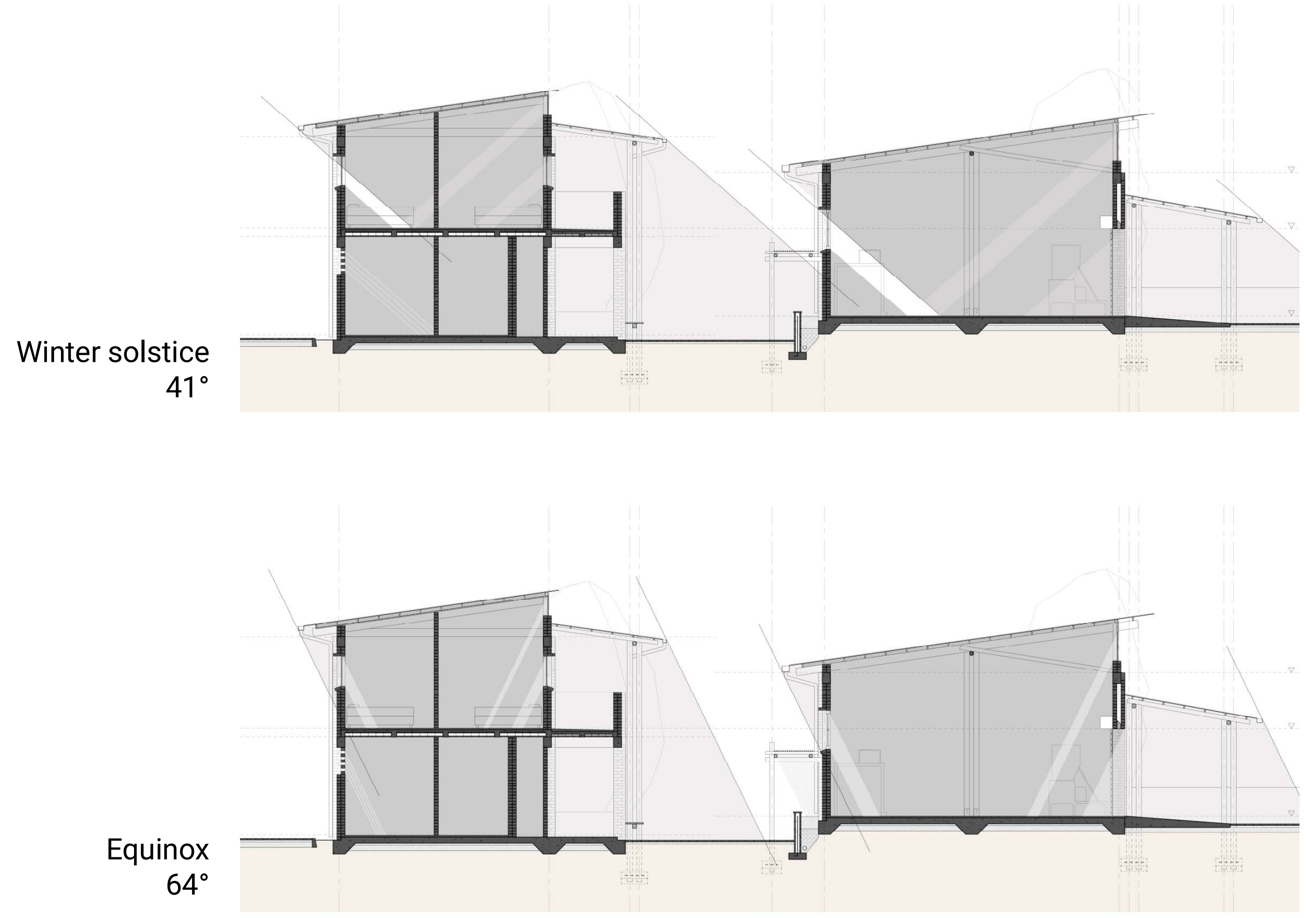


Figure 5.25. Sun angle sections (Author 2021)

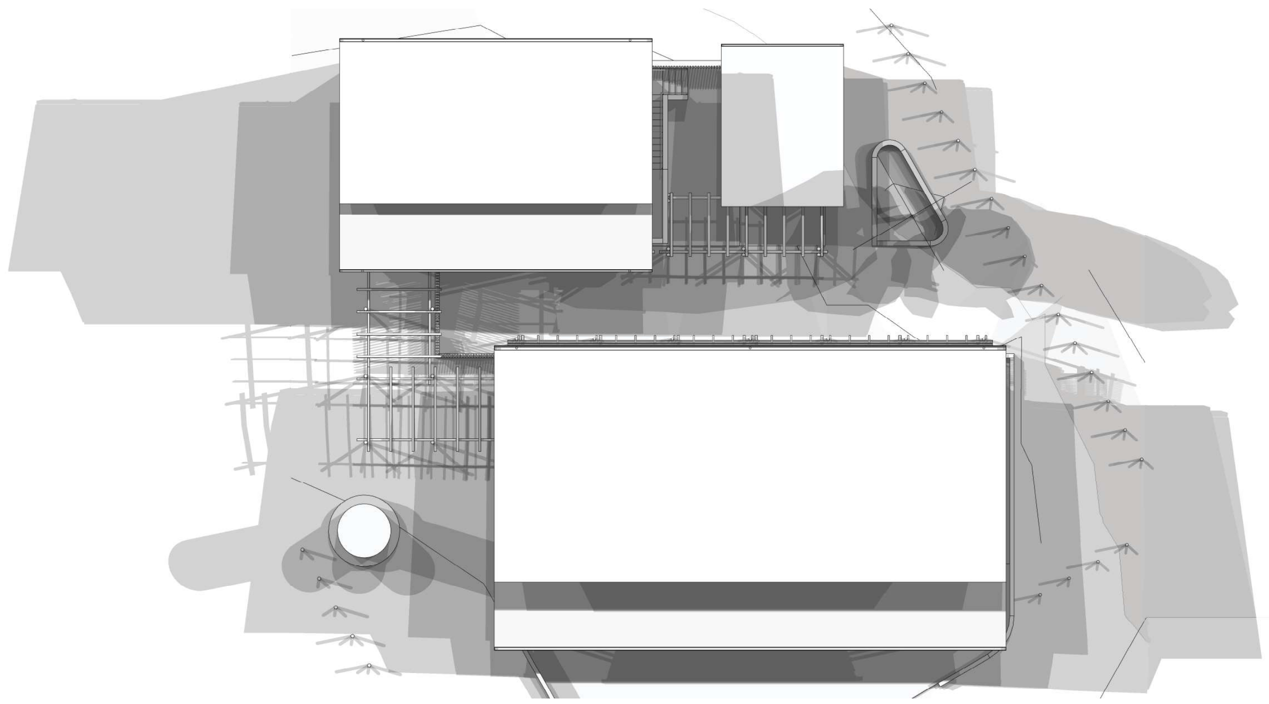


Figure 5.26. Equinox shadow study (Author 2021)

Water harvesting

The system begins with stormwater being collected on-site from roof structures and surface runoff, and greywater being collected from the living units and public ablutions. Both types of water travel via precast concrete channels and vegetated swales along the longitudinal boundaries to a preliminary storage sump. The collected water is then passed through a water treatment process of coagulation, sedimentation, filtration and ultraviolet disinfection that ultimately removes sand, bacteria, viruses, oils, metals and other debris (CDC 2015). Using a solar pump, the treated, potable water is transported to a storage tank at a higher position on site adjacent to the plastic brick factory, where it can be reused in the living units and public ablutions. The water harvesting strategy is intended to supplement the existing, limited water supply provided by the municipality.

Solar energy

Portable photovoltaic panels are currently used in Plastic View by residents to power music devices, cell phones and occasionally artificial lights; however, a lack of municipal service provision means electrical energy is limited across the settlement. The intervention proposes that solar energy is harnessed on-site through two separate systems to generate both electrical energy and heat energy. The first system consists of photovoltaic panels fixed to north-facing roofs (and north-east facing for the live/work units) that generate electrical energy for lighting, household inverters and machinery in the factory. The second system consists of solar water heaters fixed to the roofs of the live/work units and first-floor living units above the factory ablutions and the market lock-up units. These systems provide heating capacity for the geyser-stored water used in homes and the showers in the factory ablutions.

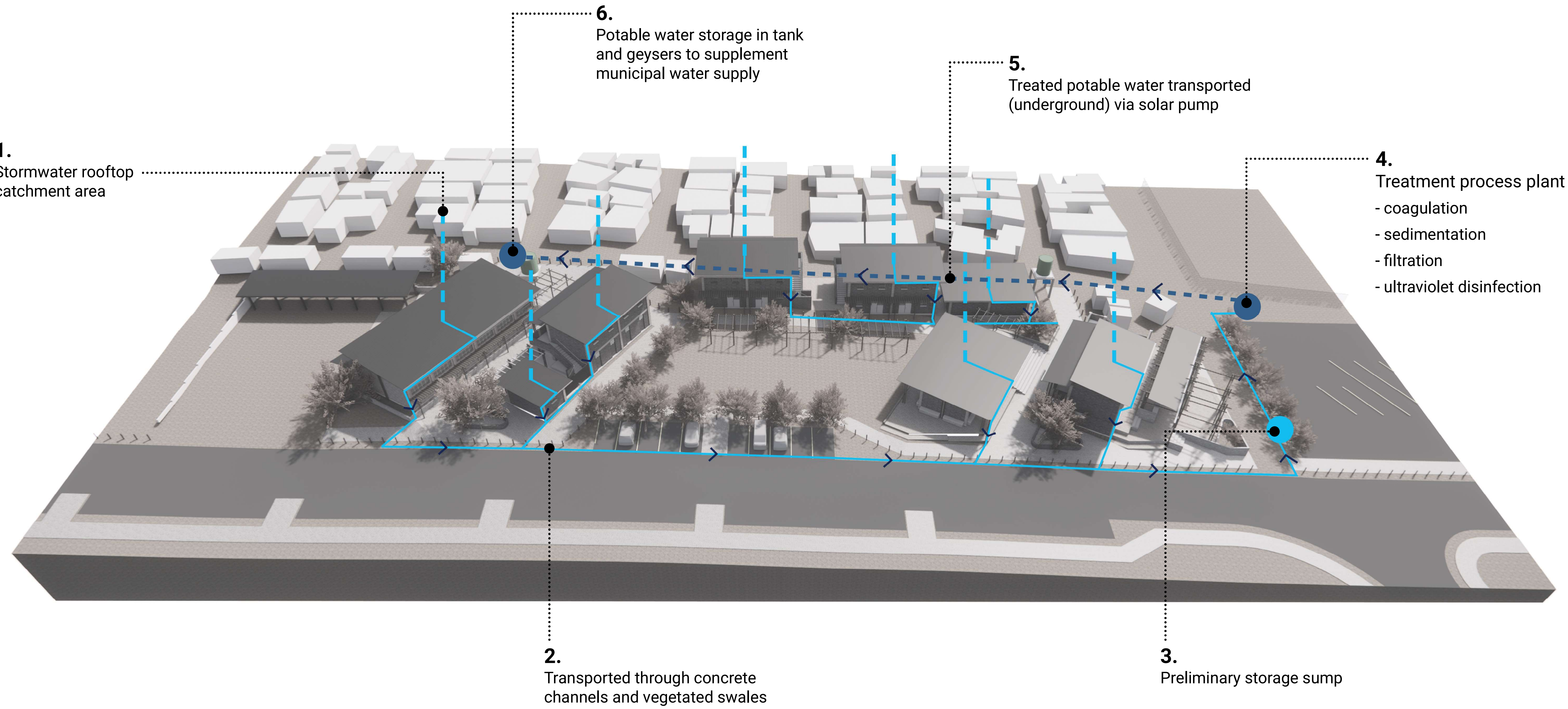


Figure 5.27. Water harvesting system (Author 2021)