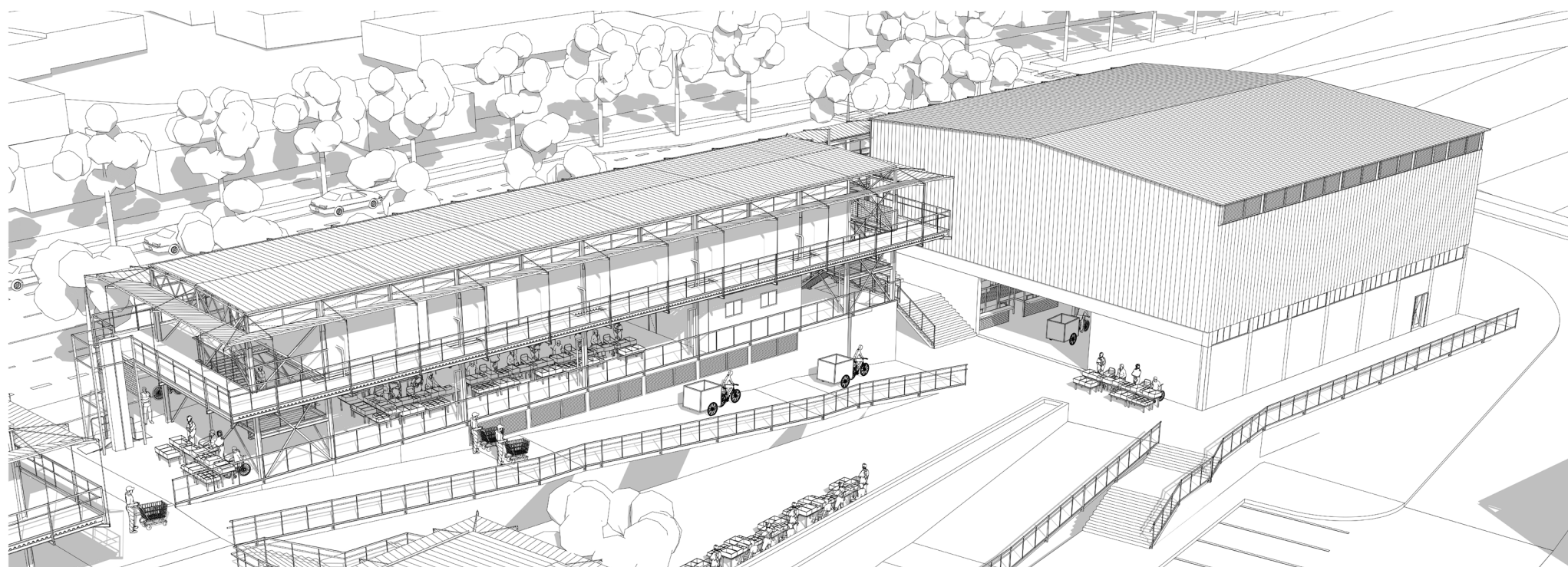


INTEGRATED SOLID WASTE MANAGEMENT:
TOWARDS STRENGTHENING HAVANA TOWNSHIP LIVELIHOODS BY THE VALORISATION OF WASTE.

By

Gerrit Coenraad Herhold van Schouwenburg



Submitted in partial fulfilment of the requirements for the degree

Master of Architecture

in the

Department of Architecture and Spatial Planning

Namibia University of Science and Technology

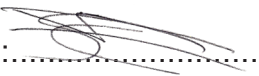
Supervisor: Prof Jaco Wasserfall

Co-Supervisor: Dr Madelein Stoffberg

Co-Supervisor: Dr Phillip Lühl

Declaration

I, Gerrit Coenraad Herholdt van Schouwenburg hereby declare that the work contained in the mini-thesis, entitled “Integrated solid waste management: Towards Strengthening Havana township livelihoods by the valorisation of waste” is my own original work and that I have not previously in its entirety or in part submitted it at any university or other higher education institution for the award of a degree.

Signature: 

Date: 23 June 2022

Acknowledgement

Getting through the Master of Architecture Programme and writing a thesis has been a challenging journey. I would like to thank everyone who assisted me with this endeavour; Dr Phillip Lühl, Dr Madelein Stoffberg and Professor Jaco Wasserfall, for providing me with assistance, encouragement, and critical engagement with my research topic over the past two years.

I would like to thank my family for providing me with financial and emotional support. I thank Stephanie Teichmann and Anita Brandt for assisting me with grammar and punctuation, thereby helping me communicate my ideas with greater clarity.

All Figures are by the author unless otherwise indicated.

Contents

Abstract	1
1. Introduction	3
1.1 Structure of the document.	3
1.2 Background to the northern periphery of Windhoek.	5
1.3 Literature Review	7
1.4 Objectives of the study	11
1.5 Research design	12
2. Mapping the socio-economic context of Windhoek	15
2.1 Urban population density and average income	15
2.2 Mode of transport versus income demographics	17
3. Spatial analysis of commodity flows and points of interest	21
3.1 Monte Christo 4-way market	21
3.2 Stop N Shop Wholesale	25
3.3 Contaminated sites along Monte Christo corridor	29
4. Recyclable commodity flows between formal and informal actors in Windhoek	33
4.1 Informal waste pickers in Windhoek.	33
4.2 C + J Recyclers Namibia	37
4.3 Rent-A-Drum	39
5. Problem statement, project brief, programme and precedent study	43
5.1 Problem statement	43
5.2 Project brief: Integration of formal and informal waste management	44
5.3 Programme	45
5.4 Precedent study “Centre Pompidou”	47
6. Working with the site context	53

7. Concept development massing and finding form	57
7.1 Concept development finding form	57
7.2 Design development phases 1-3	65
8. Final Design Drawings	68
8.1 Ground Floor	68
8.2 Lower Floor	70
8.3 First Floor	72
8.4 Long Section B	74
8.5 Cross Section C	76
8.6 Cross Section D	78
9. Perspectives	80
10. Technical documentation	92
10.1 Detailed view of structural system	92
10.2 Detail 1	93
10.3 Colour renderings	96
11. Conclusion	104
12. References APA 7 th edition	106
13. List of Figures	108
14. Appendix A: Interview with Rent-A-Drum	112

The purpose of this mini-thesis was to develop an architectural solution to address the prevailing waste crisis and related socio-economic activities within the northern periphery of the City of Windhoek. To understand the circulation of people and waste within these areas, the author interviewed various actors involved in the recycling process. The actors ranged from informal waste pickers to formal large-scale commercial operations. The author found that informal and formal actors within the waste management cycle are linked together, even if their operations seem to be completely separate and in isolation. Thus, an architectural solution is proposed to strengthen spatial agency between the existing socio-economic practices and informal actors found within this context, in conjunction with the formal actors providing economies of scale, knowledge, and market access. The project concept is based on 'mutualism', a natural process found in nature where several animal species collaborate to continue their existence.

The design suggests a community-based development initiative where solid waste collection is incentivised, transported by waste bicycle carts and trolleys to a collection and processing point where the private solid waste management company (Rent-A-Drum) sorts, and separates recyclable commodities on an industrial scale.

The waste management cycle is designed with consideration for the socio-economic context of the northern periphery of the city by providing market spaces for informal trade along prominent movement corridors.

1. Introduction

1.1 Structure of the document

The first chapter of the document discusses the background of the northern periphery of the City of Windhoek, focusing on urban population density, waste management and economic trade. This is followed by a literature review about the relationship between formal and informal waste management within the context of the Global South, as well as socio-economic policies that strengthen the township's micro-economic activity. The chapter concludes with the project's main objectives and research design methodology.

The second chapter focuses on mapping the socio-economic context of Windhoek, based on the Sustainable Urban Transport Master Plan (SUTMP). Urban population density, average monthly income and urban zoning is covered in the mapping exercise as well as modes of transportation in relation to income demographics.

The third chapter reviews spatial analysis of commodity flows and points of interest within the northern periphery, focusing on the Monte Christo 4-way market and Stop N Shop wholesale area. Contaminated waste sites are also mapped along the Monte Christo corridor.

The fourth chapter focuses on recyclable commodity flows between formal and informal actors in Windhoek, covering informal waste pickers, C+J Recyclers Namibia, and Rent-A-Drum.

The fifth chapter covers the paper's problem statement, project brief, programme and precedent study.

The sixth chapter highlights the site context and highlights prominent roads and important points of interest.

The remaining chapters conclude with concept development, final design, technical documentation and conclusion.

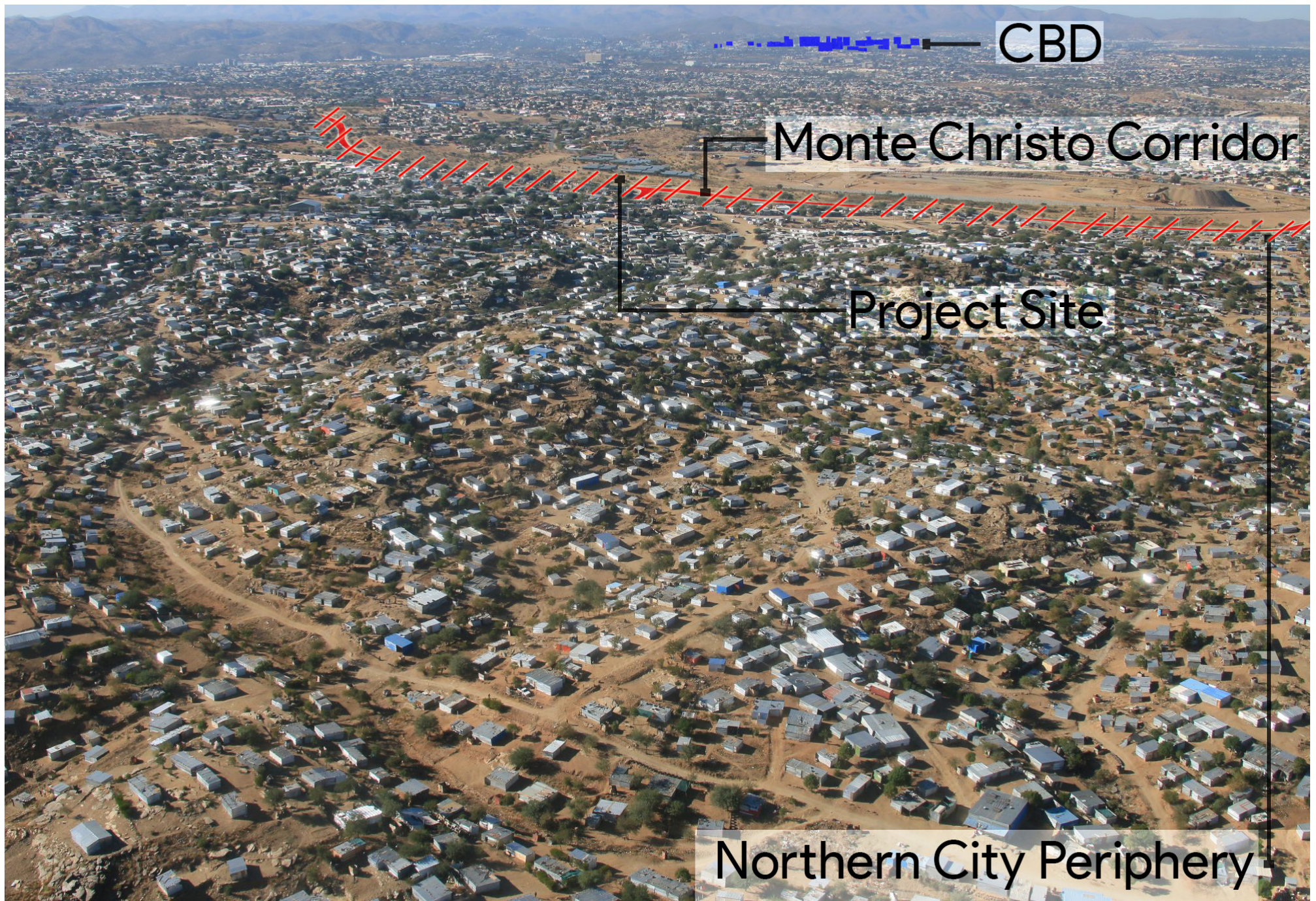


Figure 1 Northern city periphery

1.2 Background to the northern periphery of Windhoek

The northern periphery of the City of Windhoek is faced with a consistent influx of migrants that seek better living conditions and economic opportunities. Informal fringes are not well connected to basic municipal services, leaving residents with limited access to basic amenities. In the past under Apartheid Windhoek's townships, such as Katutura and Khomasdal, were effectively served in terms of solid waste management. After independence rapid urban sprawl commenced due to the collapse of Apartheid's strict control of urban movement and accommodation within the capital city. New townships such as Havana and Hakahana have a mixture of formal and informal settlers, with divergent living conditions based on their economic standards of living.

Due to high population density, service delivery is a significant challenge (Karuaihe & Wandschneider, 2018). According to Schioldborg (2014), the continuous increase in migration has led to urban sprawl. It is estimated that 600 new migrants settle in informal

settlements every month, placing pressure on the municipality's capacity to effectively manage solid waste (Schioldborg, 2014). The municipality is constantly documenting and registering new settlers in townships as well as combating undocumented land occupation within them. There have been numerous efforts by the government to provide basic services and urban infrastructure. However, their existing method of service delivery remains non-responsive to the socio-economic realities in terms of solid waste management. According to Simatele, Dlamin and Kubanza (2017), Limited capacity to deliver effective waste disposal results in the emergence of informal waste management practices such as the burning of waste and waste picking.

Informal settlements are often poorly connected to road services, resulting in a lack of access to basic services. The absence of paved roads and waste bins makes formal waste collection difficult for municipal trucks. Another important aspect to consider is

that informal waste collection is not economically incentivised by municipalities; informal waste collectors are socially frowned upon and discriminated against (Simatele et al., 2017).

Within townships, small business enterprises focus primarily on circulating consumer goods or the provision of basic services. These enterprises are usually survivalist and focus on necessity rather than an economic opportunity (Charman, et al., 2017). The viability of value-added activities is also affected by access to appropriate consumer markets and unfair competition from well-established formal businesses. Informal traders are a vulnerable population group, as their environmental conditions are poor due to limited or no access to basic services.

According to Wilson, Velis and Cheeseman (2006), recycling programmes that focus on purifying waste streams (known as source separation) is the value-added activity that supports informal micro-economics by improving efficiencies and reducing mechanical

separation. It has been proven that pickers earn more than the minimum wage in Sub-Saharan African countries (Wilson et al., 2006).

Waste picking contributes to existing formal systems and improves their efficiencies. The social and economic well-being of residents within the informal periphery and poor solid waste management is linked in terms of community health and self-worth of the residents.

1.3 Literature Review

The review focuses on the relationships between formal and informal waste management systems within the Global South, as well as on socio-economic policies that strengthen township micro-economic activities in relation to waste management.

The existence of informal waste picking is brought about by a series of spatial, socio-economic and environmental conditions, such as rapid urban migration, limited employment opportunities, stunted development and growth of the labour sector and poor municipal service delivery. Informal waste pickers are often marginalised and homeless. In South Africa Street pickers gather waste throughout the urban fabric (Simatele, Dlamini, & Kubanza, 2017). They source raw materials from mixed waste sources, such as marketplaces, garbage bins and waste collection points. Street pickers work long hours, on average 10 hours a day, and they traverse approximately 10-15 km daily. Those who cannot afford or have access to shopping carts use large sacks to gather recyclable materials. To complicate matters, waste pickers often face discrimination from the public, and are brutalised by the police (Simatele et al., 2017).

Itinerant Waste Buyers (IWB) collect waste from houses, various industrial buildings, and commercial centres (see Fig. 2). They collect, trade, and buy recyclable materials in bulk. Materials include items such as mattresses, furniture, metals, plastics, and paper. They often operate as individuals which means that their operations

are labour-intensive. They utilise specialised trolleys and modified bicycles to transport recyclable materials. Their operations require finances for equipment. The number of IWBs is increasing due to companies and wholesalers recognising the value of selling waste to them. It also provides a green image for companies (Ezeah, Fazakerley, & Roberts, 2013).

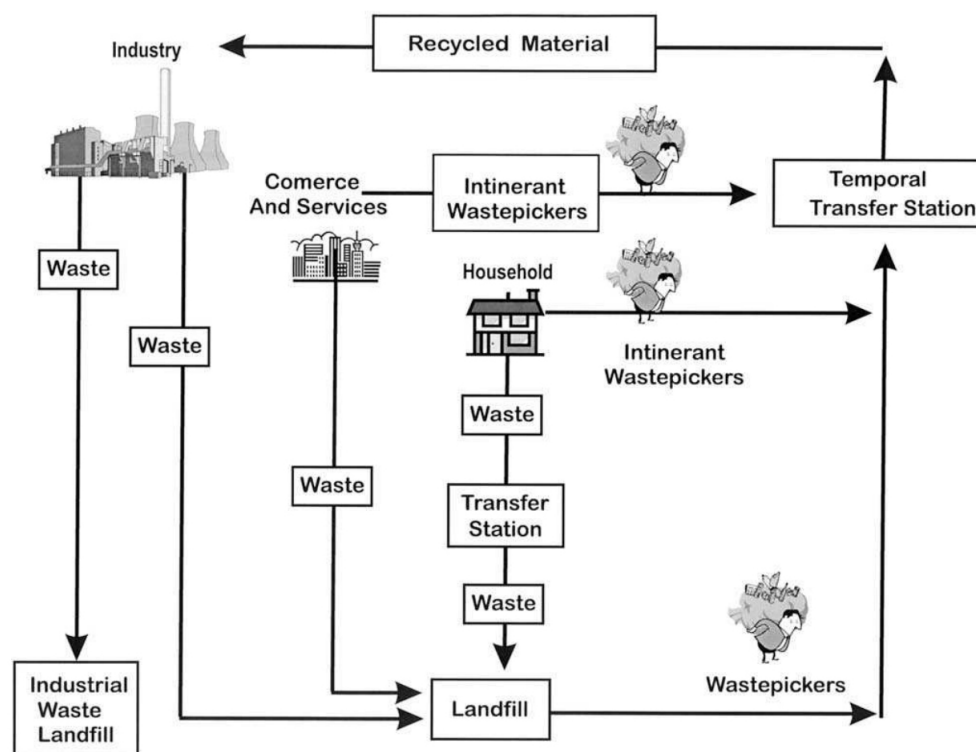


Figure 2 Waste management cycle illustrating waste picker relationship with households, industry and transfer station. Source: Ojeda-Benites et al (2008).

Decentralised waste management known as Tampouré, has been a practice for generations by Burkina Faso citizens. Organic waste is left to dry in front of houses during the dry season. It is used as a mulch layer that provides nutrients to crops during the rainy season. Since 2001, the Burkina Faso urban population increased dramatically, resulting in the need for increased waste management practices and food production. Drawing inspiration from the traditional waste management practice of Tampouré, the government started the “manure pit operation”. Since 2005, the intervention has encouraged residents to manage compost on their own plots. The government has procured funds for residents to assist them with their waste management practices (Kaza, Yao, Bhada-Tata, & Van Woerden, 2018).

According to a study by the World Bank in 2016 up to 40% of all organic waste produced by the city is recycled by residents (Kaza, et al., 2018). Compared to other African cities, the percentage of locally produced fertilizer is exceptionally high. As a result, “Burkina

Faso’s decentralised waste management system has significantly reduced the burden on the formal waste collection and disposal infrastructure” (Kaza, et al., 2018, pg. 152).

The government’s intervention drew inspiration from traditional practices, as the mindset of organic waste management was already pre-existing as a cultural aspect among Burkina Faso residents and was simply strengthened and further encouraged through government incentives. Drawing inspiration from existing waste management practices has resulted in a lasting intervention. Burkina Faso is a good example of a bottom-up design approach. It has been demonstrated that the community-based waste management practices have reduced the cost of the formal waste management system significantly, as well as contributing to food security by providing fertilizer to local farmers.

Ezeah, et al., (2013) reviewed a study done by Gesellschaft für Technische Zusammenarbeit GmbH (GTZ) titled “Role of the Informal Sector in Solid Waste Management and Enabling Conditions for its

Integration” (Gunsilius, 2021). The study modelled and measured economic costs and opportunities of two related sub-sectors: the informal waste management networks, and the formal waste management divisions within cities. The informal waste management sector was based on the following operations: firstly, to be a service provider for the disposal and collection of waste, and secondly the extraction of valuable recyclable materials that can be sold for a price in kilograms.

The GTZ research team measured the economic impact of two different scenarios. The first scenario focused on a situation where informal waste management networks and operations are severely restricted or eliminated (subtractive scenario). The second scenario focused on the formal waste management systems of a city, engaging with informal waste management networks, encouraging interactivity and collaboration (additive scenario). The study was based in

several cities within the Global South: Cairo (Egypt), Quezon City (Philippines), Lima (Peru), Lusaka (Zambia), Pune (India) and Cluj Napoca (Romania) (Ezeah, et al., 2013).

The study found that the additive scenario improved the revenue generated by informal waste management and reduced the operation cost of municipal solid waste disposal within specific cities. In Lima, the additive scenario resulted in a cost reduction for the city’s formal solid waste management sector. The additive scenario also improved the monetary gain for informal waste management actors within the cities Cairo, Cluj and Quezon. In contrast, the operational cost of Lusaka’s municipality increased slightly with the additive scenario, as compared to the subtractive scenario. In the case of the city Pune, the subtractive scenario significantly increased the operational cost resulting in low efficiency (Ezeah, et al., 2013).

These findings reveal that the collaboration between formal and informal actors generally increased the income of the informal waste management actors; and reduced the operation cost of

formal within the solid waste management divisions. The study provides hard empirical data to encourage the design of integrated systems between formal and informal actors within a city's waste management cycle. Bottom-up approaches are slower to implement and manage due to its dependency on community collaboration and are thus slower to be implemented as compared to top-down approaches. To effectively implement solid waste management systems, a balance between top-down and bottom-up approaches is therefore preferable (Ndum, 2013).

The architectural profession is mostly associated with top-down thinking. As a student I think it is more important to strike a balance between formal and informal spatial planning systems. An effective approach to solid waste management in informal settlements should therefore also preferably be community-based. This approach focusses on the moral responsibility that individuals have towards their environment, by encouraging effective disposal and management of waste. Residents' engagement is overseen by community leaders

and active change agents. Community-based waste management also focuses on socio-economic incentives providing much needed employment and lucrative economic opportunities. For community-based waste management to remain effective it needs to become part of a continuous social culture, otherwise it falters and collapses (Ndum, 2013).

1.4 Objectives of the study

The primary aim of the research is to design an architectural intervention that integrates formal and informal waste management systems within an urban context. The integrated waste management system also needs to facilitate existing micro-economic practices and should propose new possibilities for value-added activities through policy and adequate design typologies.

To achieve this requires an understanding of the relationship between micro-economic systems within informal markets in Havana, Windhoek and an investigation of how they can be integrated with formal waste management systems to create positive feedback loops to strengthen livelihoods. Based on an understanding of the Havana context and of the Global South, case studies of integrated waste management practices and design interventions between formal and informal systems were reviewed (see literature review, pg. 7).

1.5 Research design

To arrive at an architectural intervention, the research is based on understanding of the socio-economic context of the northern periphery as well as the actors involved with solid waste management. The research is structured in five different components.

The first research component was to understand the socio-economic context of the city with an emphasis on the northern periphery. A mapping exercise was conducted to understand the urban density and income demographics, and modes of transportation.

The second research component focused on mapping the socio-economic context of the northern periphery with an emphasis on specific sites of interest along the Monte Christo corridor. The mapping exercise focused on spatial relationships between different modular growth and development of informal marketplaces.

The third research component focuses on mapping the current waste management crisis within the northern periphery.

The fourth research component focused on actors involved within the waste management cycle. Emphasis was placed on actors involved within the recycling industry and how they operate. Formal and informal actors were interviewed. A photographic analysis was conducted as well as interviews with formal and informal actors associated with waste management.

The fifth research component focused on a precedent study to derive architectural form.

Data collection primarily focused on qualitative data and secondary quantitative data. Qualitative data focused on actors involved in waste management and the current challenges. The sampling strategy was purposive sampling and targeted residents of Havana township (informal waste picker/residents). This was followed by convenience sampling that targeted professionals overseeing waste management within Windhoek (Rent-A-Drum).

Data was collected through mapping, case studies, photographic analyses, interviews and precedents.

Data collected respected relevant laws of government and institutional bodies. Questions in interviews focused on socio-economic aspects of township economies and waste generation within informal settlements and its effects on the urban landscape and neighbourhoods. Data collected was evaluated from a non-biased perspective. Interviews were only conducted with participants' consent. If the interviewee wished to withdraw his or her contribution, data was redacted before the final publication of the research document. Data collected from individuals was considered confidential and private if the information was sensitive. The author also made full use of ethics resources concerned with data collection.

Interviews with residents were limited to neighbourhoods along Monte Christo corridor within the northern periphery. Desktop data collected focused on the Global South with emphasis on socio-economics and solid waste management between formal and informal systems.

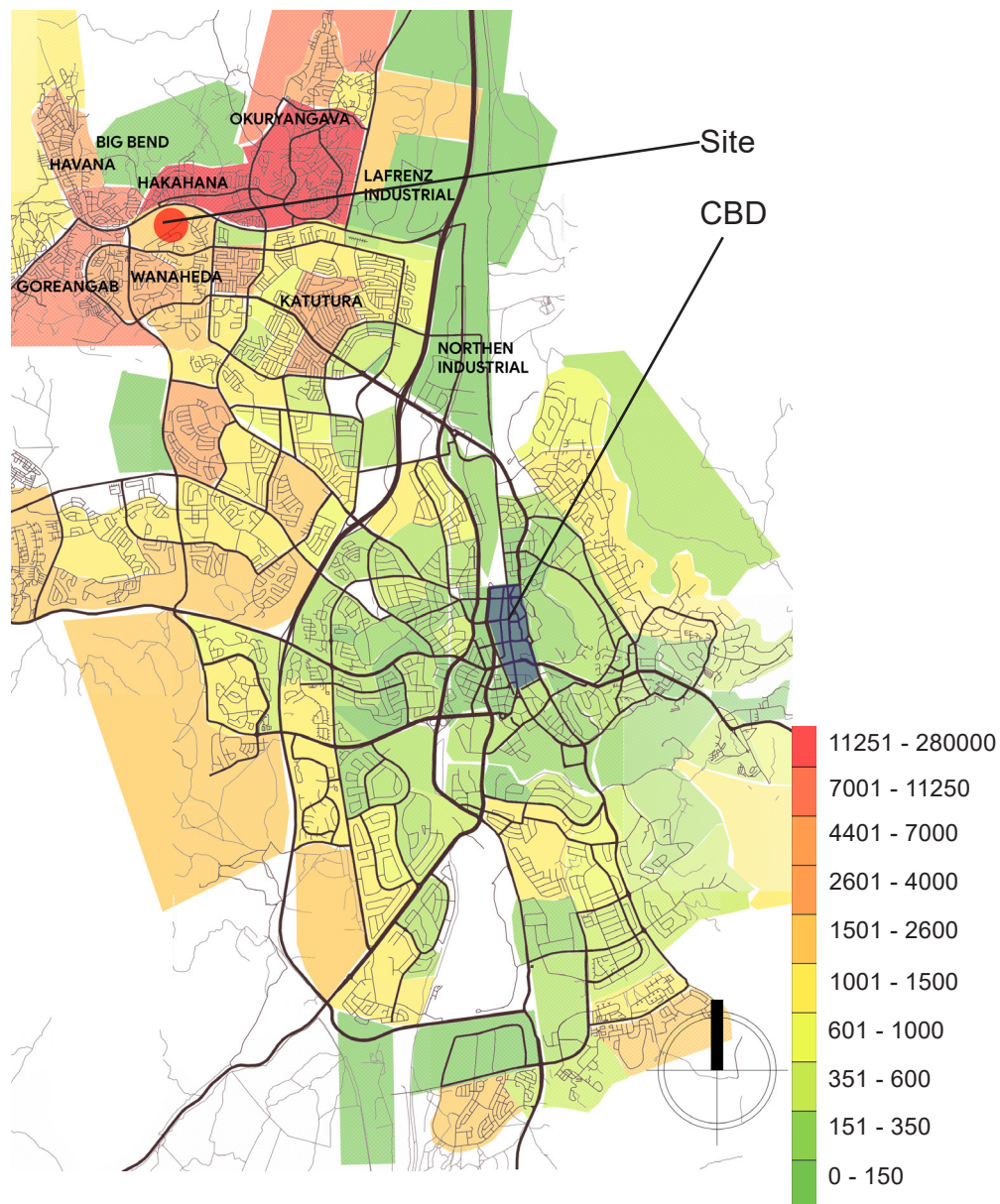


Figure 3 Urban population density, residents per hectare (Redrawn by author based on SUTMP report map pg. 27). Source: Heidersbach & Strompen (2022).

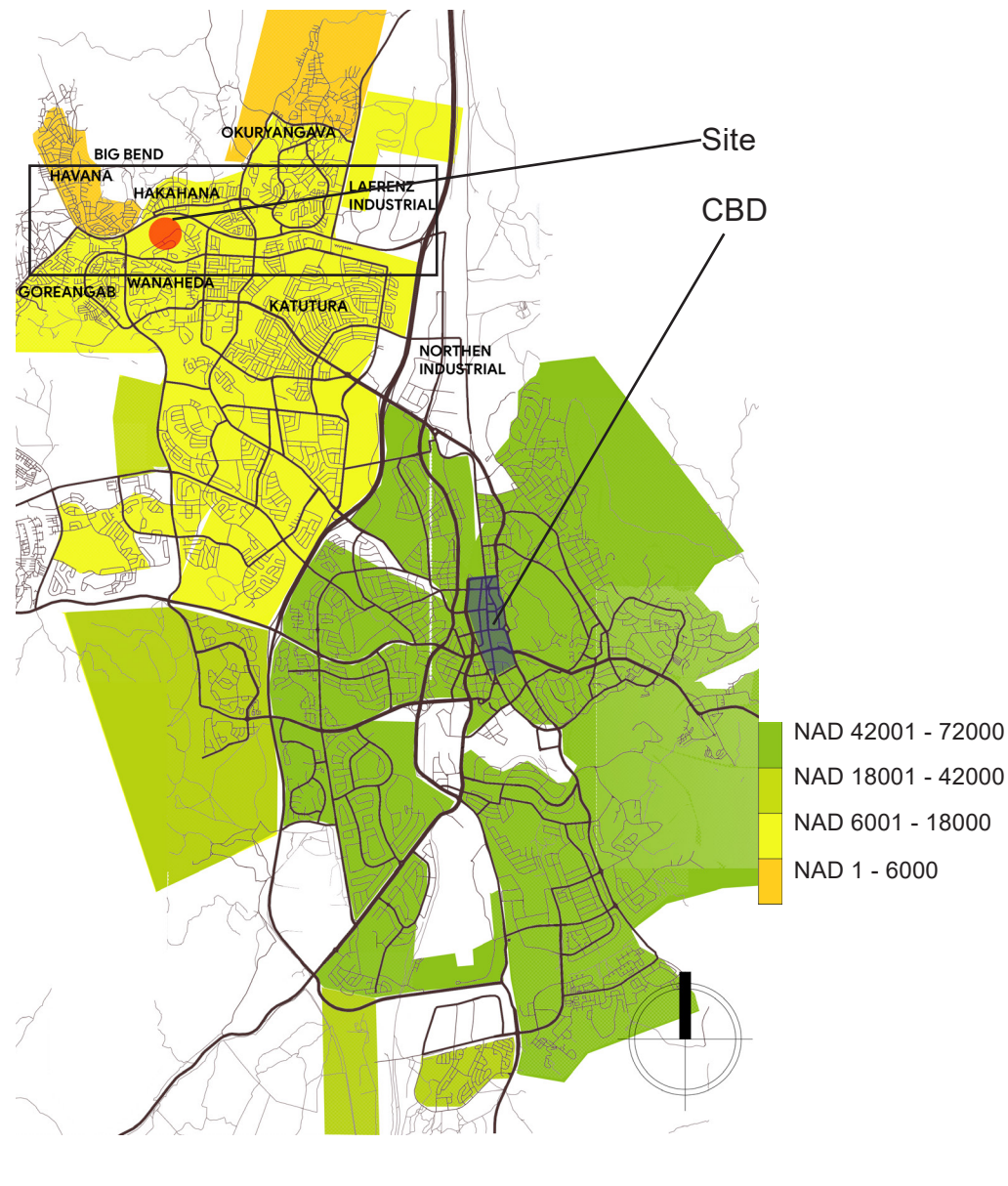


Figure 4 City average income NAD per month (Redrawn by author based on SUTMP report map pg. 28). Source: Heidersbach & Strompen (2022).

2. Mapping the socio-economic context of Windhoek

2.1 Urban population density and average income

This section is largely based on the SUTMP report of 2013 and focuses on elements within the document such as the relationship between motorised and non-motorised transport (NMT), public transport (buses) and pedestrian walkways. Interest has been placed on the lower income areas in the northern parts of the city and its relationship with the Central Business District (CBD). A series of maps have been redrawn including urban population density (see Fig. 3), average monthly income (see Fig. 4) and urban zoning within the northern periphery (see Fig. 5).

A third of the city's 400 000 inhabitants live within the informal periphery (Heidersbach & Strompen, 2022). This can be attributed to the legacy left by Apartheid planning and the mushrooming of settlements around the periphery. Neighbourhoods mostly comprise of informal structures are made primarily of wood and corrugated iron.

A comprehensive site analysis in the SUTMP points out that there is a severe lack of infrastructure in the city, such as bicycle lanes and pedestrian walkways. Roads have negative lines-of-sight (LOS) at most traffic junctions for cyclists. Pedestrian walkways are also

of poor quality. The poor conditions of pedestrian walkways create an issue with mobility especially for informal traders that need to transport their goods in trolleys, as road surfaces are of poor quality (Heidersbach & Strompen, 2022). Thus, the absence of a NMT system highlights a significant opportunity, especially for lower income areas with a high urban population density. The project emphasises the Monte Christo corridor (See Fig. 5) because of its active street frontage and its direct connection to the surrounding neighbourhoods.

The proposed NMT network will enable new employment opportunities for those who do not have vehicles, as well as opportunities for individuals who are dependent on vehicles. An effective NMT network will ensure more freedom for residents to manage their lives and improve social wellness through improved environmental conditions. The NMT network can be strengthened further by businesses and institutions that encourage and promote social capital. The NMT network can make a significant contribution to the movement and flow of commodities and solid waste. This has a direct implication as Namibia is a middle-income country

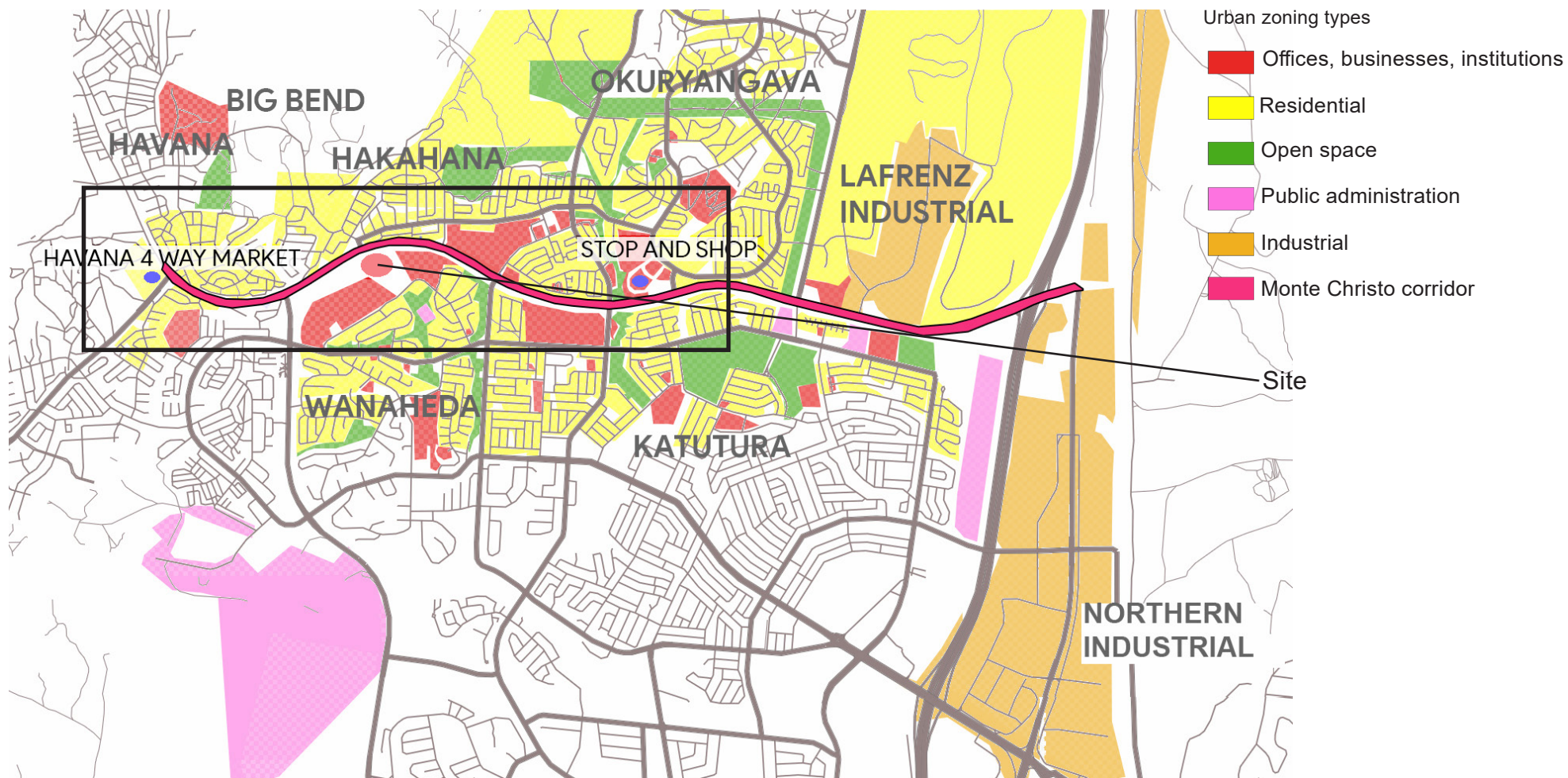


Figure 5 Urban zoning types (Redrawn by author based of SUTMP report map pg. 25). Source: Heidersbach & Strompen (2022).

2.2 Mode of transport versus income demographics

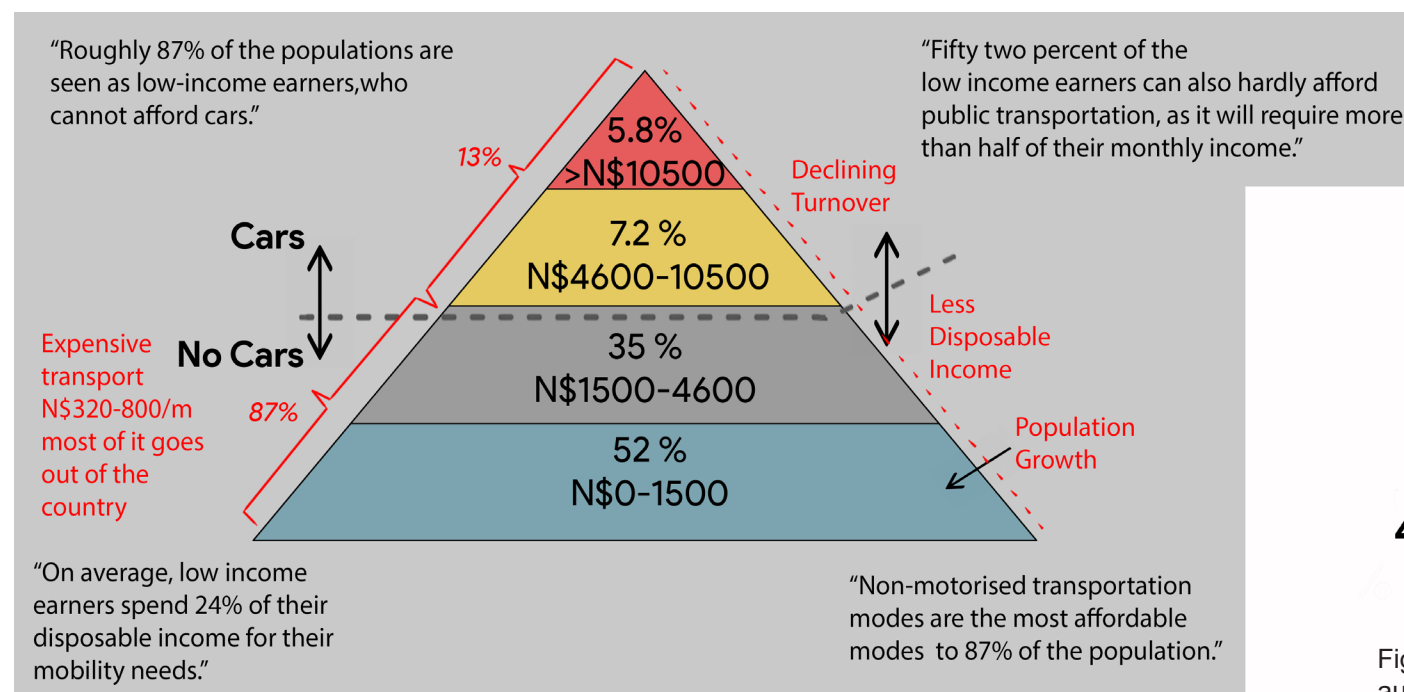


Figure 6 Income demographic versus transportation modes (Redrawn by author based of SUTMP report graph pg. 36). Source: Heidersbach & Strompen (2022).

according to its GDP; however, it is one of the most unequal in terms of income. According to the SUTMP report, 5.8% of the population earns more than N\$10 500 per month while 52% earn between N\$ 0 and N\$1 500 per month. Low income is further strained by high cost of transportation fees (see Fig. 6). "On average, low-income earners spend 24% of their disposable income for their mobility needs" (Heidersbach & Strompen, 2022, pg. 36). The predominant form of public transport is taxis at 40% and private vehicles at 29%, with walking at 29%. The least favoured transport methods include

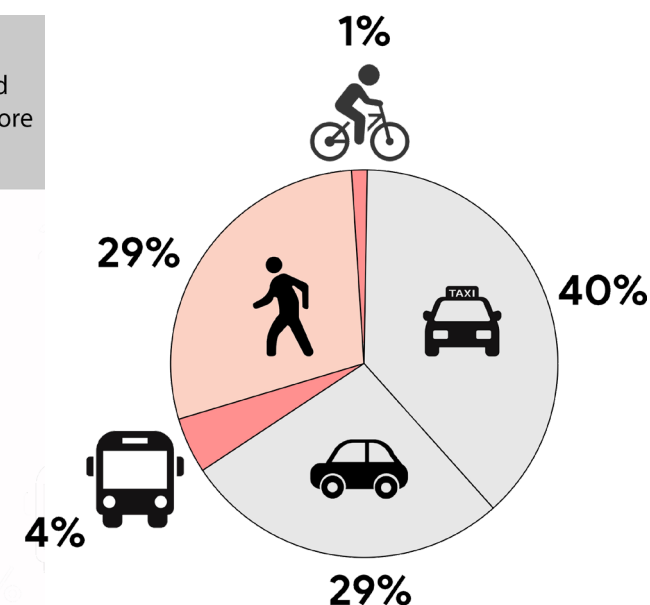


Figure 7 Transportation demographics (Redrawn by author based of SUTMP report graph pg. 36). Source: Heidersbach & Strompen (2022).

buses at 4% and cycling at 1% (see Fig.7). Windhoek's taxi fares are four times more expensive compared to most Southern African cities (Heidersbach & Strompen, 2022).

High population densities and low-income demographics contribute to a waste management crisis. The introduction of a NMT network can strengthen accessibility of collection of waste and can also improve existing socio-economic activities along the Monte Christo corridor.

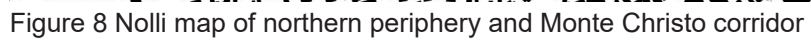






Figure 9 Traders selling wide variety of foodstuffs and domestic supplies



Figure 10 Overview of informal spatial agency and economic trade

3. Spatial analysis of commodity flows and points of interest

3.1 Monte Christo 4-way market

The Monte Christo 4-way market (see Fig. 9, 10, 11 and 12) was an active commercial hub for small businesses and local traders providing food and other necessities for the surrounding neighbourhoods. Vendors had taken advantage of the various transportation modes and pedestrian movements that intersected at the 4-way junction. The 4-way market is currently being displaced by a large dual-carriageway road upgrade; this urban intervention seemingly does not consider the existing socio-economic activities of significant importance for the residents that depend on it for their livelihoods.

Informal trade at the 4-way market generates waste, comprised mostly of organic material and stagnant water bodies due to poor surface water drainage. All the waste is collected at a strategically placed skip container. Waste is seen as a nuisance due to poor service delivery from the municipality and its recycling is not encouraged.

The marketplace supported livelihoods for many years; some vendors occupied their respective positions within the marketplace for over 7 years. The market sold a wide variety of commodities including general foodstuffs and domestic supplies, as well as indigenous food (kapenta, lemons, mopane worms and kapana).

Most standard foodstuffs were acquired from the Stop N Shop wholesalers' area. For the analysis, traders are divided into two categories: temporary and permanent. Temporary trade stalls sell a variety of fresh and traditional foods and temporary traders are responsive towards high movement through the Monte Christo corridor

Food was often bought from a supplier and resold on the same day. Traders pack up their tables and containers daily. Some of the traders store their belongings in the surrounding buildings for a small fee. Permanent shops occupy a fixed location and are open from 6am to 6pm. They operate as small convenience stores selling a large variety of goods. Others are often specialised, offering specific services such as selling gas, printing services and barber shops.



Figure 11 Monte Christo 4-way market 10 am and 3 pm depicting low operational hours

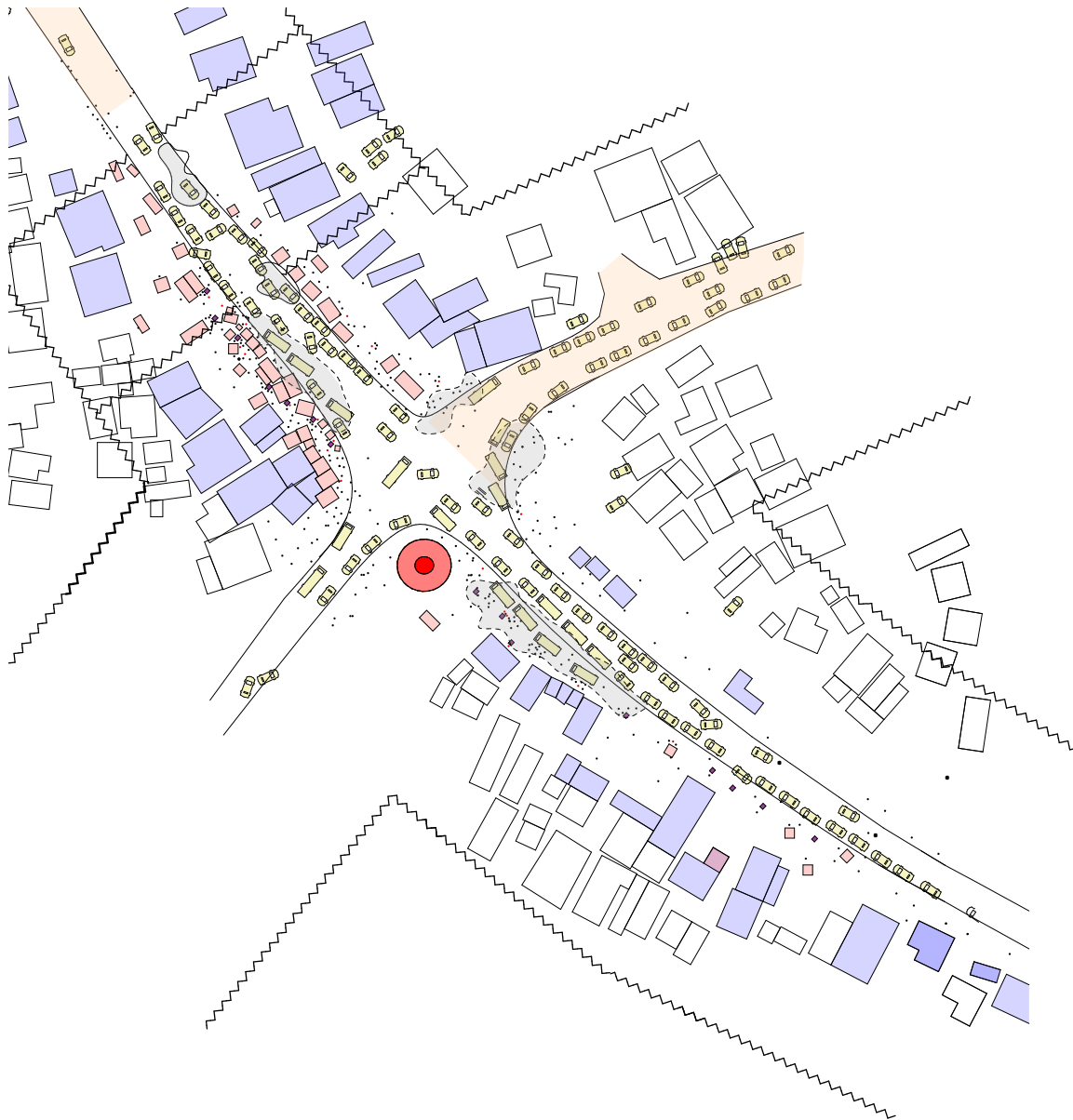


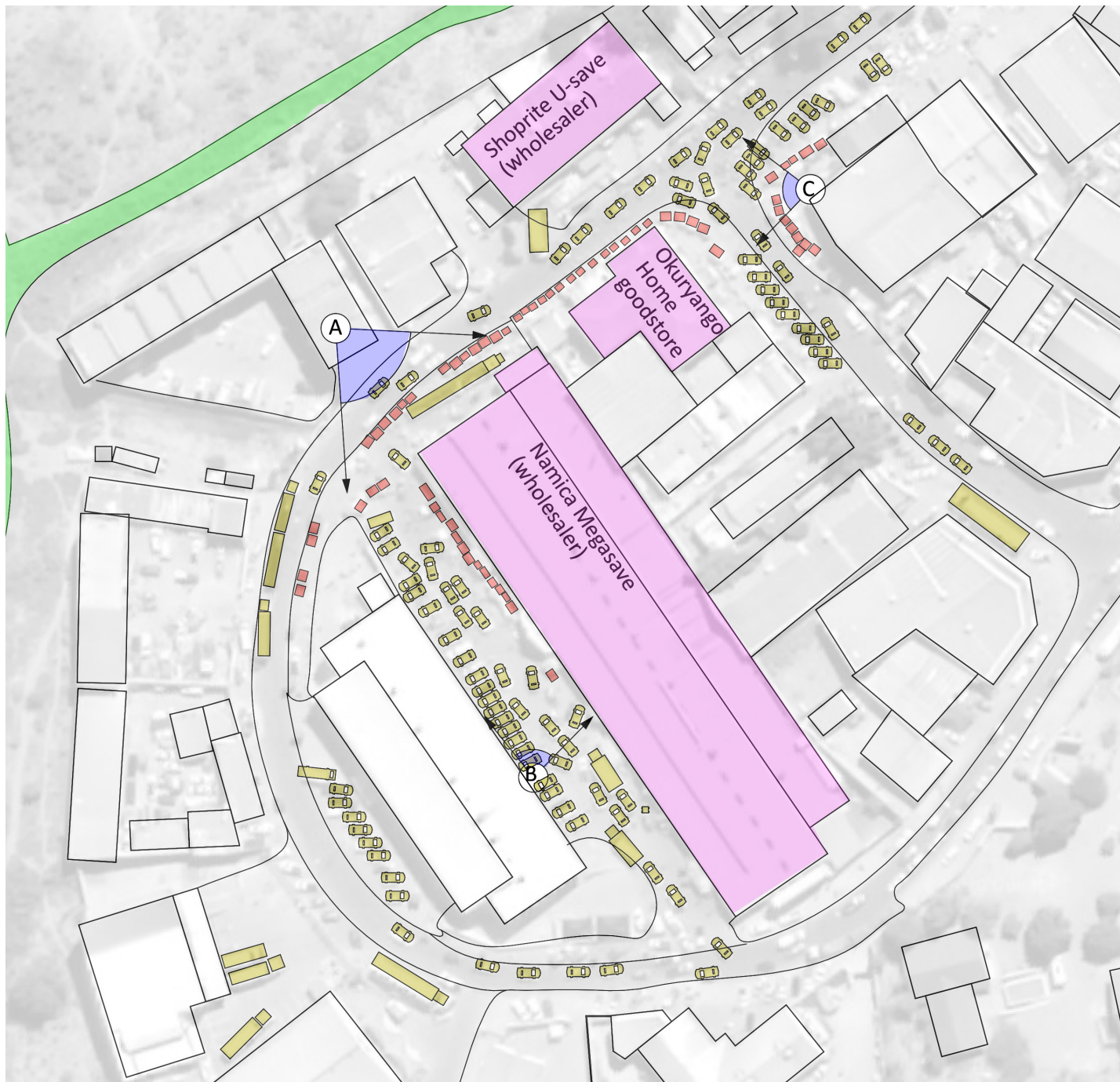
Figure 12 Monte Christo 4-way market 8 am and 5 pm depicting high operational hours



Figure 13 Stop N Shop informal traders. Refer to C in Fig 14

3.2 Stop N Shop Wholesale

'Stop N Shop' is a fresh produce wholesale distribution hub (see Fig. 13, 14, and 15). It is situated on Ongava Street, a road that branches off the Monte Christo corridor. Informal traders commute from 6am to purchase fresh produce in bulk to resell for a small profit. The wholesale area produces spatial agency within its immediate context, and the larger city as a whole. The wholesale warehouses are surrounded by informal vendor trade stalls. The roads around the wholesale area are dominated by taxi drivers, waiting to pick up informal traders that have bought produce. Taxi drivers also drop off consumers that buy from the informal vendors. Roads are congested by trucks that offload fresh produce throughout the day, arriving from other regions and mainly South Africa. The highly organised wholesalers group represents a formal actor, with selling in bulk as the primary business concern. It does not concern itself with the socio-economic context of the buyer. The wholesalers benefit significantly from the bulk buying power of informal traders, as a third of the city's population live within the city's northern periphery.



Legend

- Wholesalers
- Informal traders
- Transportation taxi and trucks
- View cone, site views of Fig 13 and 14

Figure 14 Stop N Shop Wholesale analysis



Figure 15 View of Stop N Shop Wholesale. Refer to A in Fig 14



Figure 16 Sense of space in relation to the waste crises

3.3 Contaminated sites along Monte Christo corridor

Within the northern periphery of the city, domestic waste accumulates in contaminated sites throughout the urban fabric (see Fig. 16). The solid waste management department does not have the service delivery capacity to address this waste issue. Waste is still managed to an extent by the residents; it often ends up in riverbeds where it is burnt to prevent the spread of diseases (see Fig. 17). This is arguably the best practice available to residents due to the municipality's limited capacity to offer services. Industrial skip containers designated for garden waste are used by residents for the disposal of general waste. These skip containers are often highly contaminated, with the result that municipal ward contractors resort to burning waste within the containers (see Fig. 20). While this practice is considered illegal by the municipality's waste management department, it is tolerated. Another issue is the lack of effective surface water drainage in conjunction with contaminated waste. These septic water bodies create defined movement barriers; it also creates negative perception of informal settlements within the northern periphery (see Fig. 19-21).



Figure 17 Burning of waste in Havana riverbed

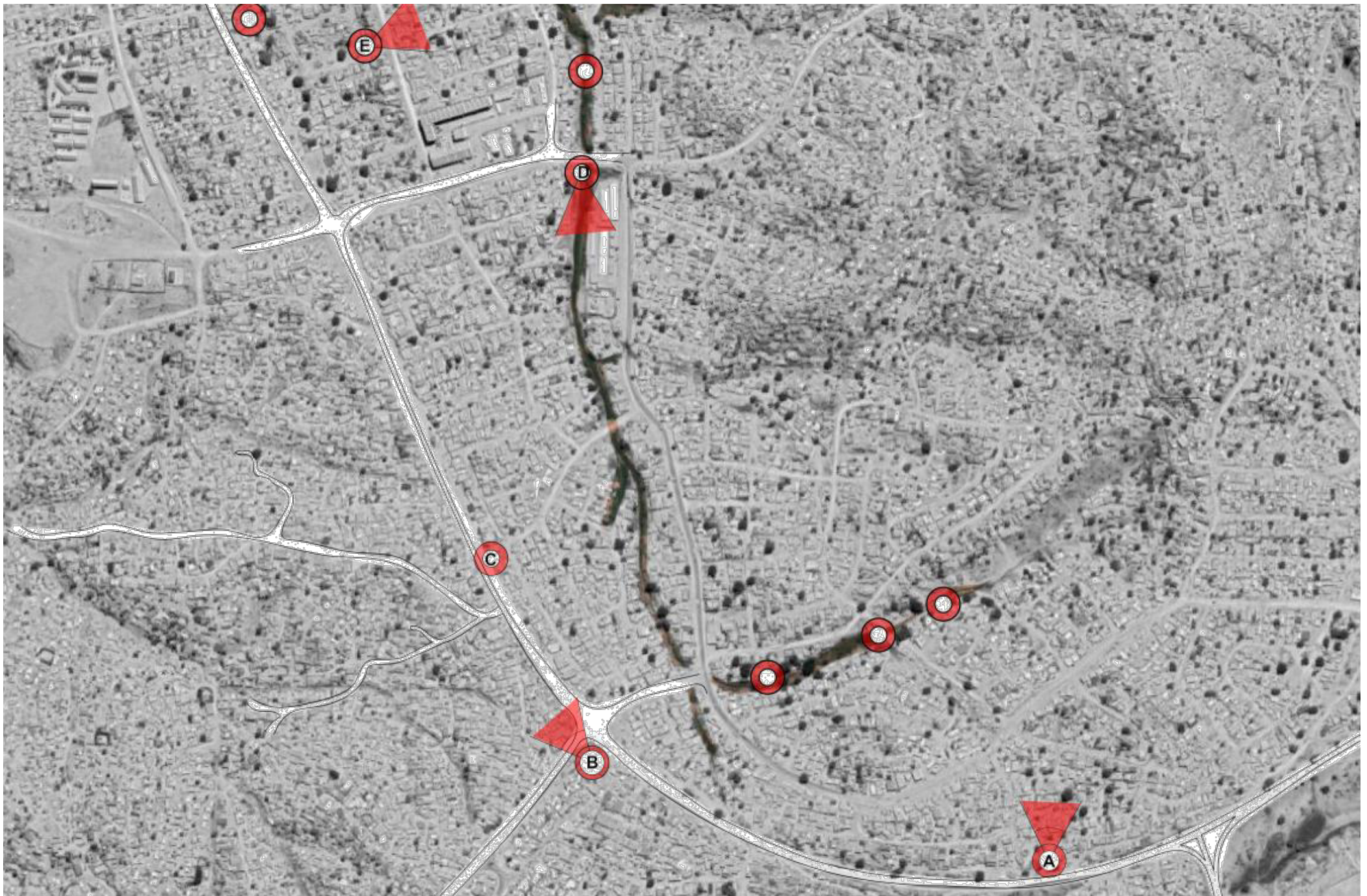


Figure 18 Map illustrating contaminated sites along Monte Christo corridor



Figure 19 Monte Christo 4-way market contaminated site



Figure 20 Burning waste in skip container



Figure 21 Havana 4-way waste collection point with contaminated water



Figure 22 Local community members specialising in glass bottle collection in Hakahana



Figure 23 Bag of collected glass bottles

4. Recyclable commodity flows between formal and informal actors in Windhoek

4.1 Informal waste pickers in Windhoek

Informal waste pickers within the Hakahana neighbourhood specialise in the collection of glass bottles. The group operation consisting of five individuals interviewed for this study, are considered to cover the whole area of the City of Windhoek. The glass bottles are gathered close to the group's residence and repackaged in heavy-duty plastic bags. The bags weigh approximately 50 kilograms when filled and sell for 40 Namibian dollars (see Fig. 22-23). The group manages to collect around 5 to 7 bags per day. After they collect a significant number of bags, ranging from 70 to 100, they rent a truck for N\$500 to pick up all the bags. The glass collectors make a modest living from the glass collection initiative. Apart from the monetary incentive, they stressed the important role that they are playing in cleaning up the environment and mentioned the support that they get from their community.

The representative of the group who was interviewed, stressed the importance of removing glass bottles as a community safety precaution. They operate during daylight hours, finding bottles in

riverbeds and open fields throughout the city. They are wary of using roads due to fear of being hit by oncoming traffic. I asked them whether they had thought that they should get some form of assistance since they are cleaning up the environment. The general response of the group was that they should be able to manage on their own, without any formal help from the government.



Figure 24 Waste picker trolley



Figure 25 Informal waste picker in the CBD

Waste pickers who specialise in the collection of aluminium, tin cans and other metal waste prefer operating during evening hours. Collecting recyclables from residential wheelie bins, they make use of the empty roads and streetlights, traversing 10 to 15 kilometres daily (see Figs. 24-25). They operate at night before the day on which municipal waste is collected early in the morning, at roughly 6 am. Even though waste pickers are not formally recognised as service providers, the practice of waste picking provides monetary incentives as well as environmental benefits. Individuals who find themselves picking waste are generally homeless and represent vulnerable groups, without other employment opportunities. Some individuals involved in waste picking admitted that they struggle with alcohol abuse. Waste pickers interviewed reiterate the fact that they collect waste throughout the city.



Figure 26 Overview of C+J Recyclers

4.2 C + J Recyclers Namibia



Figure 27 Waste picker unloading recyclables from shopping trolley

C+J Recyclers Namibia is a metal scrap salvage company founded by Johnny Mahecic (see Fig. 26). Mr Mahecic has been buying and selling scrap metal for over 25 years. He employs 30 individuals, which include individuals that handle and sort waste, forklift operators, truck drivers, cashiers, and quality control inspectors. The scrapyards has a series of specialised scales that weigh commodities (see Fig. 28). Waste pickers often use shopping cart trolleys to transport aluminium and tin cans that they find by picking household waste from suburban neighbourhoods. The commodities are separated into specific types by waste pickers: light metal, heavy metal, aluminium and copper (see Fig. 27).



Figure 28 Bag with presorted aluminium cans weighed on scale.



Figure 29 Workers processing metal cans

Waste pickers can earn more if they separate metal components into specific types, as this cuts down on the scrap yard's labour cost. Aluminium cans are separated from their plastic lining by manual labour (see Fig. 29). C+J Recyclers forms an important role in the waste recycling process as middlemen, as recycling wholesalers only buy recyclables in significant bulk quantities to sell to South Africa. To be able to deliver on this demand the owner of C+J utilises his own trucks and baling machine. These high-cost operations of transportation and baling is performed at the transfer station, a site where recyclables are stored, processed and transported and sold to South Africa. The transfer station is a fundamental part of the waste pickers' waste cycle (See literature review pg. 7).



Figure 30 Overview of Rent-A-Drums material recovery facility

4.3 Rent-A-Drum

Rent-A-Drum is a prominent family business that provides waste management services within Namibia. The company has operated in Windhoek since 1989 and has since spread to all major regions within the country. Rent-A-Drum provides a waste management service, the “clear bag operation”, which they offer to residents in formal neighbourhoods at no charge. Residents have the responsibility to separate recyclables into clear bags supplied by Rent-A-Drum, which are picked up in parallel with municipal waste. They also provide specialised services for commercial companies and institutions, such as the shredding of confidential documents, and the disposal of packing material. Rent-A-Drum is in direct competition with the informal waste pickers, as they remove the most valuable waste (aluminium cans) from the clear bags. Also, the bags are often stolen by the waste pickers.

Rent-A-Drum has a specialised Material Recovery Facility (MRF) (that separates and sorts 22 different types of commodities (see Fig. 37). They also produce a “refuse derived fuel” called ‘RDF’. The

RDF is comprised of materials that cannot be recycled for industrial uses, such as single-use plastics and composite materials. RDF is a shredded composite material that is produced at the MRF. Percentages of different materials are combined to increase RDF combustibility. It is sold to the local cement manufacturer Ohorongo Cement as an alternative fuel source for its fuel burning needs. The MRF separates waste through a series of steps:

Step 1: Trucks arrive with the clear bags and are weighed at the truck scale to account for the amount of waste that arrives on site. Step 2: The material is offloaded within the MRF in proximity to the crane operator that loads the bags onto an ascending conveyor belt where the bags are shredded. Step 3: The ascending conveyor belt offloads the material onto a sorting conveyor belt, where the 22 different commodities are sorted directly and are placed by hand (manual labour) into shoots that connect to “waste storage bunkers” below (see Fig. 32). Step 4,5,6: When the bunkers are full of recyclable materials, a control board operator commands the



Figure 31 Step 1



Figure 32 Step 2



Figure 33 Step 3



Figure 34 Step 4



Figure 35 Step 4



Figure 36 Step 5



Figure 37 Step 6



Figure 38 Step 7



Figure 39 Step 8



Figure 40 Step 9

bunker to discharge its contents onto a conveyor belt that feeds into a baler machine (see Fig. 36). The machine compresses the bales with a significant amount of hydraulic force and binds the bales with metal wires. Step 7: The bales are then weighed on a scale, weighing approximately one ton each. The bales are catalogued with a printed bar-code and are then stored in an external delivery area (see Fig. 39). Forklift operators finally upload the bales onto trucks that depart to South Africa where materials are recycled. Rent-A-Drum employs 100 people, separated into day and night shifts to keep up with the supply of unsorted waste.

Interested individuals can sell recyclables by registering as buy-back centres. They offload material at the facility. To make a decent profit, it is preferable that the materials are pre-sorted. Payments are made monthly and through bank account transactions only. The amount that the buy-back centres can earn is based solely on the quantity of the materials that are delivered. The MRF forms a fundamental part of the concept formulation for this project, as it offers potential

spatial agency for other economic activities to take place; and allows residents the opportunity to recycle a larger variety of commodities (see concept development pg. 57).

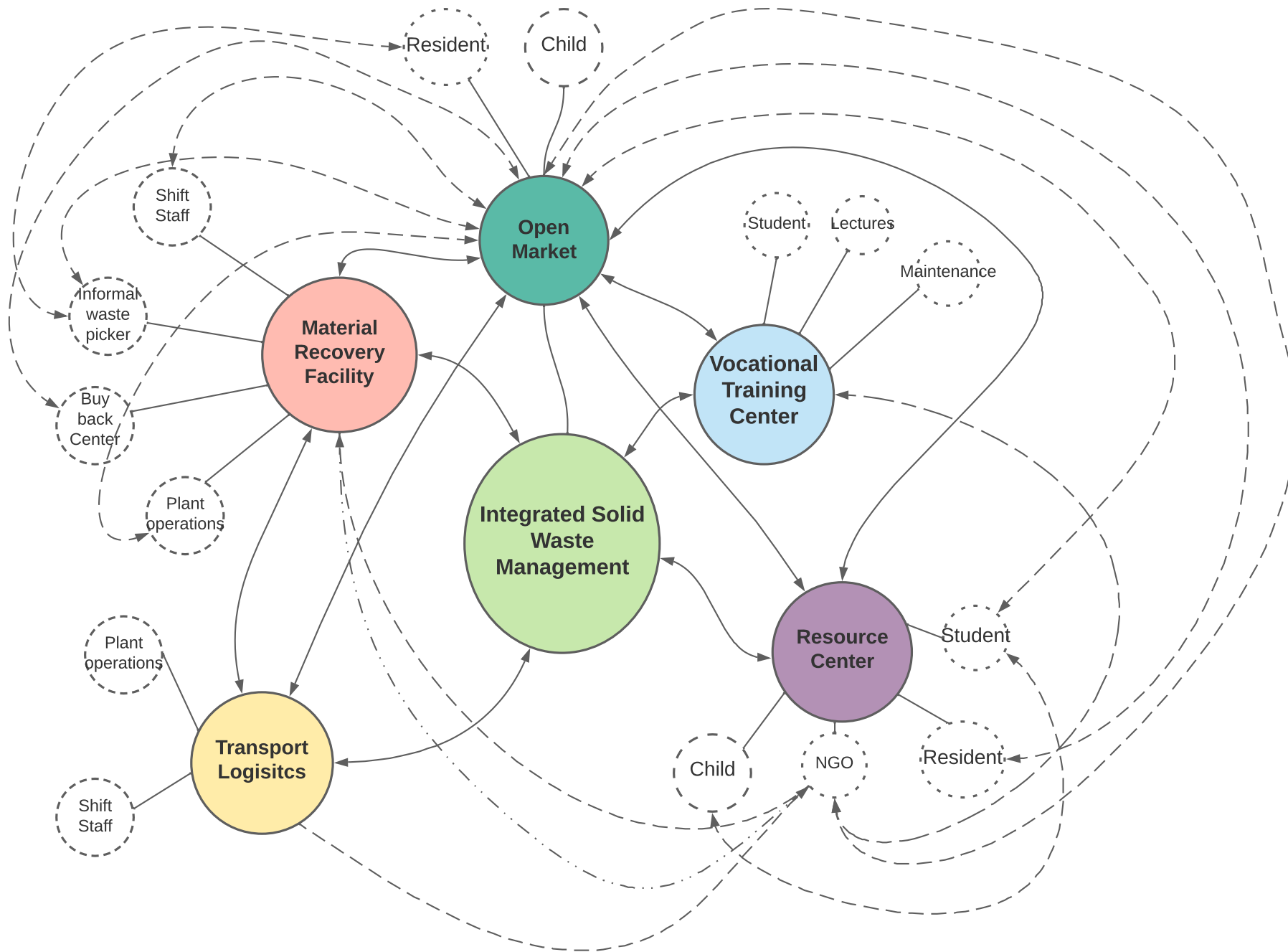


Figure 41 Interrelated map of actors and activities

5. Problem statement, project brief, programme and precedent study

5.1 Problem statement

Currently solid waste management is not integrated effectively with other socio-economic practices that generate waste within informal settlements. The lack of waste removal and surface water drainage remains an issue, especially in the vicinity of the Monte Christo 4-way marketplace. The core problem identified is the limited interaction between formal and informal actors involved in waste management within the socio-economic fabric of Windhoek. Waste pickers have no support system that exist outside this framework of collection and selling of recyclable commodities. Existing models for industrial recycling are hyper specialised and their main concern is the acquisition and sale of recyclable commodities. The gap that has been identified is the need to surround this highly specialised industrial operation (Material Recovery Facility) with a spatial intervention that derives form from the spatial agency (informal trade) that surrounds a point of economic interest (See Fig. 41). Yet despite the flaws of the existing recycling industry in Namibia the author recognises its importance as an income source for vulnerable and marginalised people without formal employment opportunities.

5.2 Project brief: Integration of formal and informal waste management

Based on the analysis of the Windhoek waste management system the project aims to systematically integrate formal and informal recycling activities along the Monte Christo corridor, impacting the city at multiple scales. The central theme for the spatial intervention is the creation of mutual relationships and interdependence between spatial functions to create resilience in the overall development scheme (see Fig. 39). The project aims to create a spatial node that links formal and informal waste management practices and actors.

A primary objective of the programme is the need to integrate existing economic activities through an architectural spatial typology that directs pedestrian movement to points of interest and creates ideal exposure for vending activities. The modular architectural typology was designed to allow for growth and expansion, inspired by the spatial temporality and informal marketplaces and their organic growth over time.

The objectives of the project's brief are:

1. Integrate cycles/scales of waste management collection to empower waste pickers and to intensify waste collection within the northern periphery of Windhoek.
2. Create potential for secondary economic informal activity and other forms of collaboration such as knowledge exchange.
3. Provide relevant socio-economic knowledge through capacity building.
4. Provide technical vocational training relevant to the context of the northern periphery.
5. Create an incremental, phased and expandable architectural typology.

5.3 Programme

The project's primary functions are based around an ideal of collaboration between different scales of socio-economic activity, service providers and institutions. An industrial architectural language is proposed to provide emphasis on the actors involved with socio-economic activity. The programme includes:

1. Waste-sorting facility and large-scale storage and logistics hub.
2. Marketplace that accommodates informal vendors.
3. Offices for a support NGO that provide administrative oversight and resources for knowledge exchange.
4. Vocational school that provides a library, workshops and lecture rooms.



Figure 42 Site view of the Centre Pompidou. Source: <https://www.atlasofplaces.com/architecture/centre-pompidou/#figure-2>

5.4 Precedent study “Centre Pompidou”

I chose the Pompidou Centre for inspiration due to its industrial modular architectural language and its provision of large open spaces that create urban interaction and spatial agency (See Fig. 42).

In 1969 President Georges Pompidou proposed a project for a new contemporary cultural centre in Paris. The brief required a modern art museum, a public library, a design centre and an institute of contemporary music. In the 1930s the project site was a slum neighbourhood. These housing blocks were later demolished, creating a large parking area and the ideal location for the project. For the first time in France an international architectural competition was launched; 81 entries were received. Three renowned architects, Oscar Niemeyer, Jean Prouve and Phillip Johnson acted as the competition jury. Only one project, number 493, proposed the development of only half the site, leaving the rest open as a public piazza (See Fig. 43).

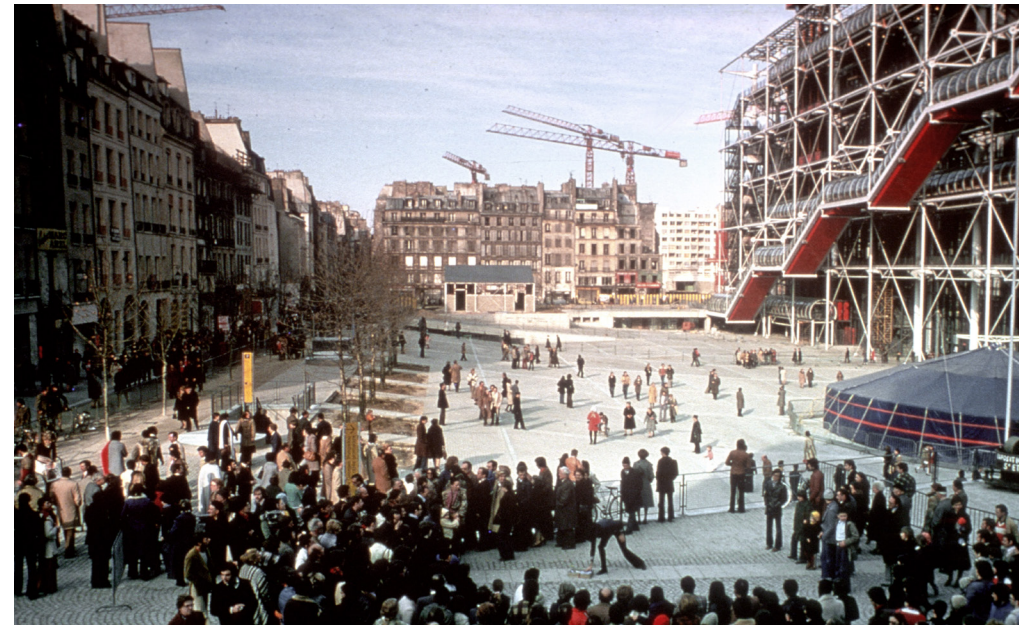


Figure 43 View of plaza. Source: <https://www.atlasofplaces.com/architecture/centre-pompidou/#figure-23>

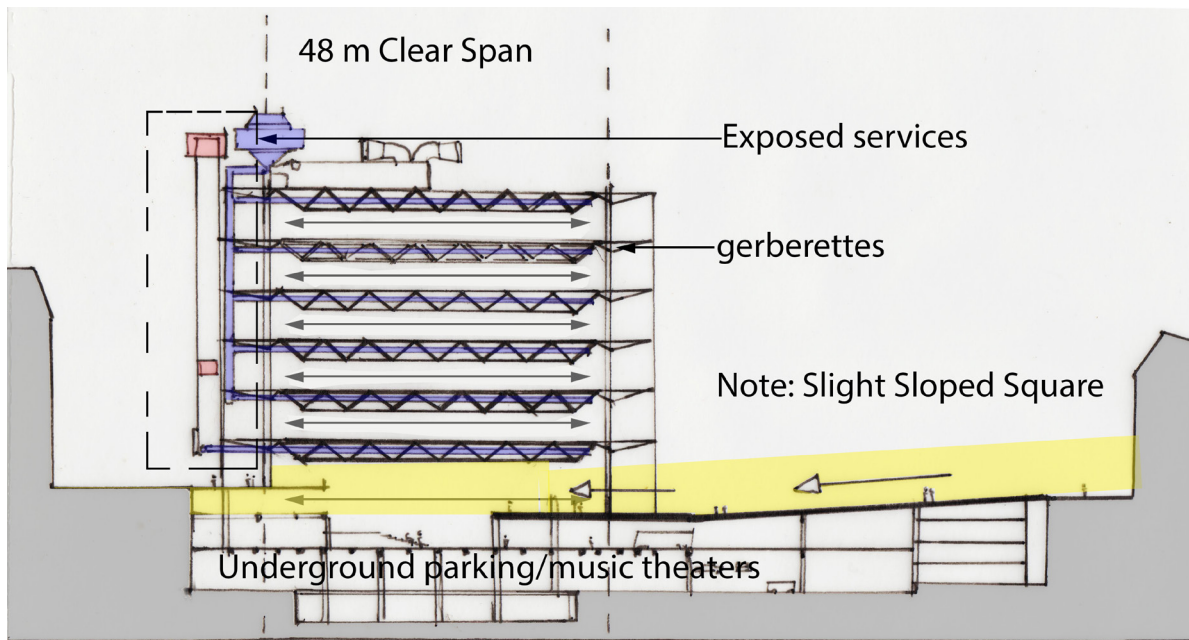


Figure 44 Cross section

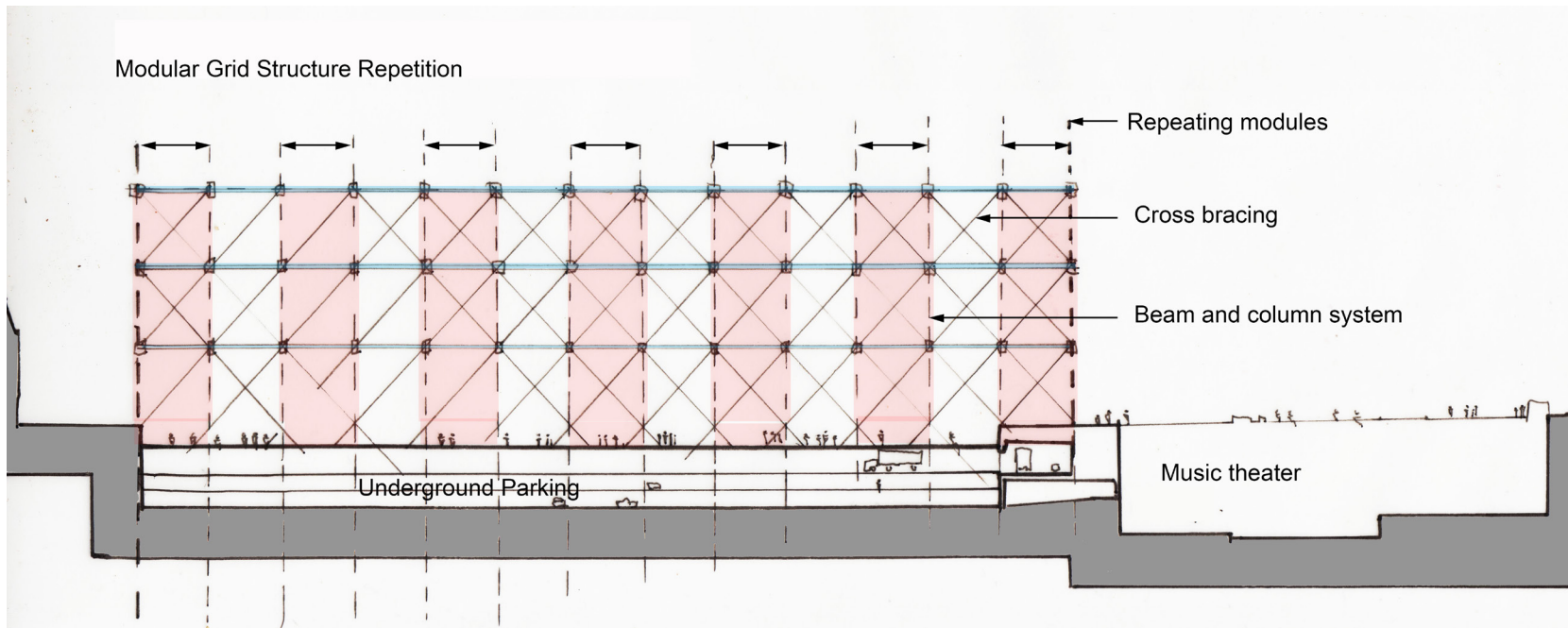


Figure 45 Long section

Peter Rice designed the structural systems for the Centre. The building's primary and secondary superstructure is made of steel. The structure is comprised of a set of building elements. Hollow steel tube columns span the height of the superstructure. Cast-iron gerberettes connect with a pivoting pin connection to the columns (See Fig. 44). Large warren trusses rest on the gerberettes between the columns. A light construction system frees up the floor plans of heavy structural elements. If a fixed connection system was used it would have been more expensive and would have created a significantly heavier appearance.

The modular design of the Centre is in the form of repetitive portal frames that span seven stories within the building (See Fig. 45). This creates large, open, and uninterrupted spaces that can be modified and altered by occupants of the building (See Fig. 46). The exposed services provide transparency to the viewer and communicate design intention through materiality. The open piazza in front of the building expands its presence significantly, creating space for people

to socialise and to exchange ideas. These aspects of urban public space are fundamental considerations which inform the design for the waste management centre.

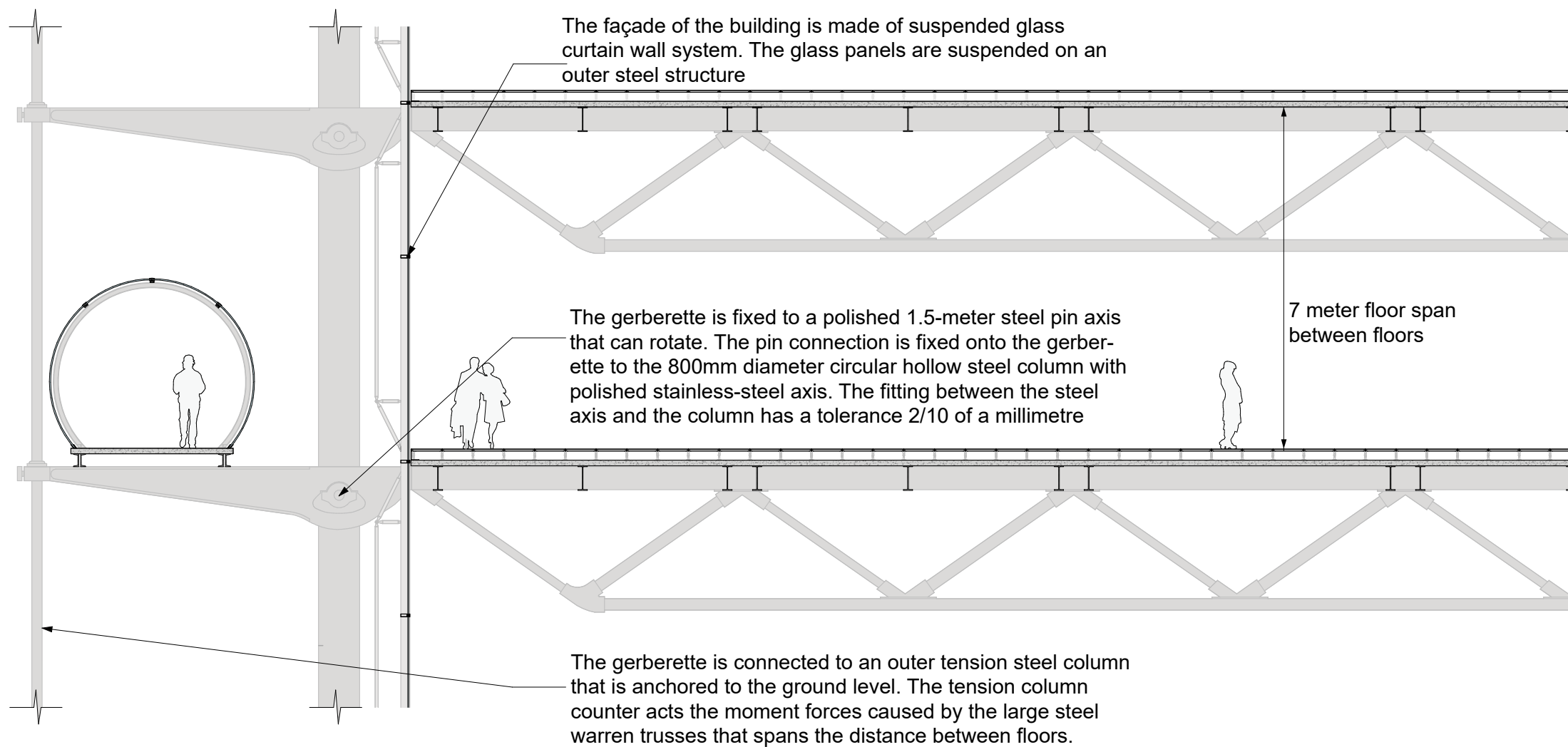
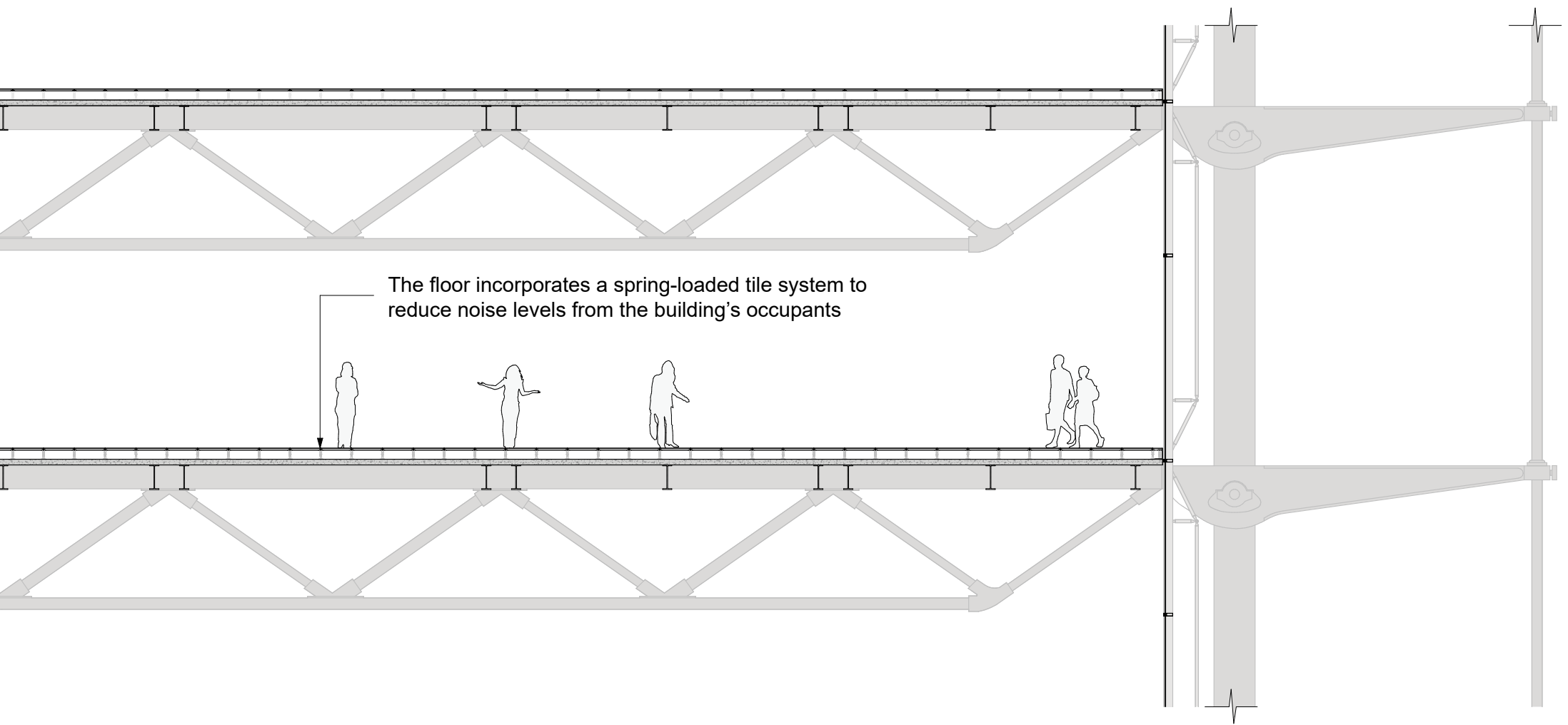


Figure 46 Detailed cross section of the building floors, Pompidou Centre





Northern Periphery

Site

Legend

- Monte Christo corridor
- Omulunga Street
- CJ Brandt High School
- (AMTA) Construction site

Figure 47 Site Diagram



6. Working with the site context

The site selection considered the following factors:

1. Its proximity to the waste crises found throughout the northern periphery where there is limited access to sustainable waste management practices.
2. Its proximity to the Monte Christo corridor where there is a considerable amount of informal socio-economic activity along its length.
3. Its proximity to low-income demographics that can benefit from selling recyclable materials, enrolment in vocational training programmes and participation in socio-economic trade at the project site to strengthen livelihoods.
4. Its potential to benefit from a non-motorised transport network i.e. bicycle lanes and pedestrian walkways along the active Monte Christo corridor.

The site location is a green field that is often used by local residents to move between residential areas (See Fig. 47-51). Footpaths are unsafe due to poor visibility caused by vegetation. Criminals use the coverage to attack unsuspecting pedestrians. Despite the risk, green spaces are used as shortcuts between neighbourhoods and as alternative pedestrian walkways. Notable informants within the proximity of the site include the Afro-Marketing and Trade Center (AMTA) construction site, currently a suspended government project envisaged as a food trading hub. If the project is eventually completed it will significantly strengthen the socio-economic context of the surrounding area. Another building of importance in the vicinity is the C J Brandt Secondary School; the project proposes a connection to the school through proposed pathways.



Figure 48 Site View angle map

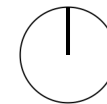




Figure 49 Site View A



Figure 51 Site View C



Figure 50 Site View B

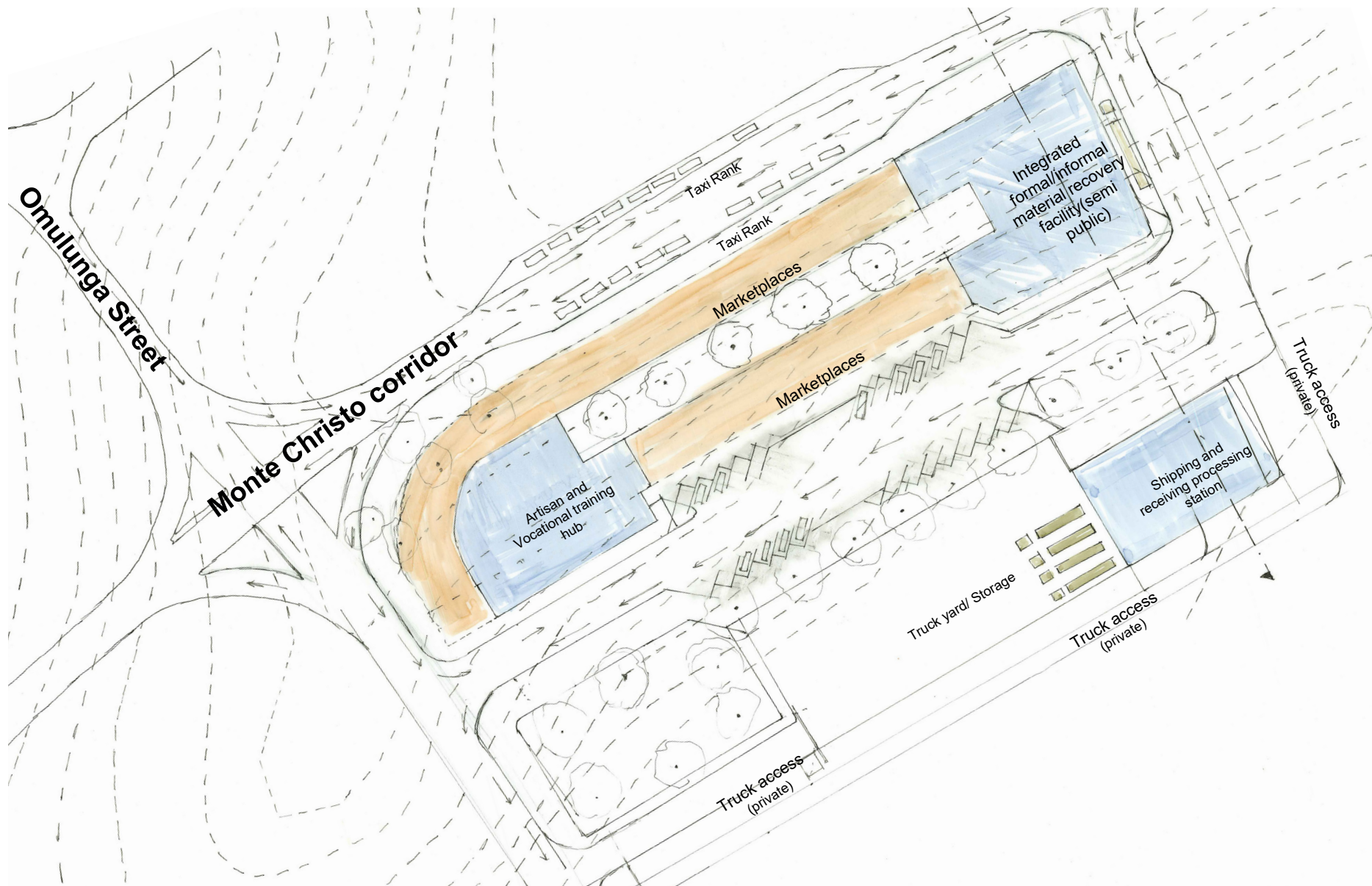


Figure 52 Consolidated site plan and spatial arrangement for the building's primary functions



7. Concept development massing and finding form

7.1 Concept development finding form

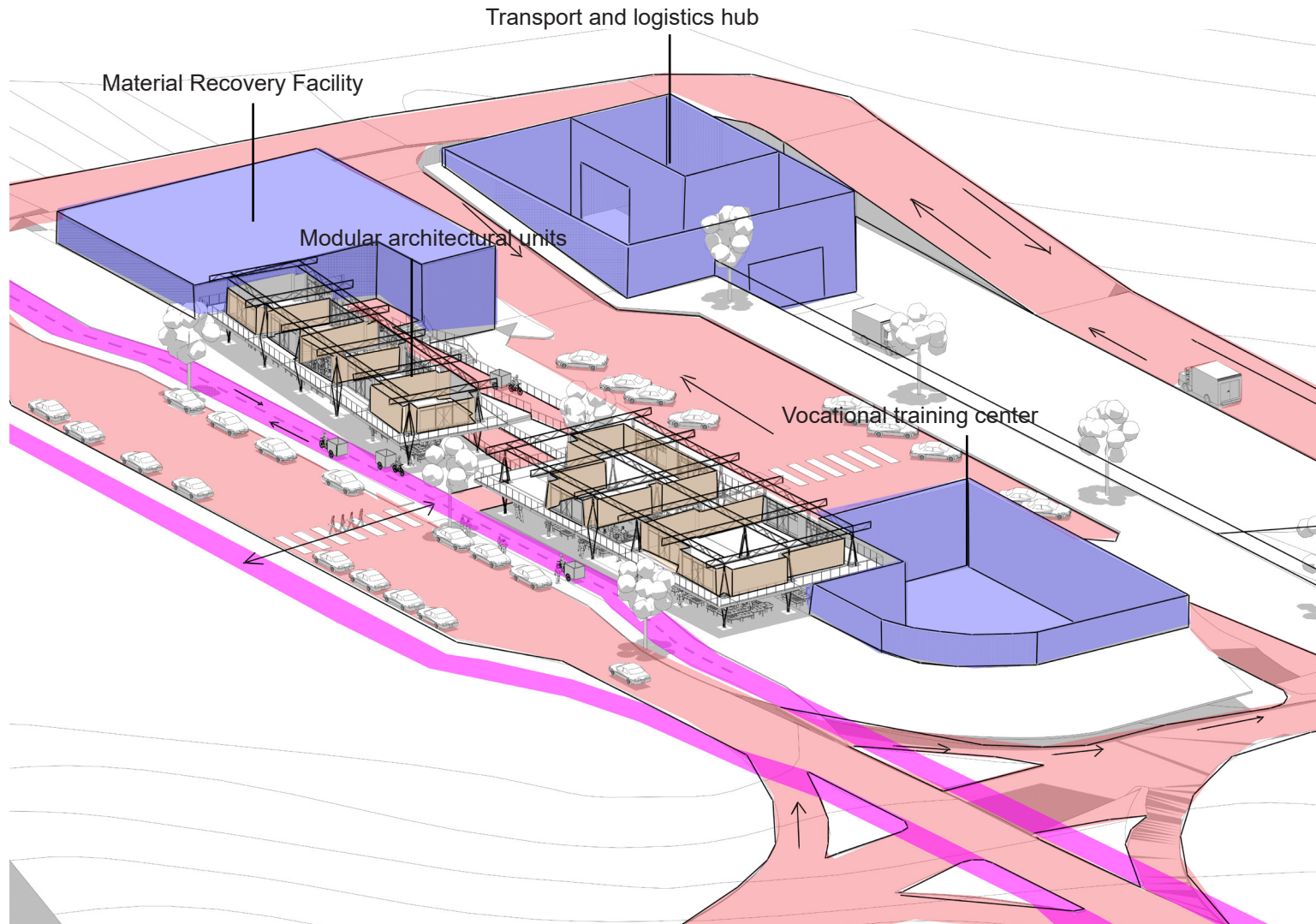


Figure 53 Early massing model indicating spatial form and arrangement on site

The early design massing model illustrates the primary building requirements and its spatial arrangement. The primary functions are a Material Recovery Facility, vocational training centre, a transport and logistics hub and open marketplaces for informal trade (see Fig. 52, 53).

A modular architectural typology was suggested for the marketplaces on the ground floor level. Secondary administrative functions operate on the first floor. The need to integrate socio-economic activity with pedestrian movement was an important consideration.

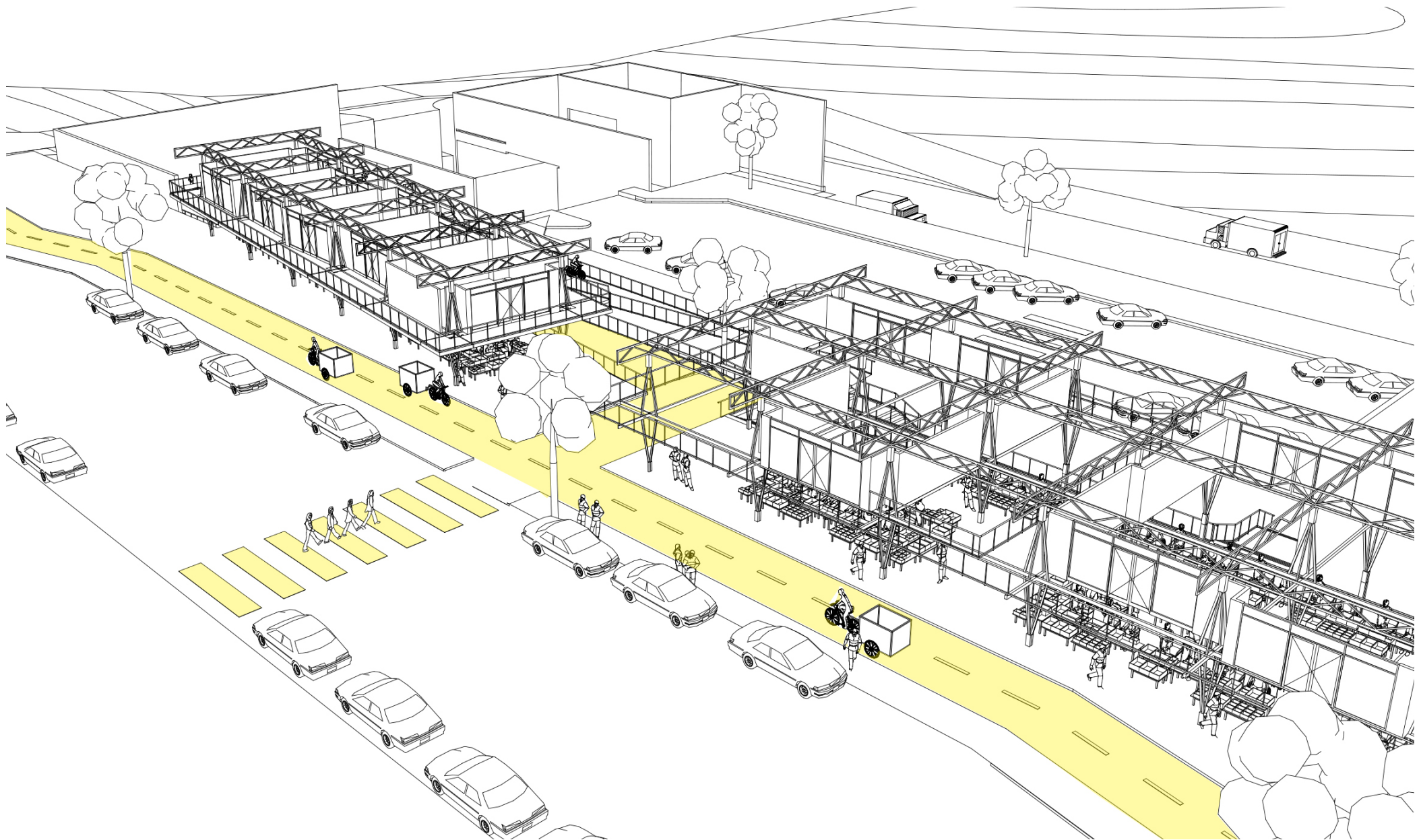
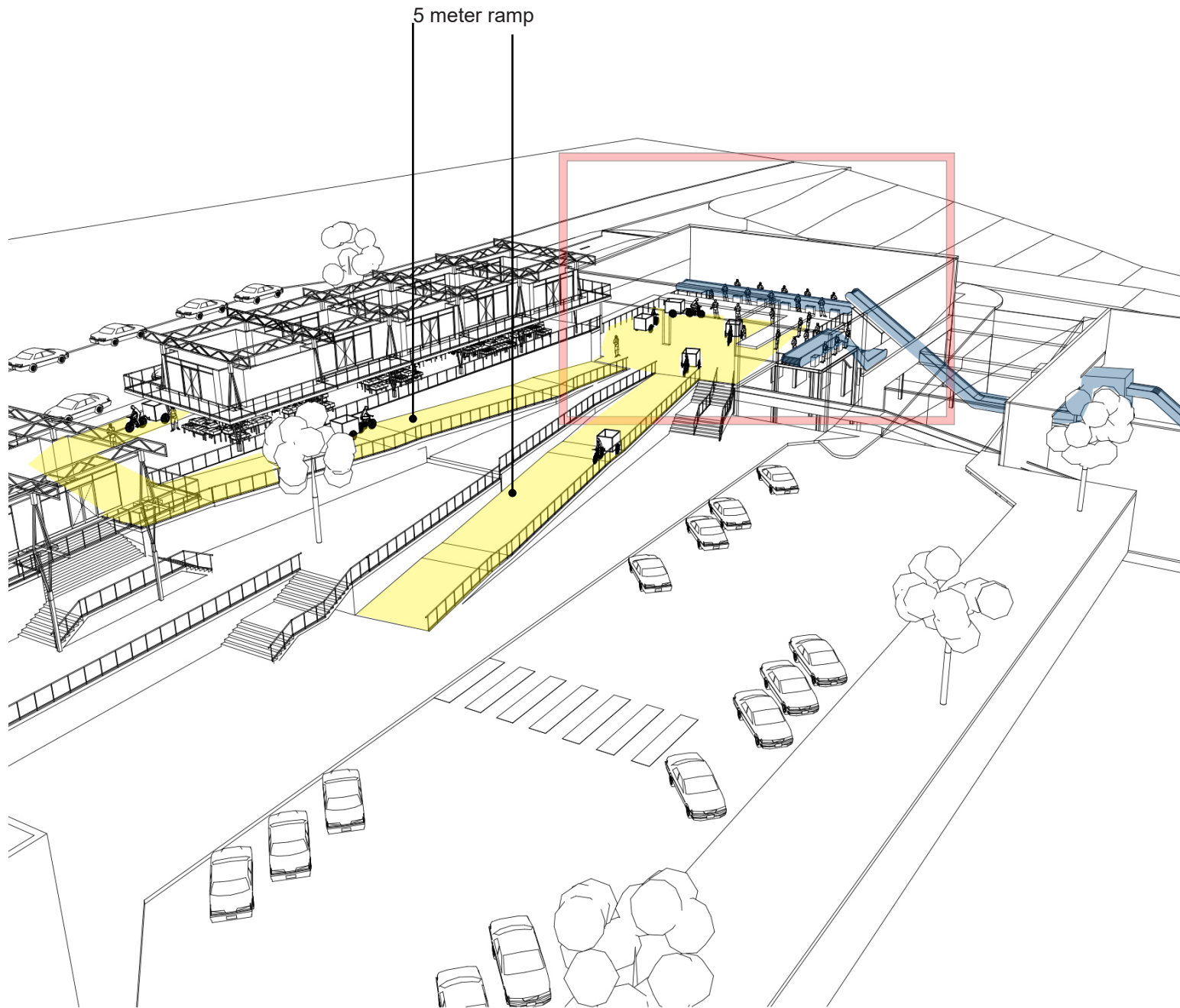


Figure 54 Circulation pathways with highlighted pedestrian movement along Monte Cristo corridor



The site's topography slopes downwards from Monte Christo corridor. The design incorporates a large ramp that leads towards a point of spatial agency, the Material Recovery Facility, located on the lower level. The ramp is 5 metres wide, allowing for informal trade and waste pickers to transport their recyclables effectively (see Fig. 55). Open stalls are situated parallel to the street, allowing informal traders and pedestrians to engage with the traders (see Fig. 54).

Figure 55 Highlighting the sorting facility as the major anchor/ point of interest

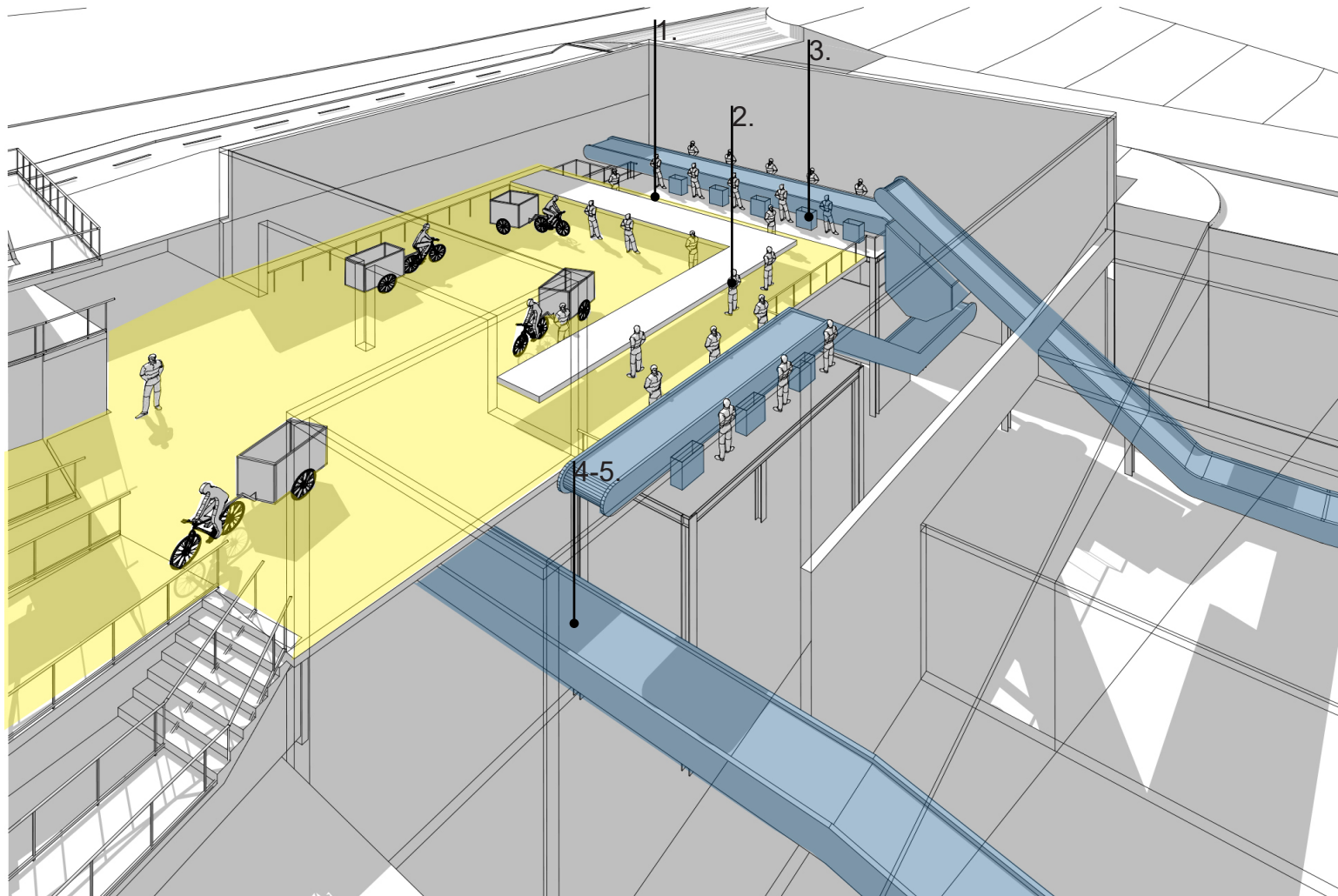
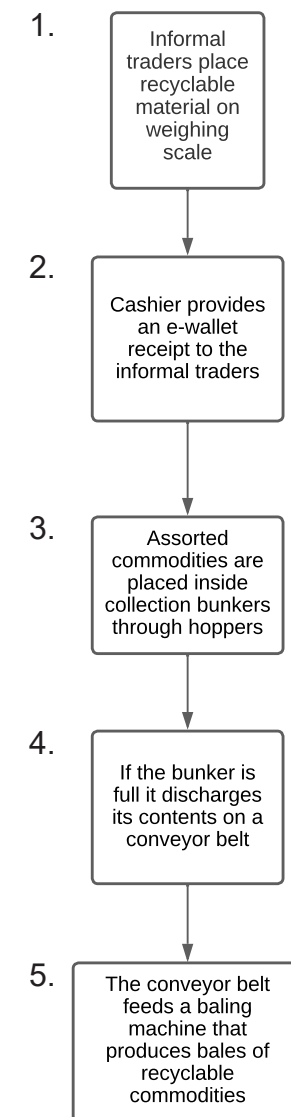
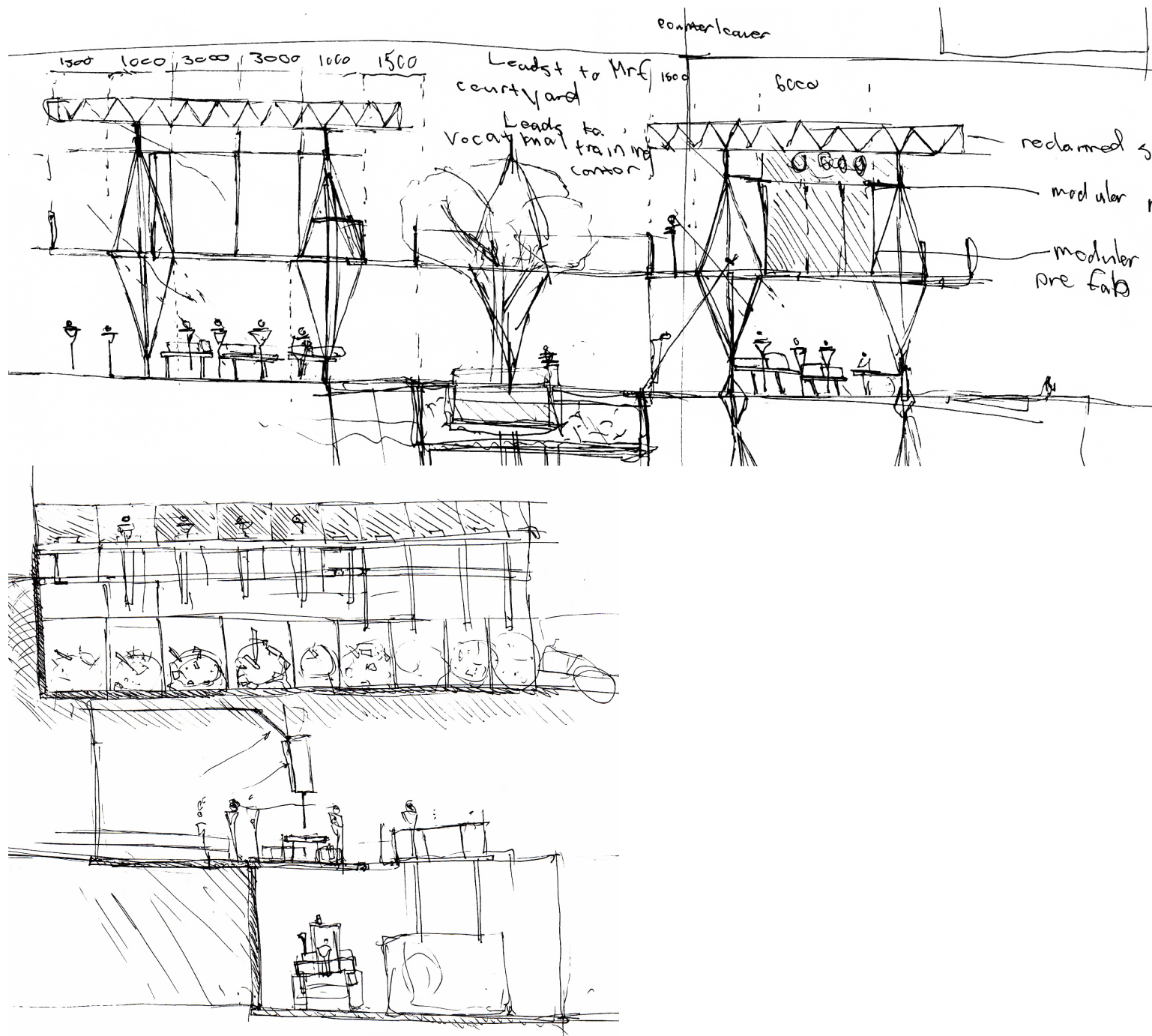


Figure 56 Concept of Material Recovery Facility interface and operations diagram





Designing the interface of the Material Recovery Facility with informal waste pickers in mind necessitated the integration of industrial operations with an architectural solution (see Fig. 56).

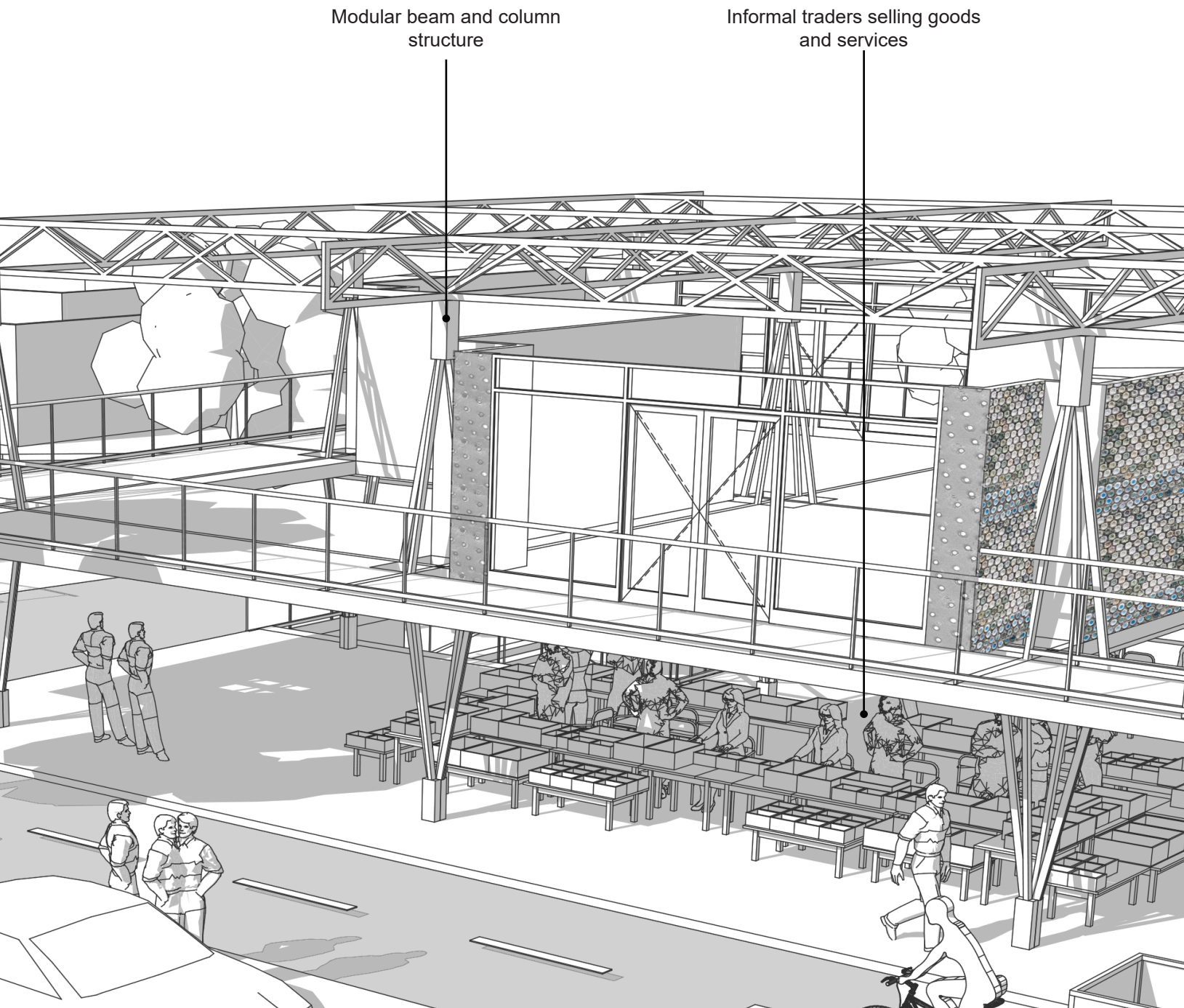
The sketches show an early modular design concept creating a multi-functional space to accommodate socio-economic activity and informal waste management (see Fig. 57).

Figure 57 Early concept sketch ideas

Informal recycling trader using
pedestrian network



Figure 58 Overview of socio-economic activity integrated in spatial typology



The perspective indicates the socio-economic activity parallel to Monte Cristo corridor. The project proposes an integrated architectural industrial language to accommodate different actors (see Fig. 58, 59).

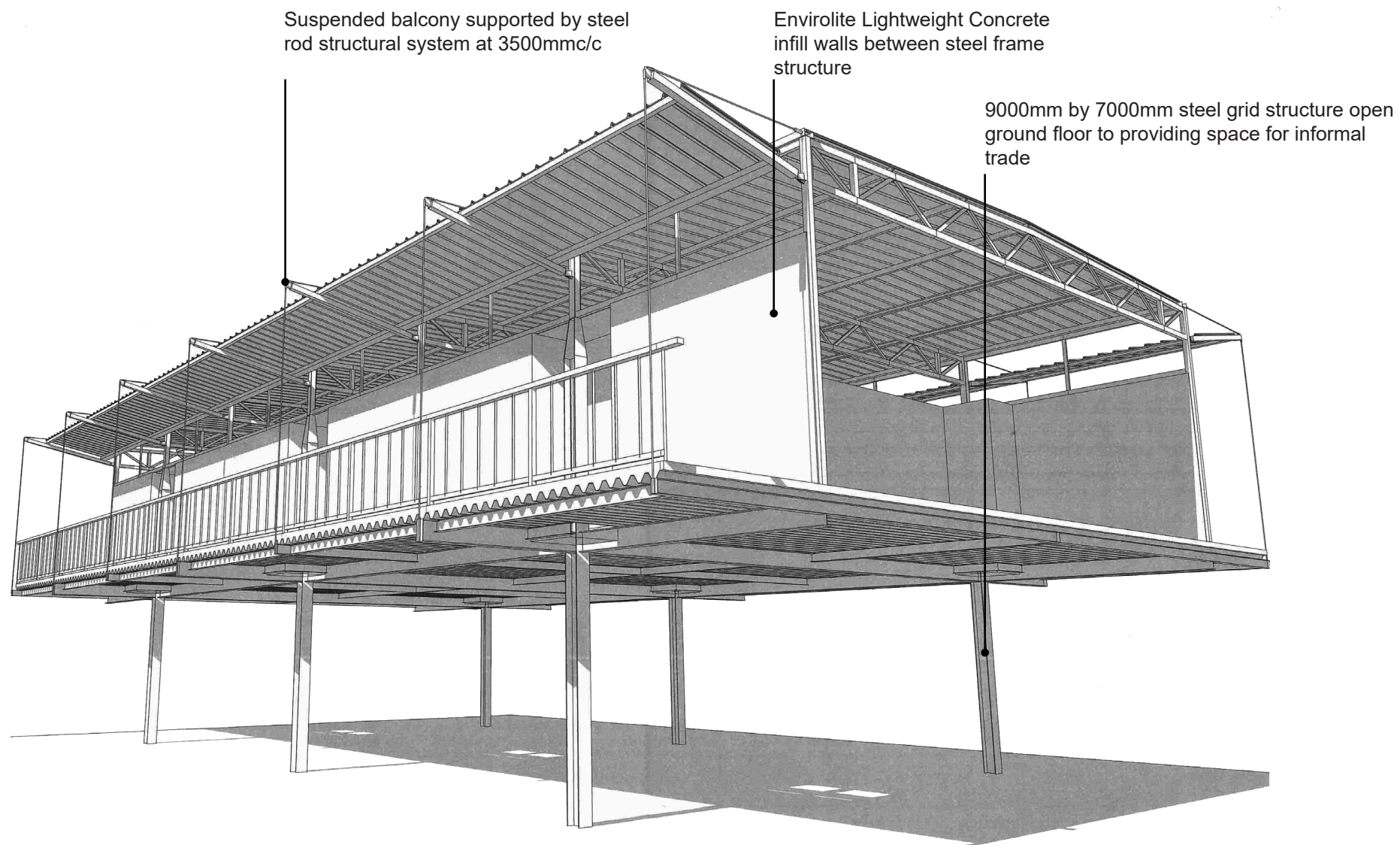
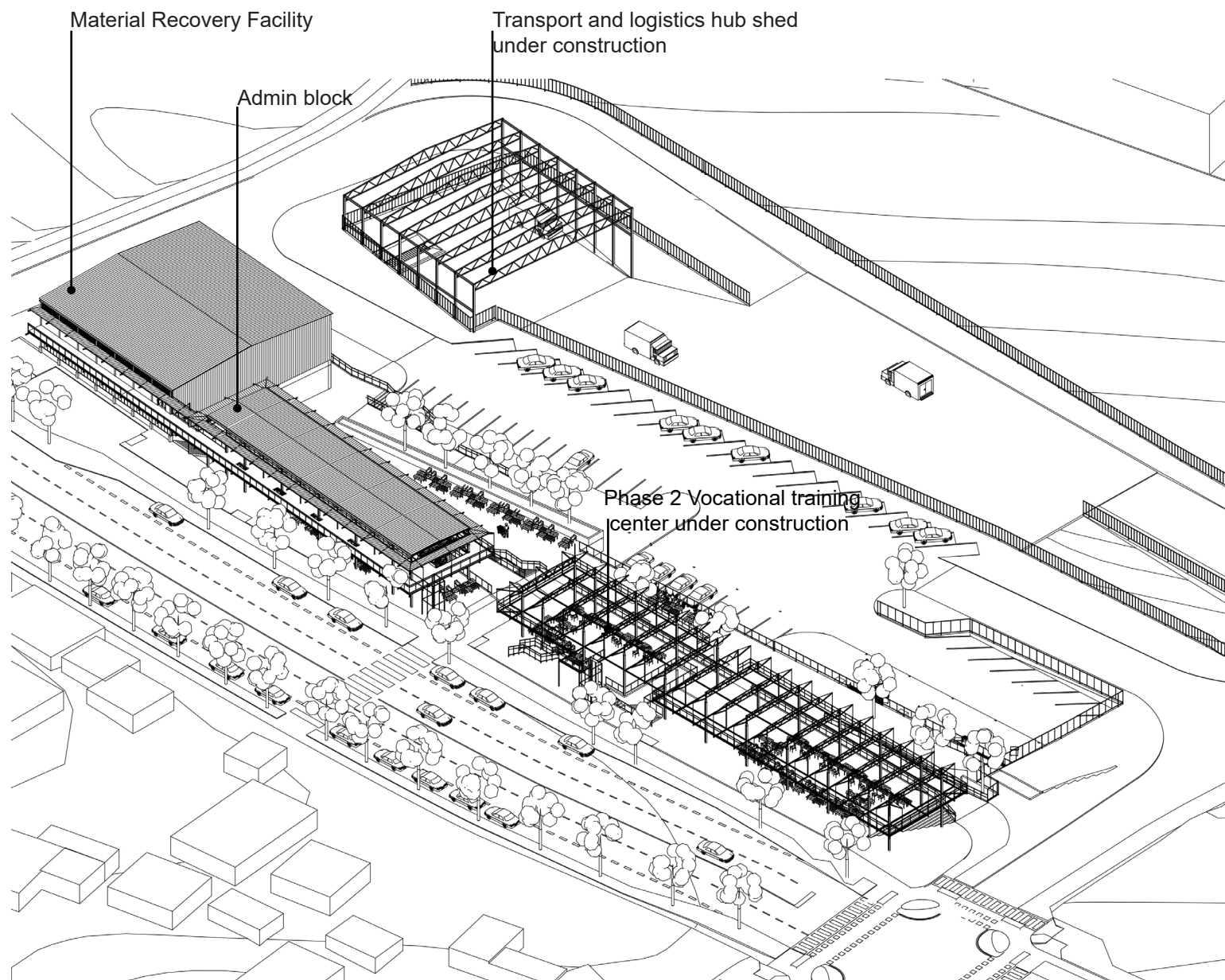


Figure 59 Conceptual modular structure

7.2 Design development phases 1-3



The project is designed in phases. The first phase provides the client, Rent-A-Drum, with a Material Recovery Facility, transport logistics hub, open markets, and administration offices. As the project develops more phases can be added. Over time it can grow and develop by providing more functions that strengthen livelihoods, such as the addition of the two vocational training centres (See Fig. 60, 61 and 62).

Figure 60 Isometric view Phase 1 development

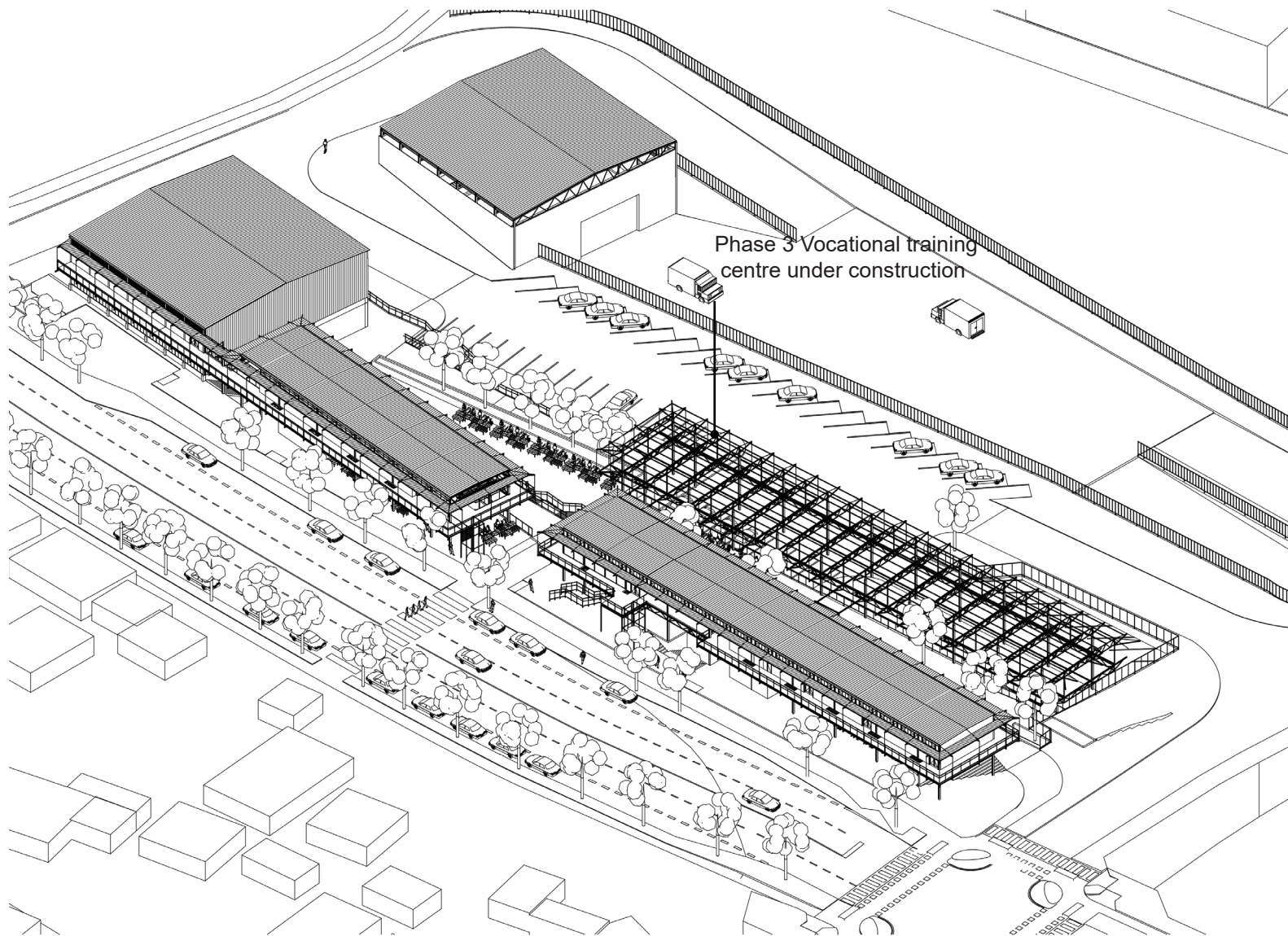


Figure 61 Isometric view Phase 2 development

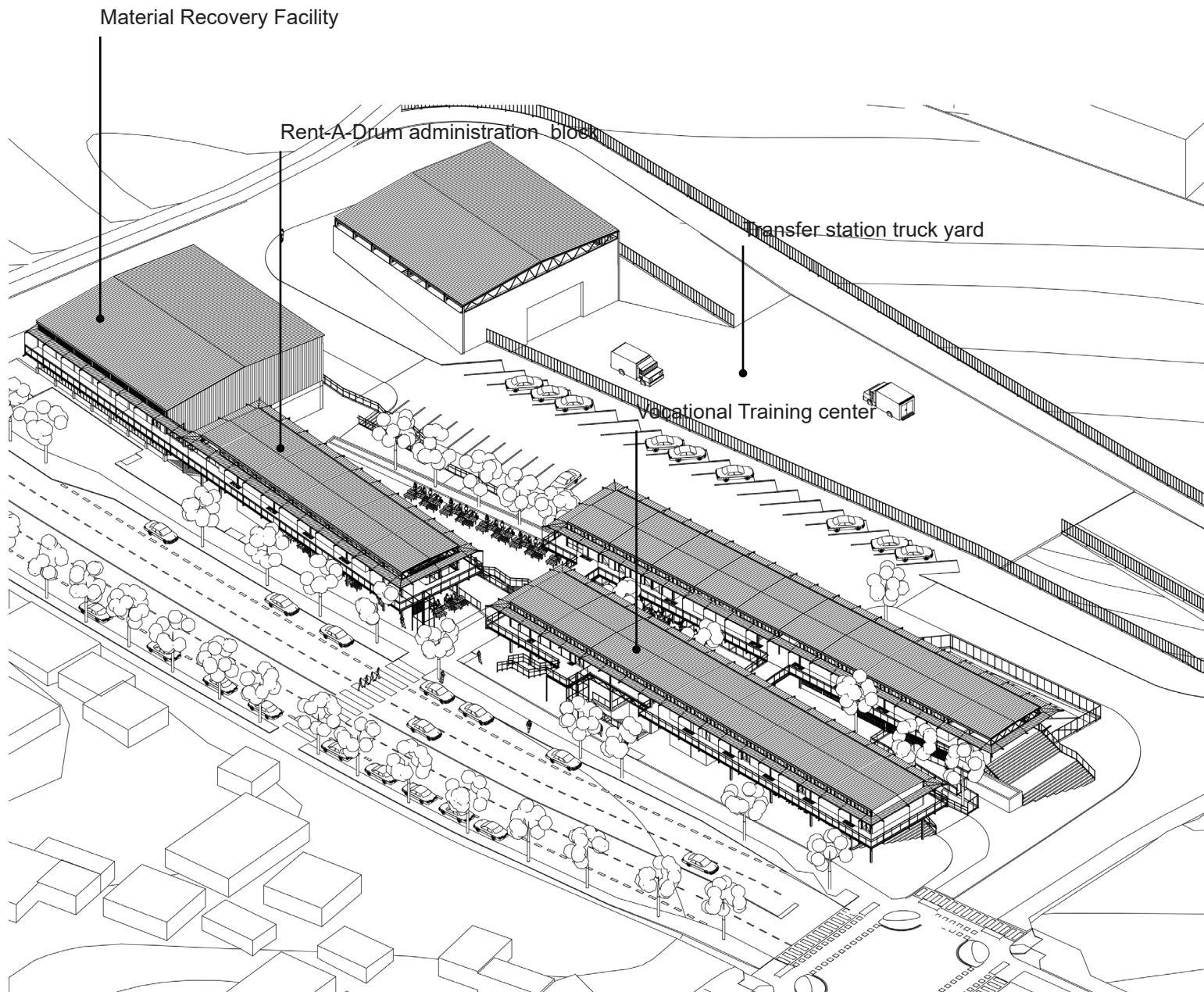


Figure 62 Isometric view Phase 3 development

8. Final Design Drawings

8.1 Ground Floor

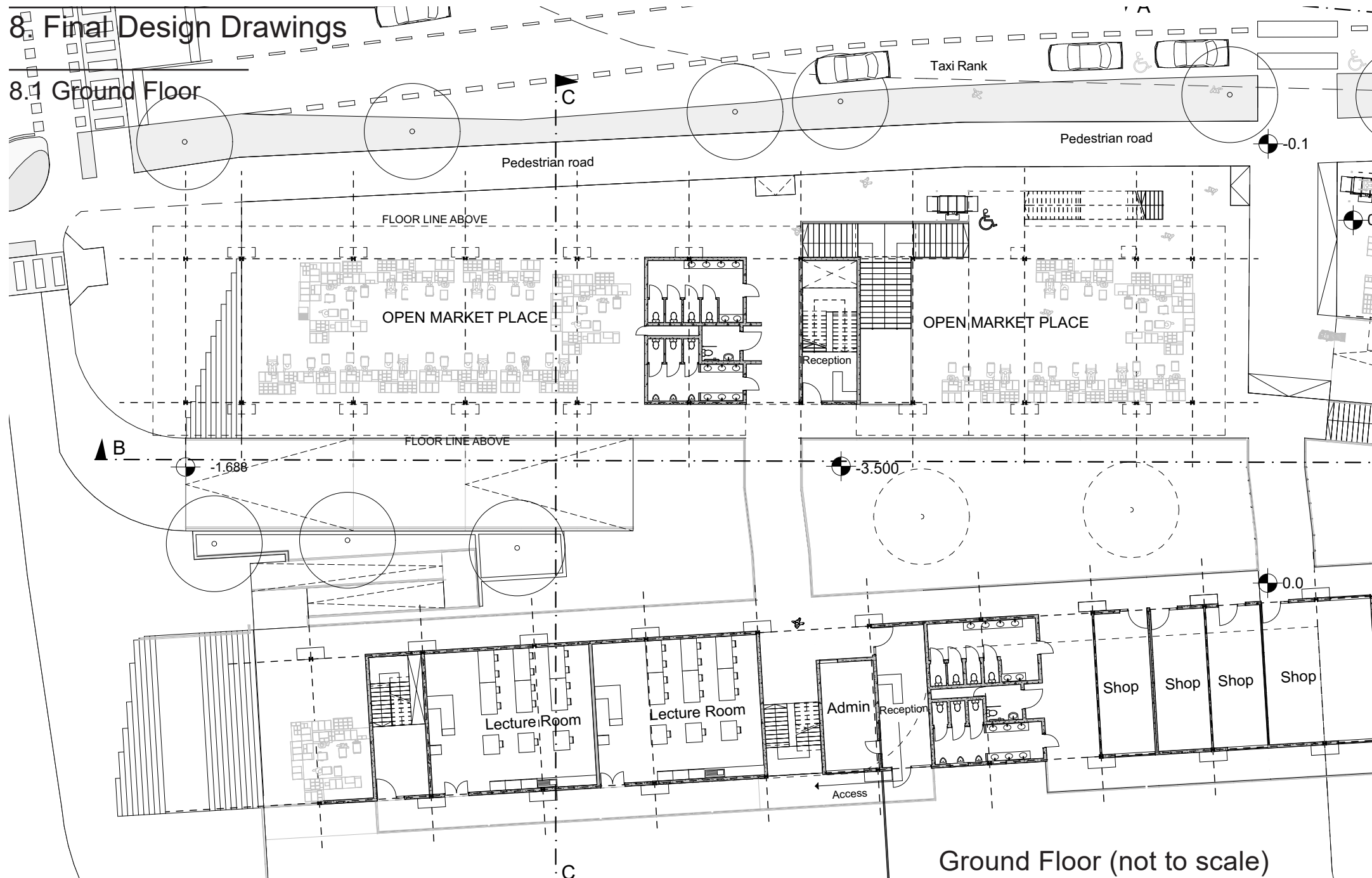
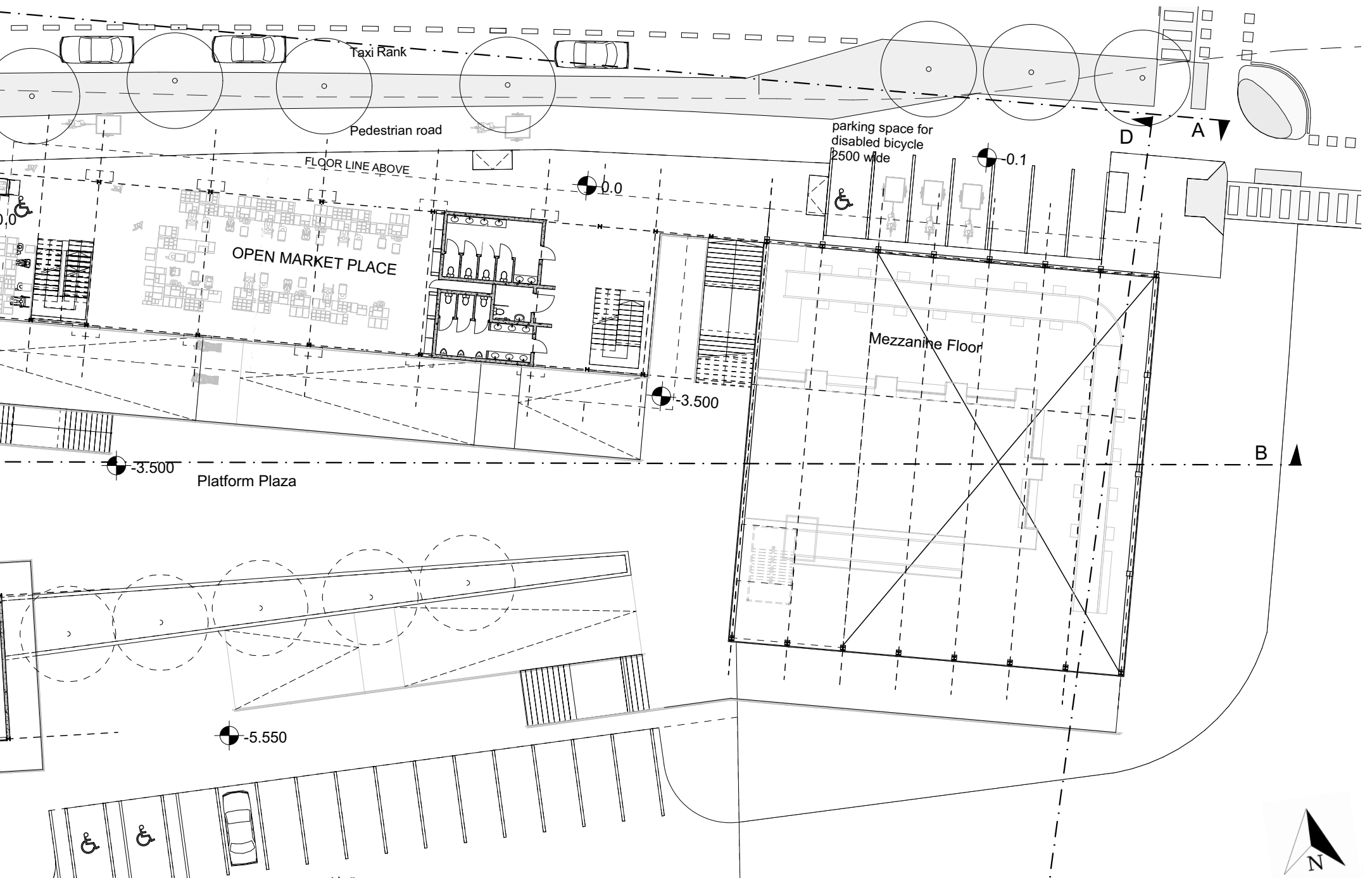


Figure 63 Ground Floor



8.2 Lower Floor

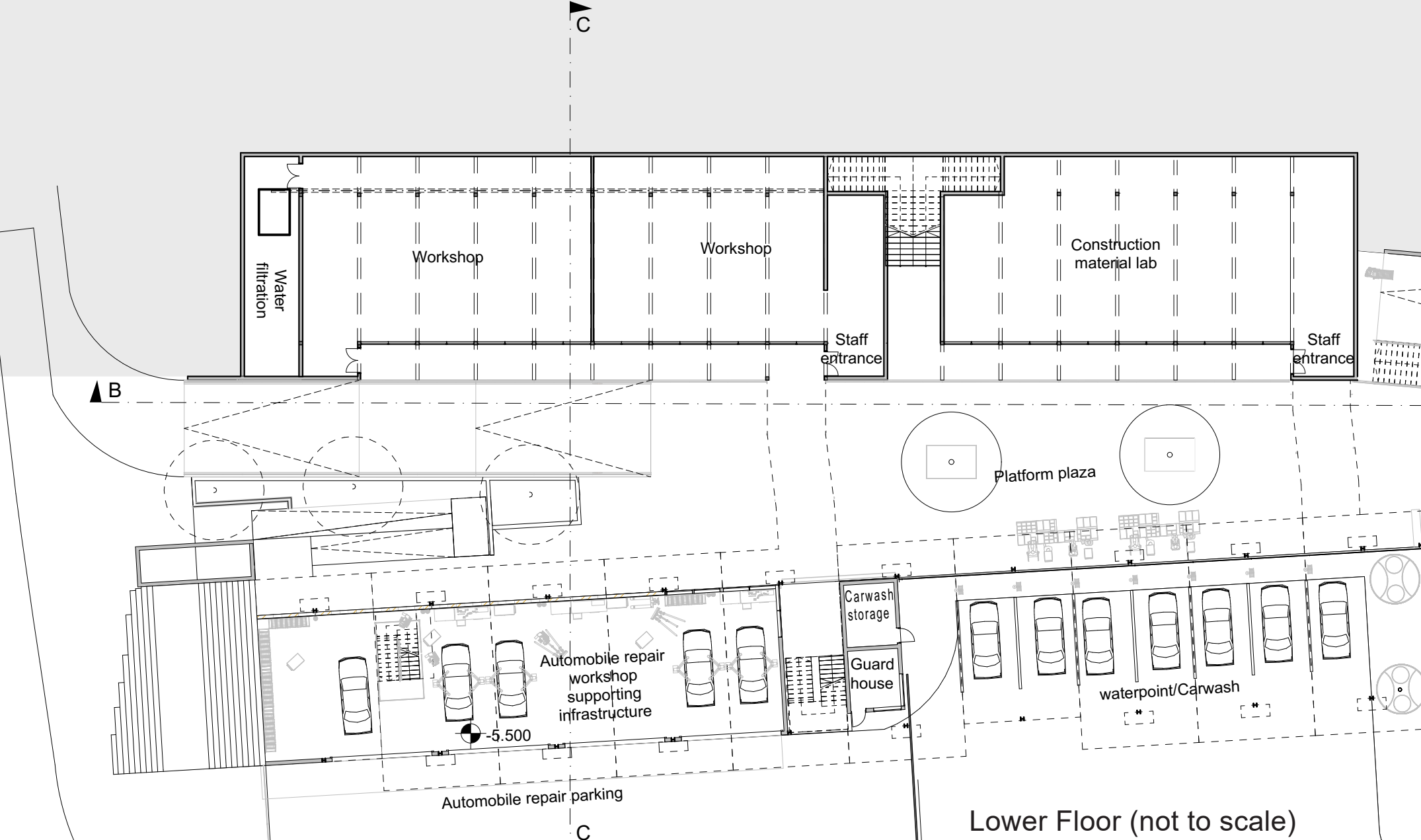
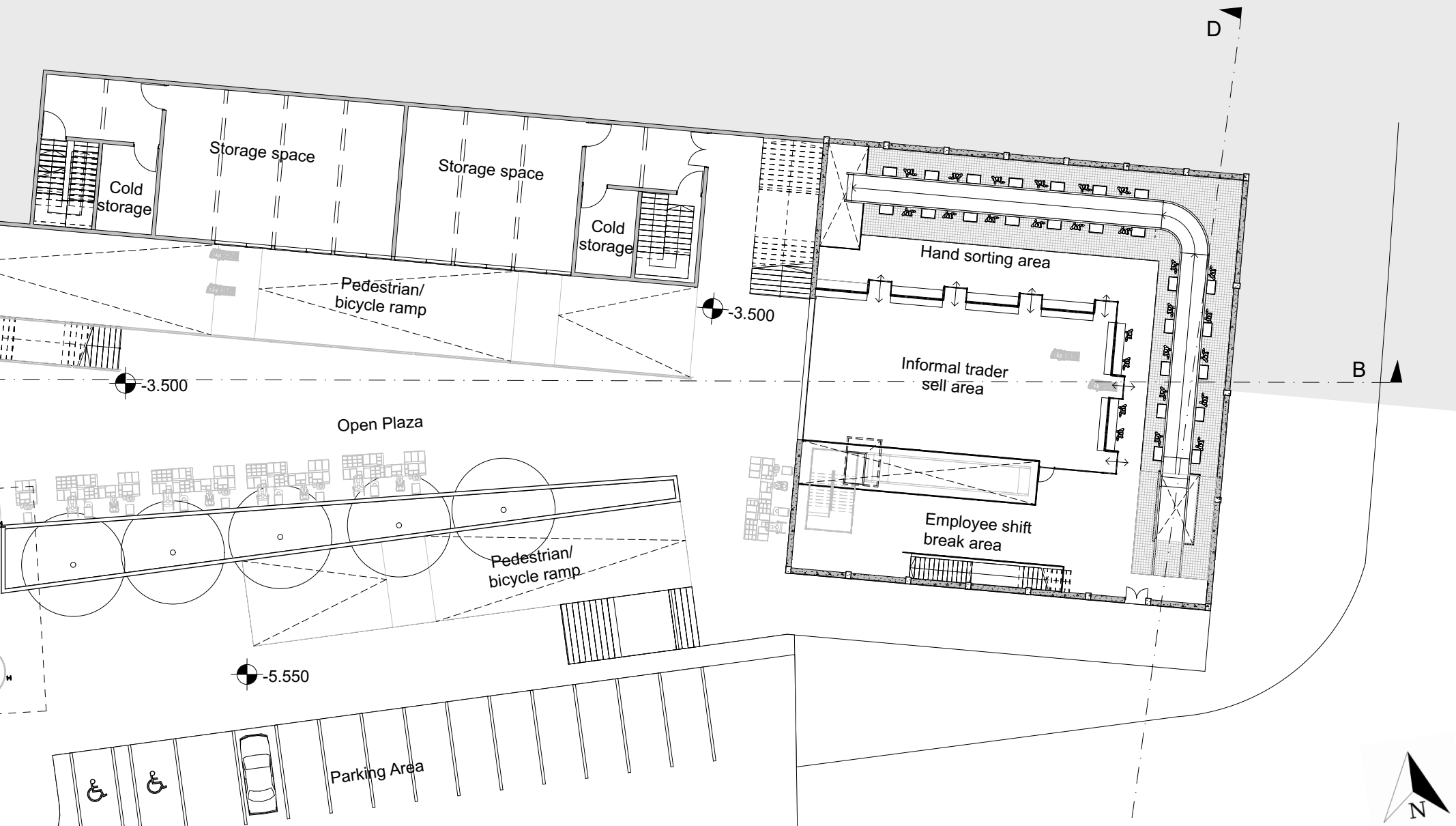


Figure 64 Lower Floor



8.3 First Floor

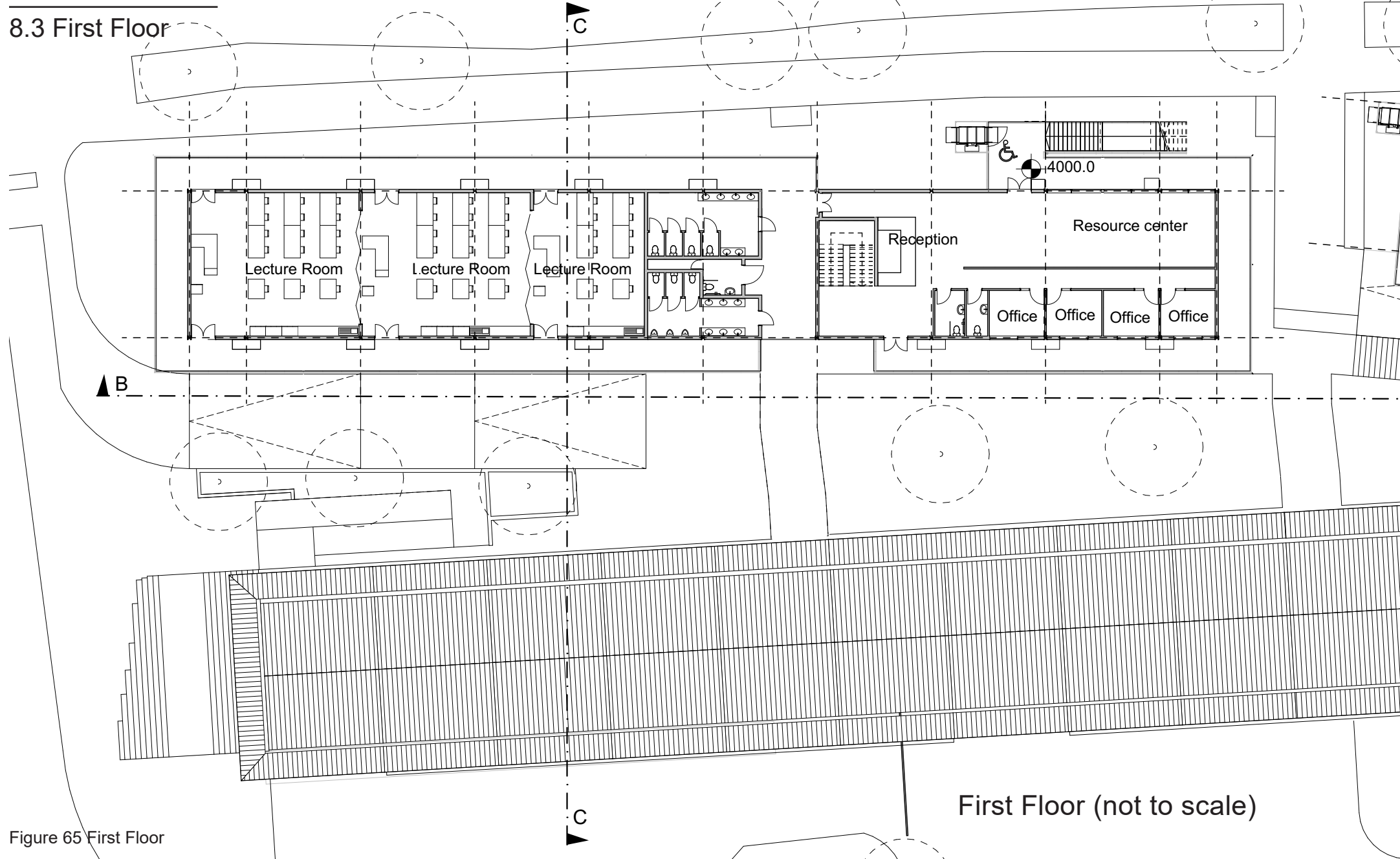
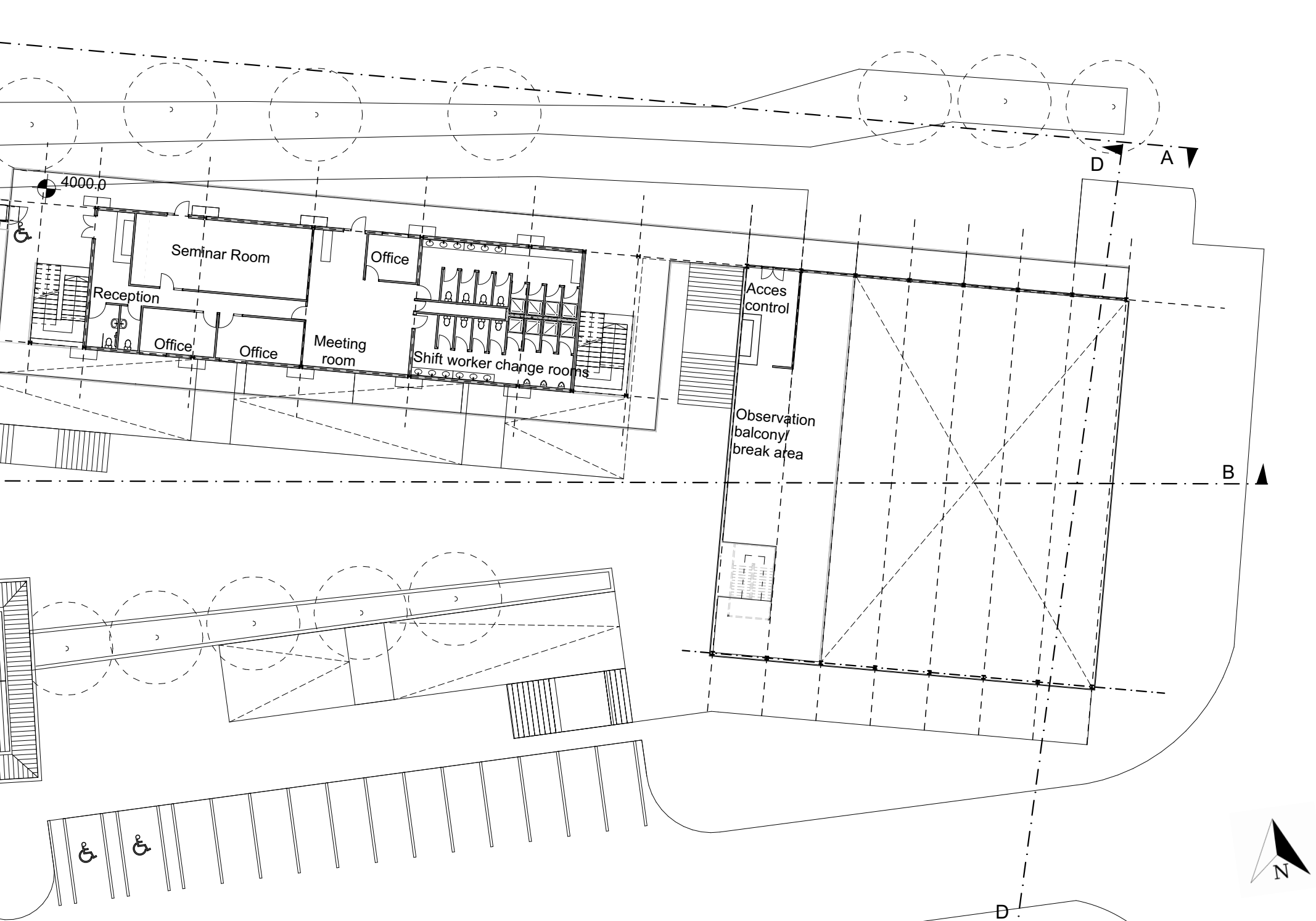


Figure 65 First Floor



8.4 Long Section B

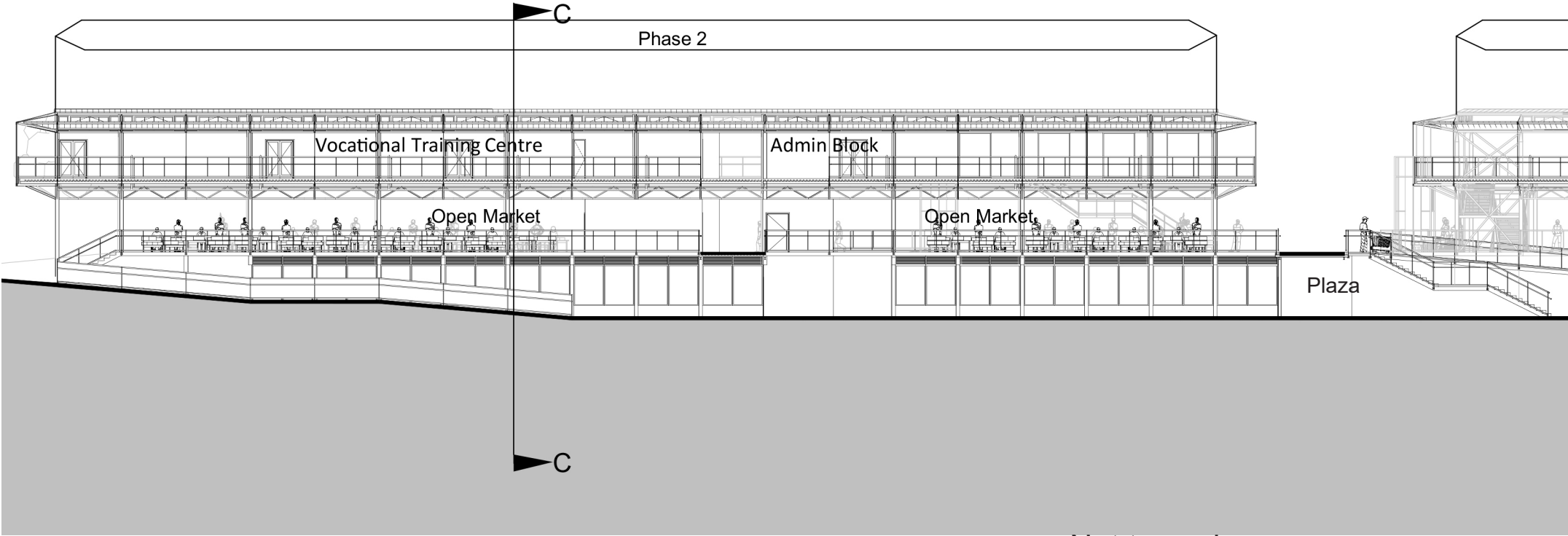
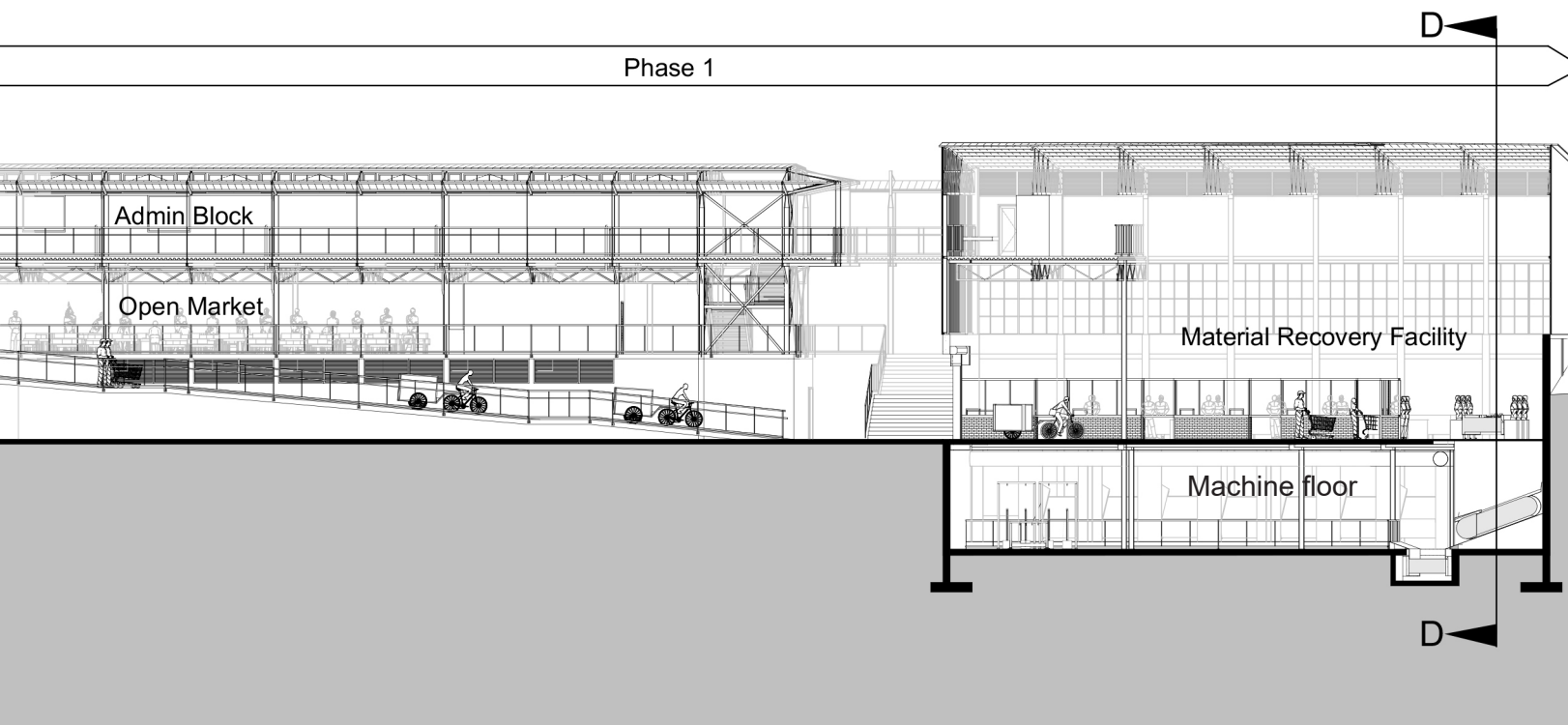


Figure 66 Long Section B

Not to scale



The following section illustrates the site accessibility through ramps that allow for the effective transport of recyclable commodities along the ramp route, where informal traders can interact with vendors that provide goods and services (see Fig. 66).

8.5 Cross Section C

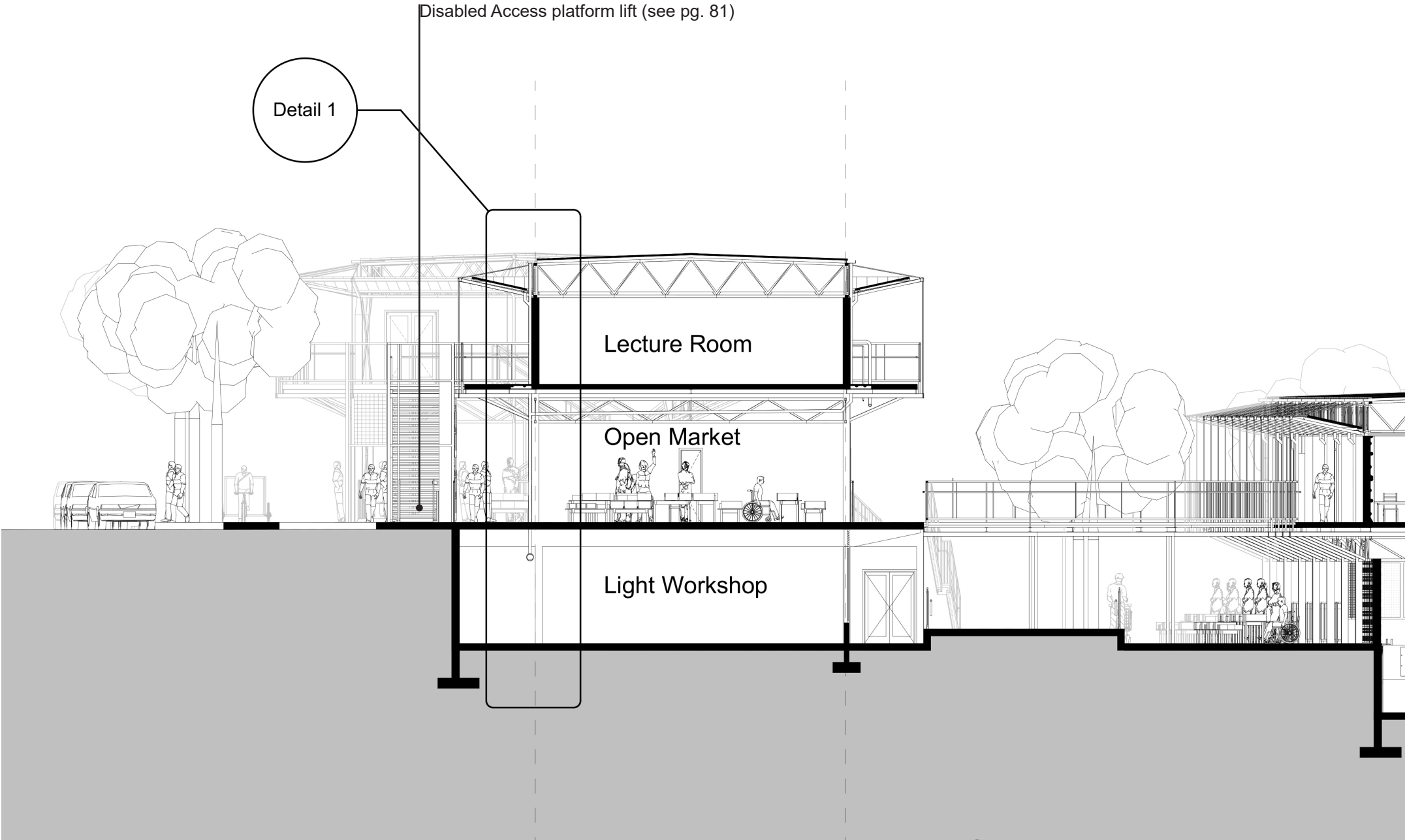
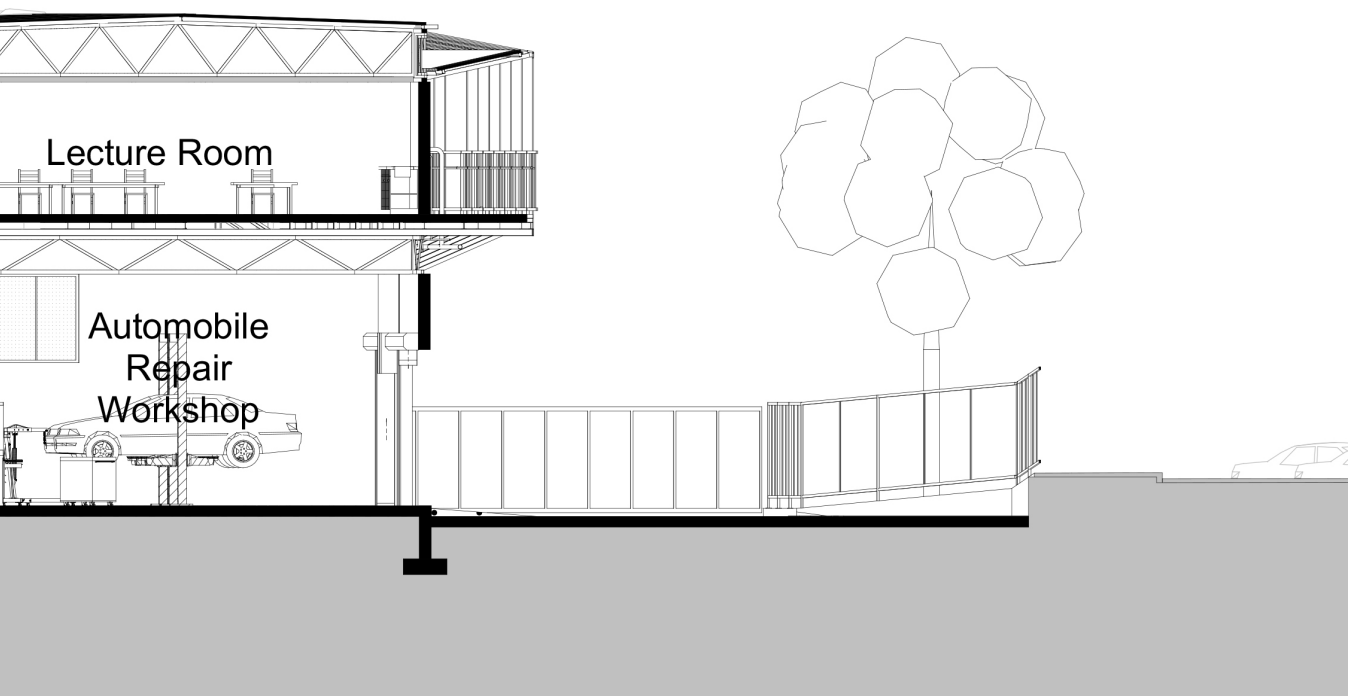


Figure 67 Short Section C

Scale 1:200



The following section illustrates the central plaza between the two vocational training centres: Phase 2: vocational training: south-facing facade incorporates large windows allowing visitors to peer into the workshops to be inspired by the activity. The building needs to show the idea of individuals improving their livelihoods (see Fig. 67).

Bridge connections allow access between phases and improves accessibility for the occupants of the buildings (see Fig. 67).

8.6 Cross Section D

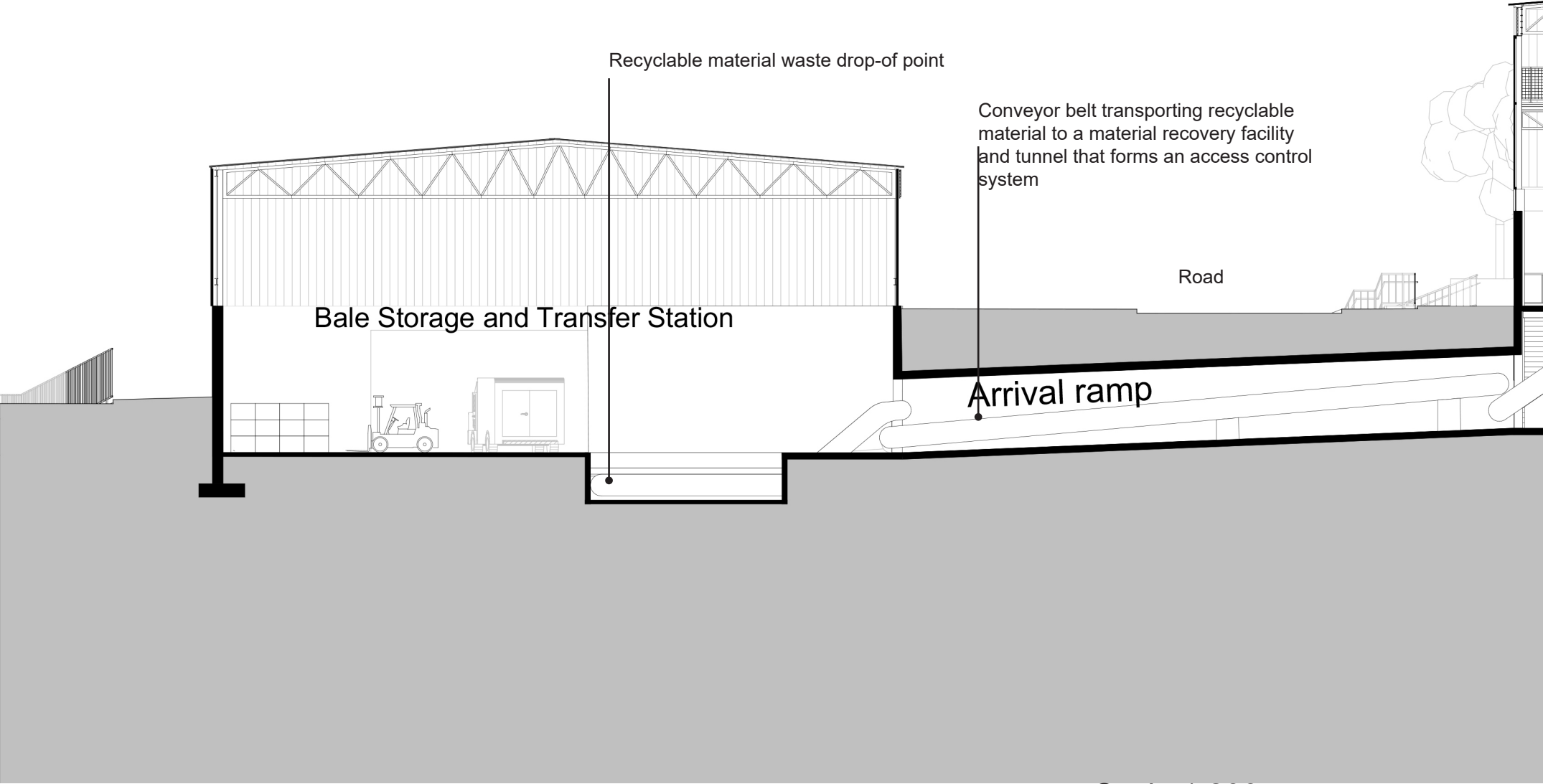
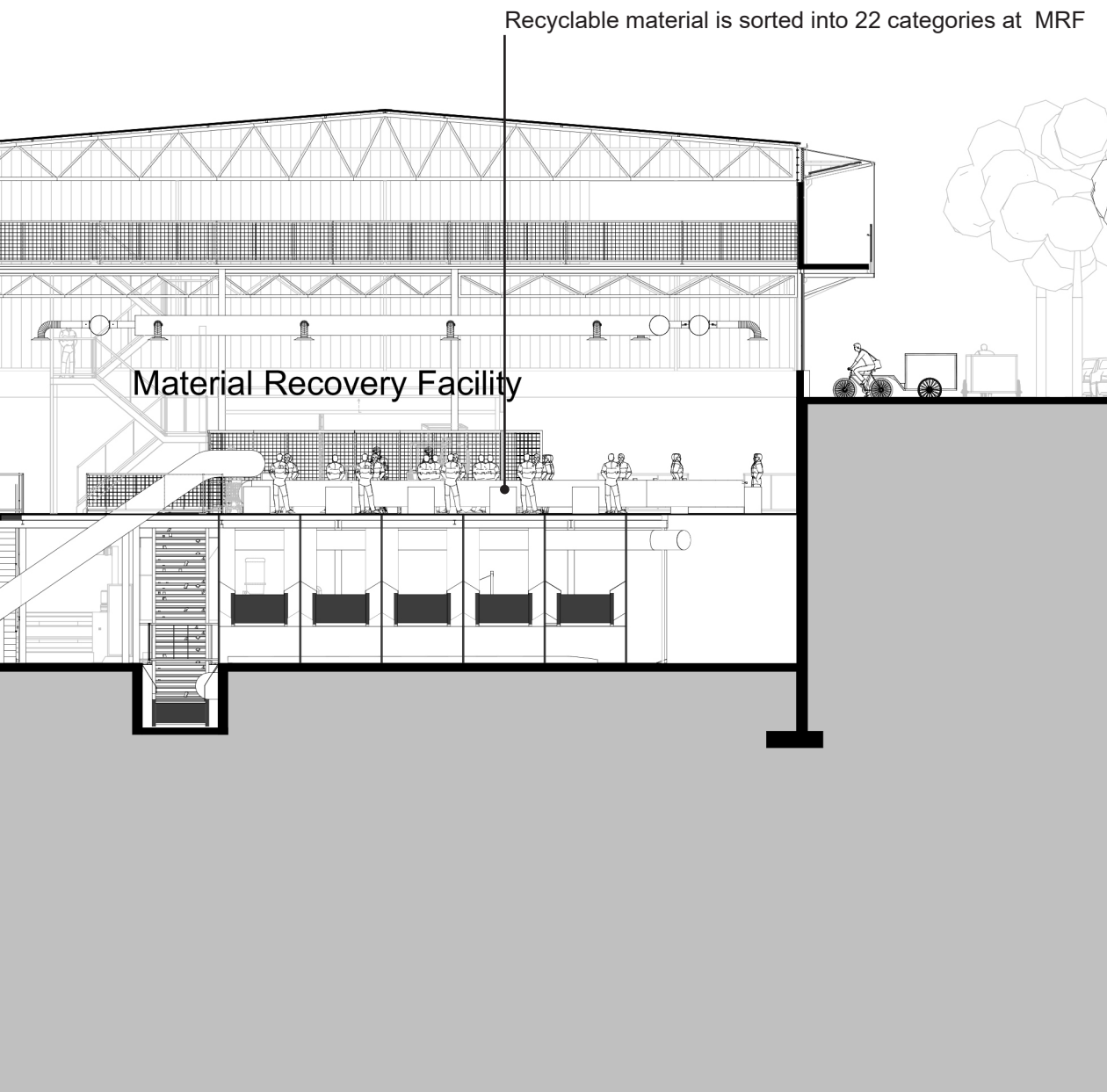


Figure 68 Short Section D

Scale 1:200



The following section illustrates the interconnection between the transfer station and the Material Recovery Facility. The tunnel controls movement of recyclables between the transfer station and the Material Recovery Facility (see Fig. 68).

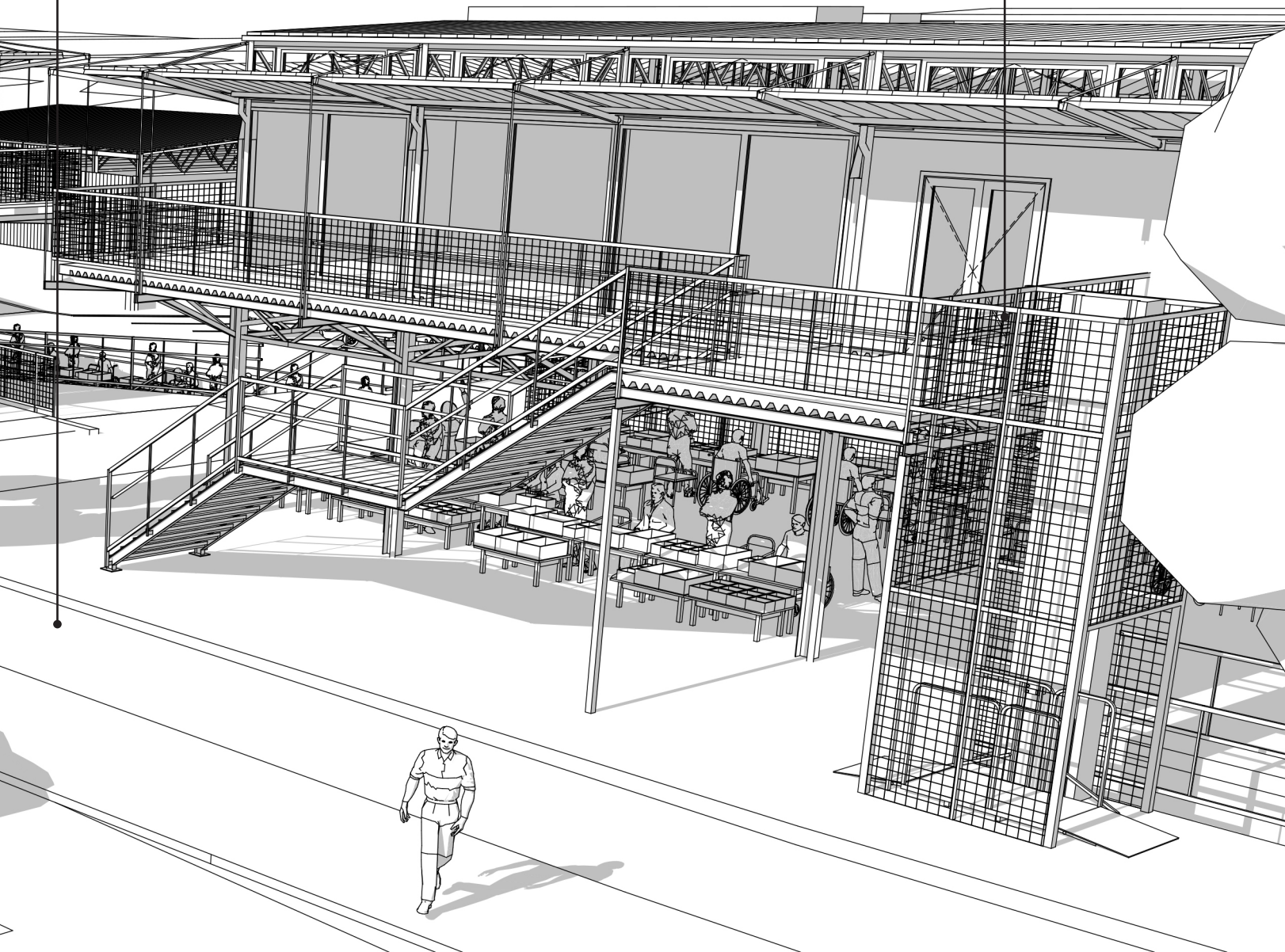
9.Perspectives



Figure 69 Perspective of project from Monte Christo corridor

Main entrance to project

Disabled platform lift



View of informal socio-economic activity incorporated within the building form at the main entrance of the building. Informal waste pickers can transfer their goods along the bicycle lanes. All floors within the building are accessible by inclusive design. Vertical platform lifts are incorporated for easy access between levels (see Fig. 69).

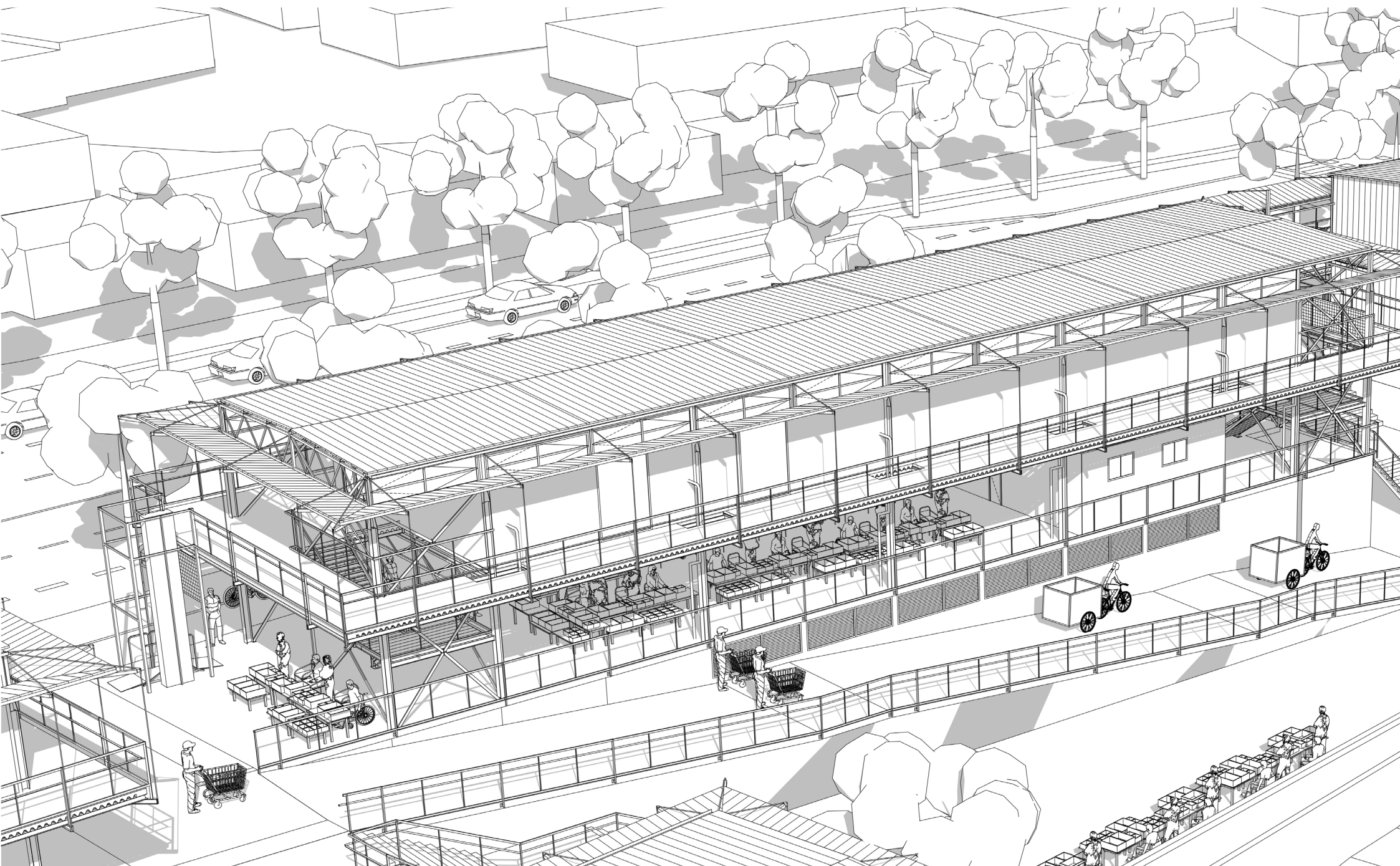
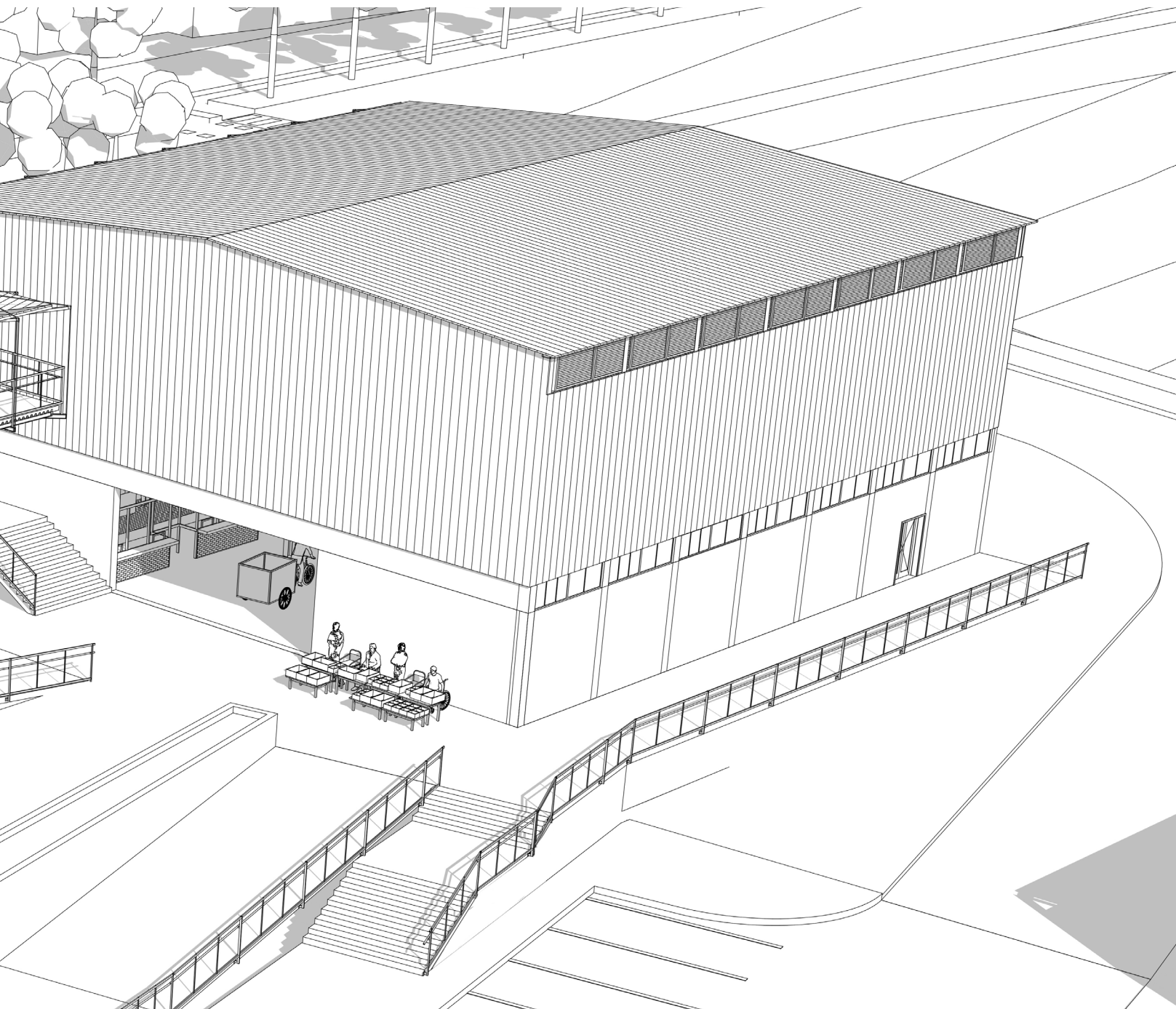


Figure 70 Ramp leading to Material Recovery Facility



View of informal waste pickers transporting recyclable materials along ramp towards anchor point of socio-economic agency (see Fig. 70).

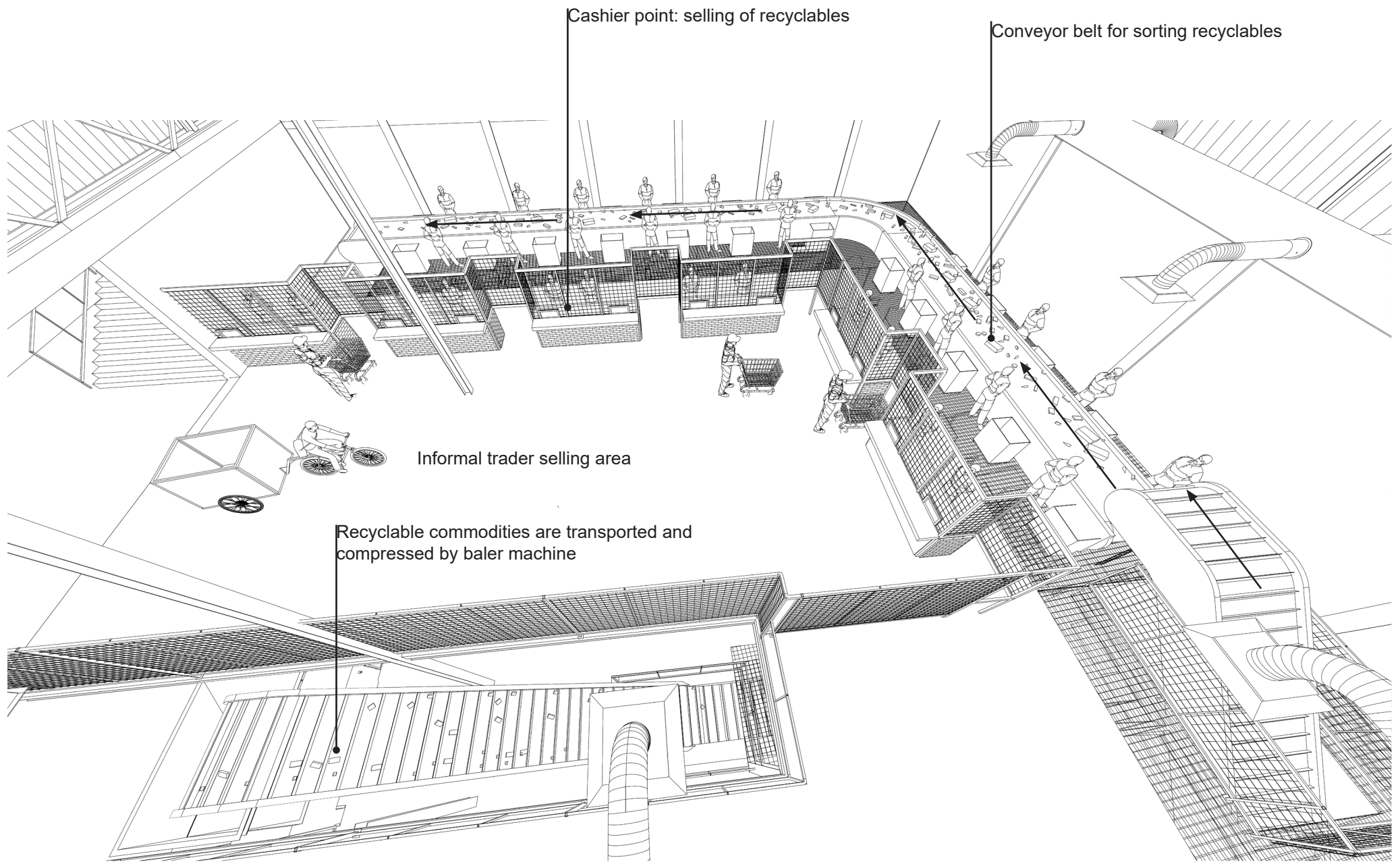
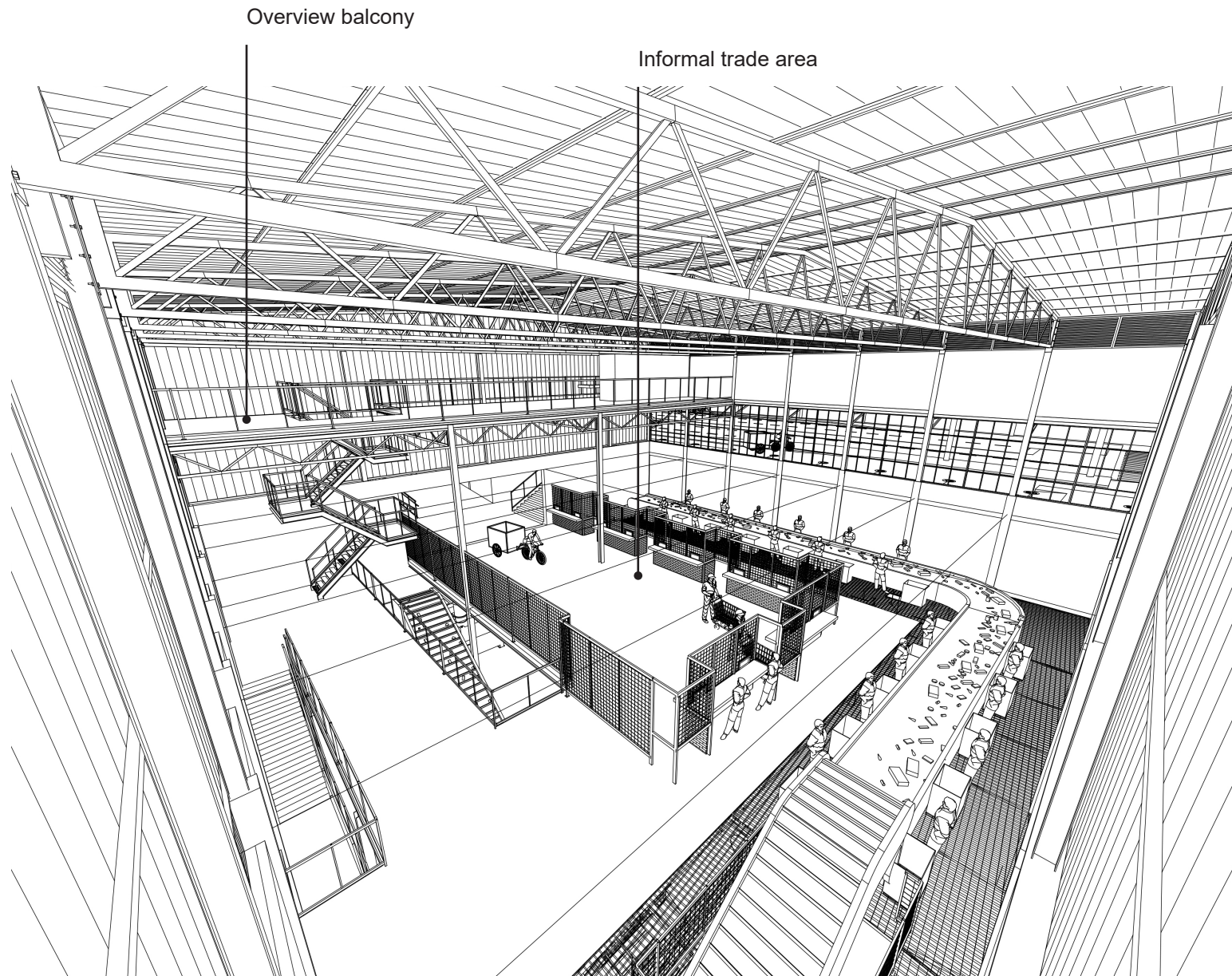


Figure 71 Interior view of MRF 1



Interior view of the integration of formal and informal actors involved with recycling activity; vendors sell directly to Rent-A-Drum. The material recovery sorts 22 types of commodities improving the types of recyclable materials that can be recovered from the northern periphery (See Fig. 71-74).

Figure 72 Interior view of MRF 2

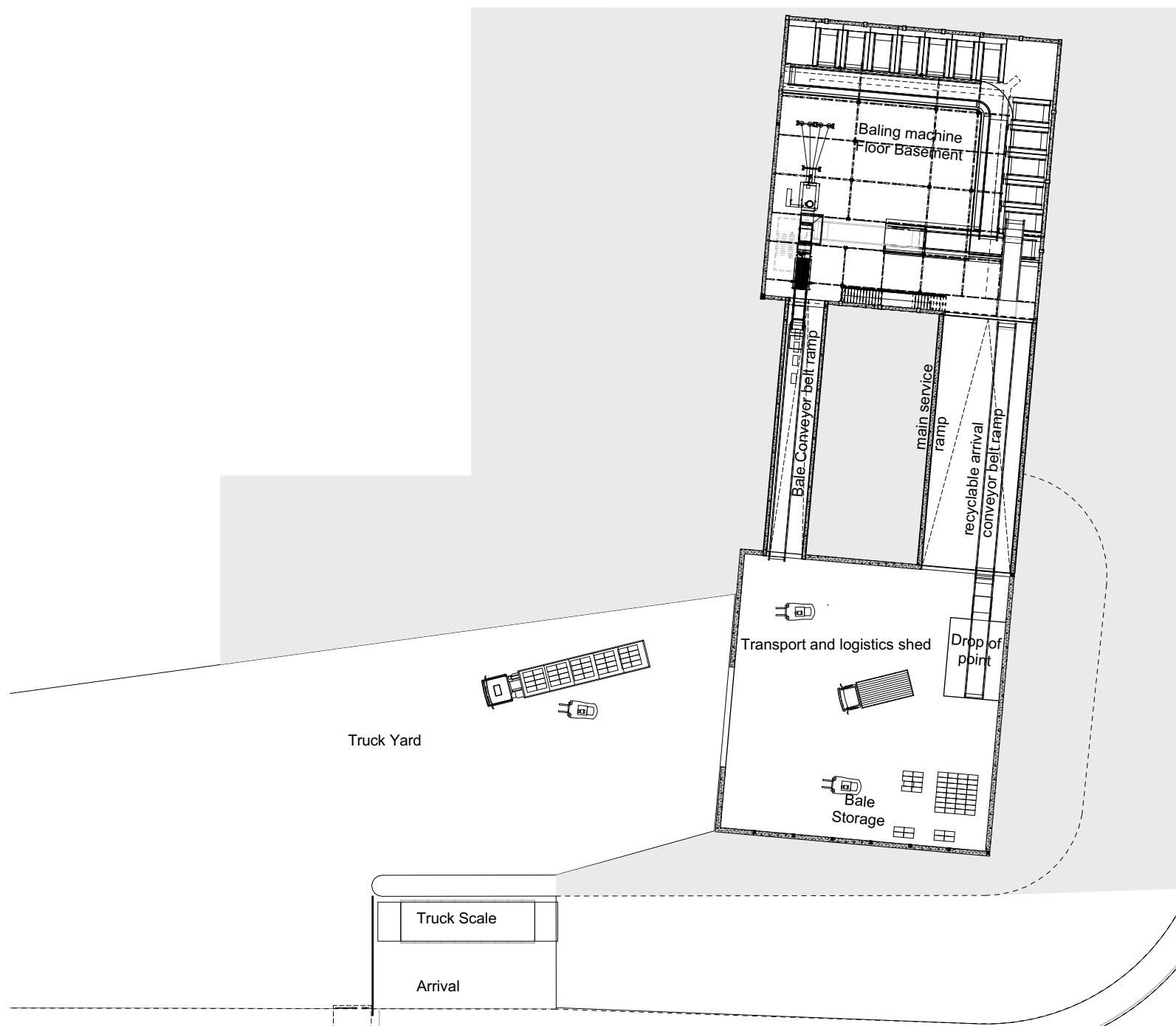
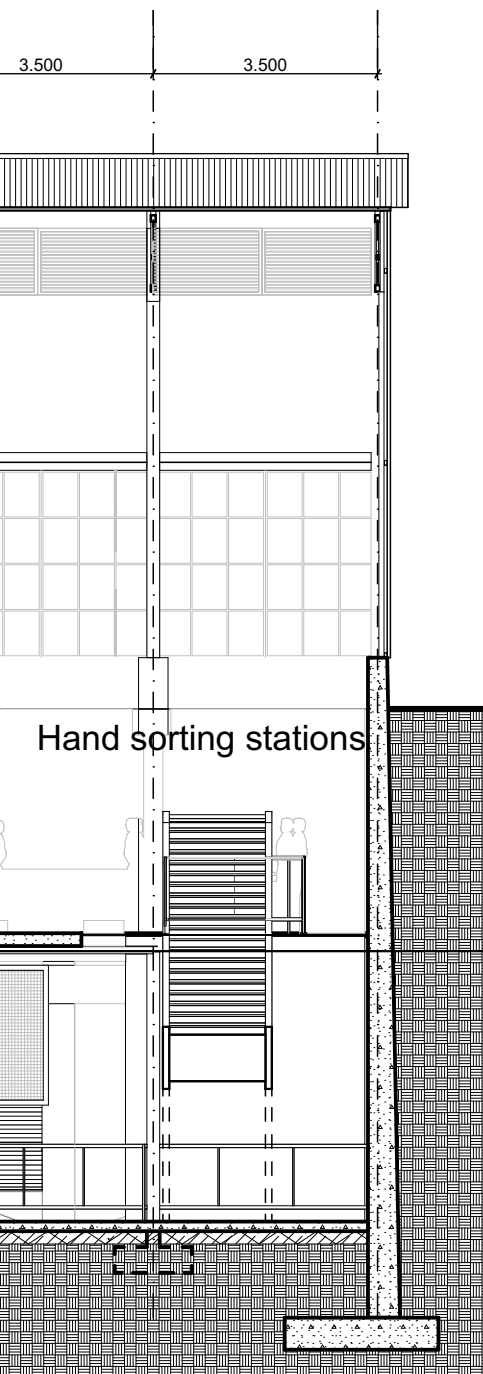


Figure 74 Machine floor plan scale 1:500

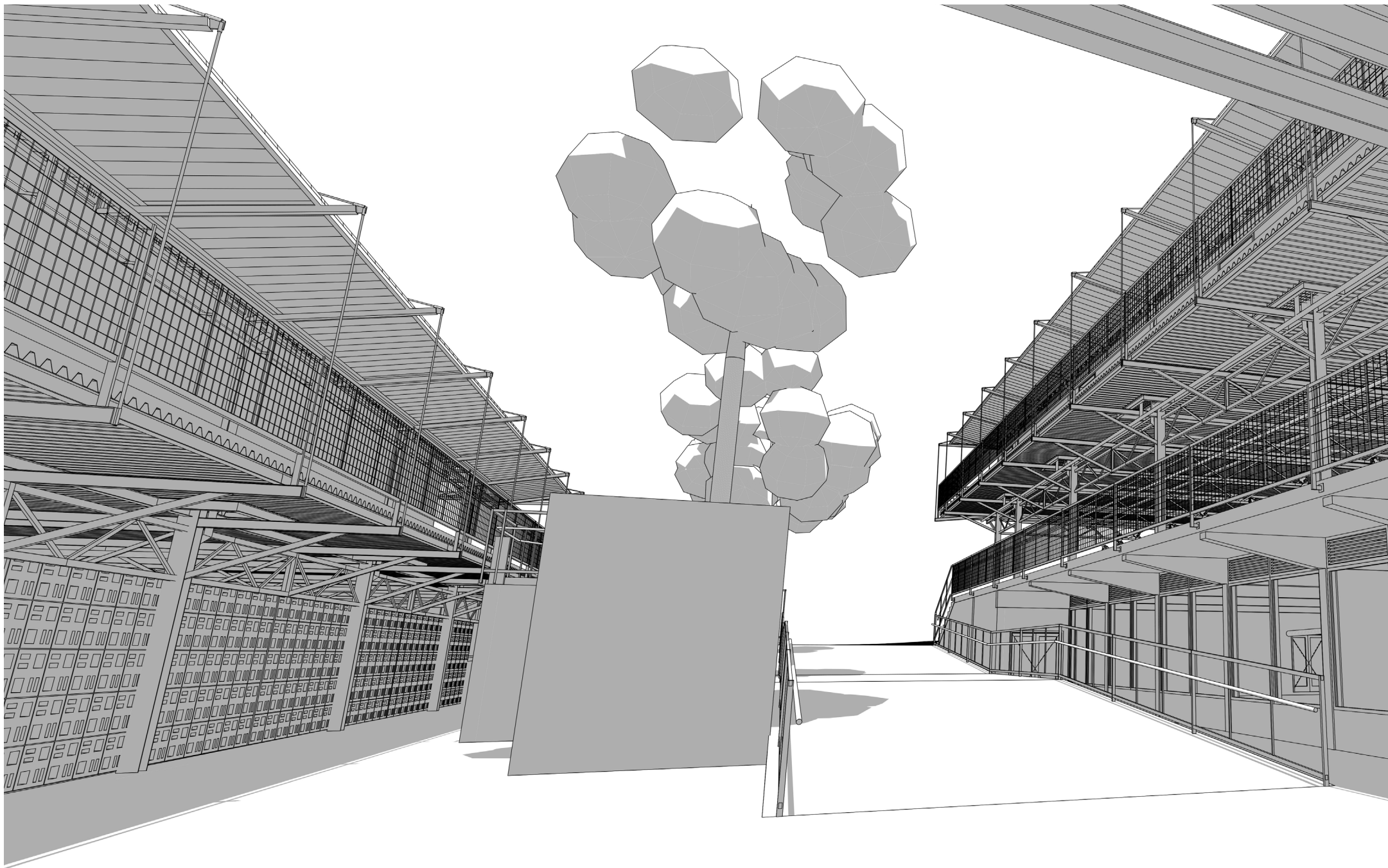
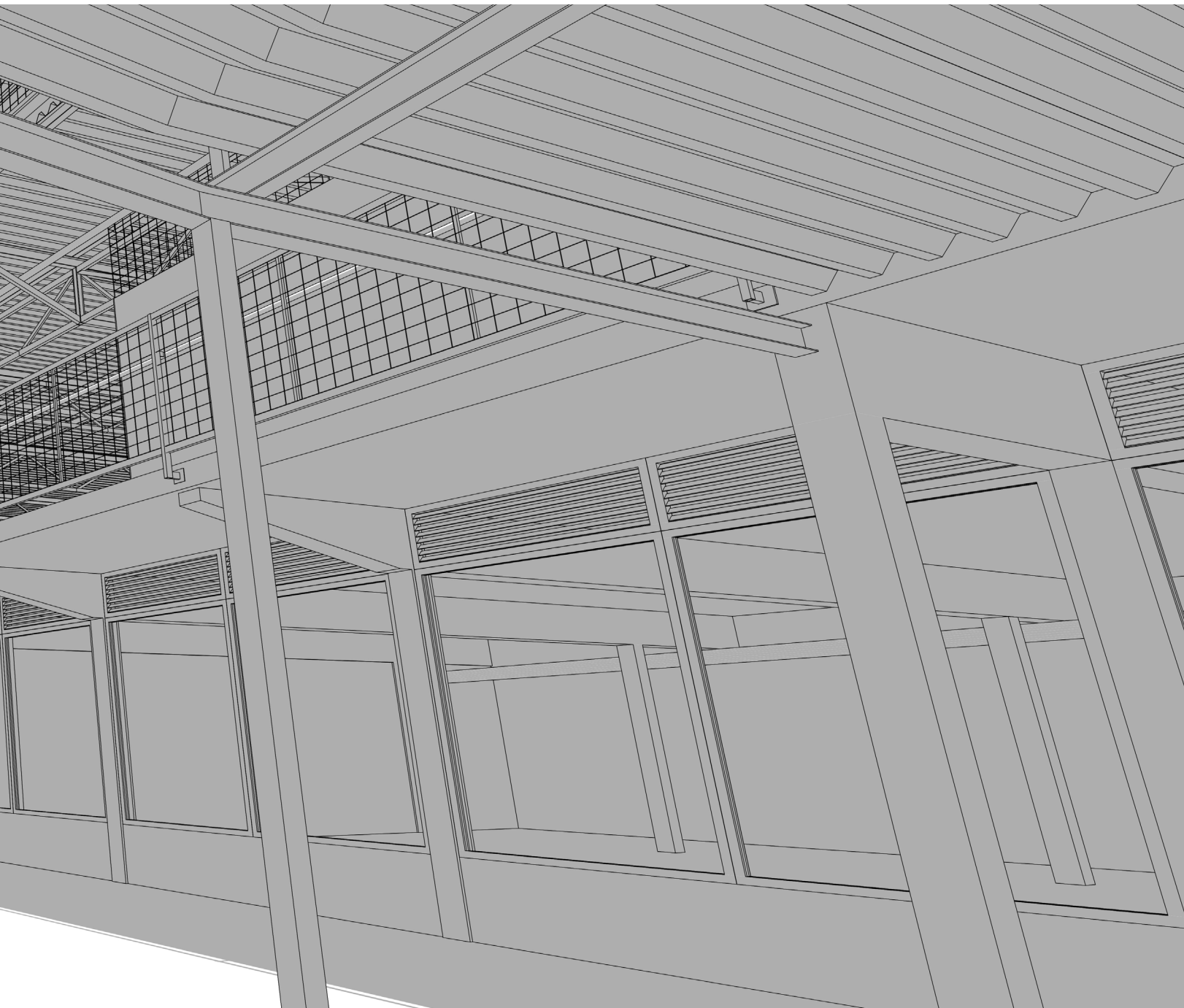


Figure 75 Interior view of corridor



View of the interior courtyard: Visitors can view activity through the glass façade (see Fig. 75). The automobile repair workshop facade is constructed out of recyclable composite breeze blocks that are composed of recycled glass aggregate and cement. The blocks are constructed by the vocational training students. The modular steel frame structure accommodates all load bearing requirements allowing infill walls to be constructed out of a wide range of possible infill materials that are not constricted by load bearing requirements. Infill walls can be replaced if needed to accommodate change and adaptation over time.

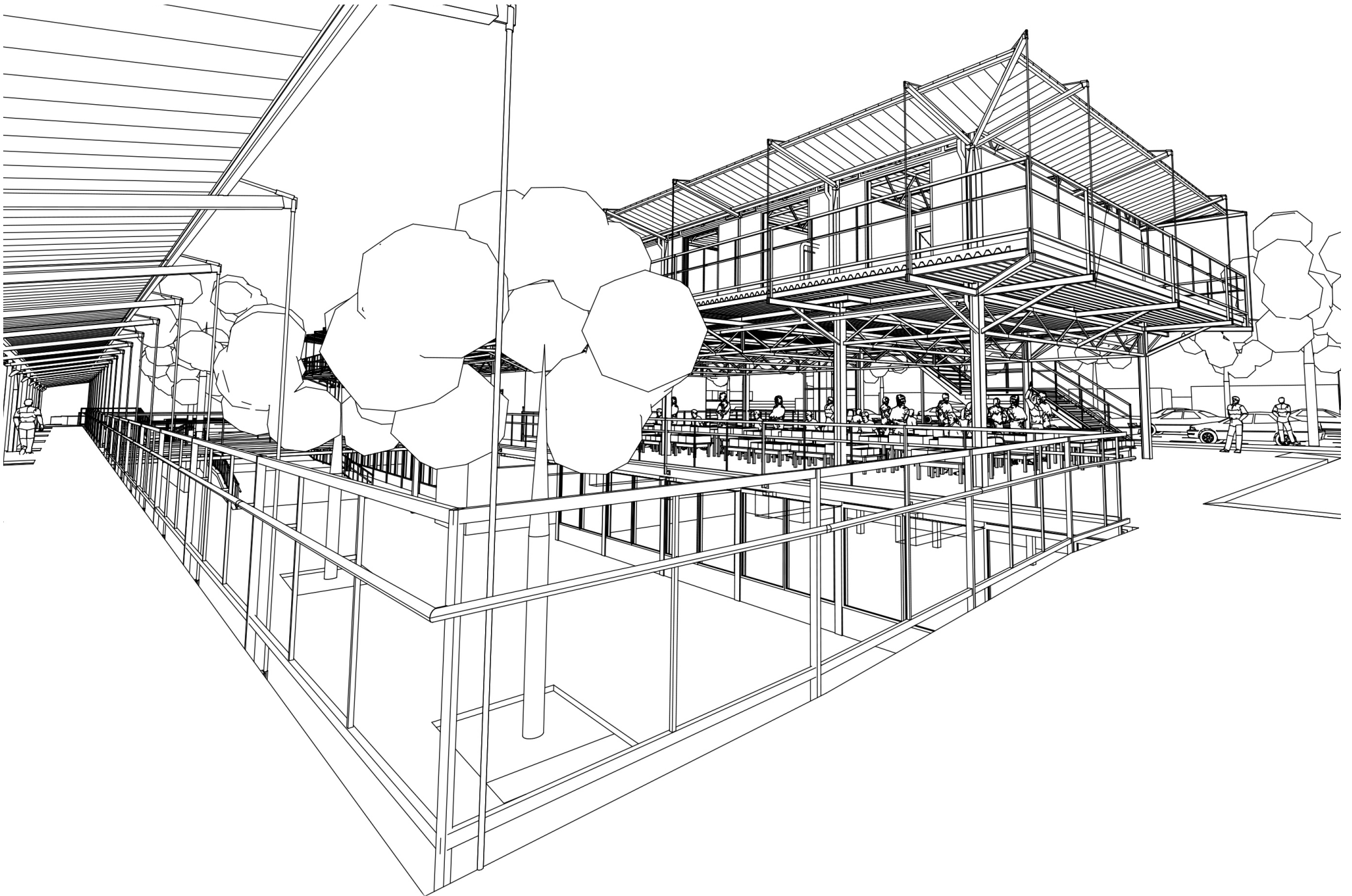
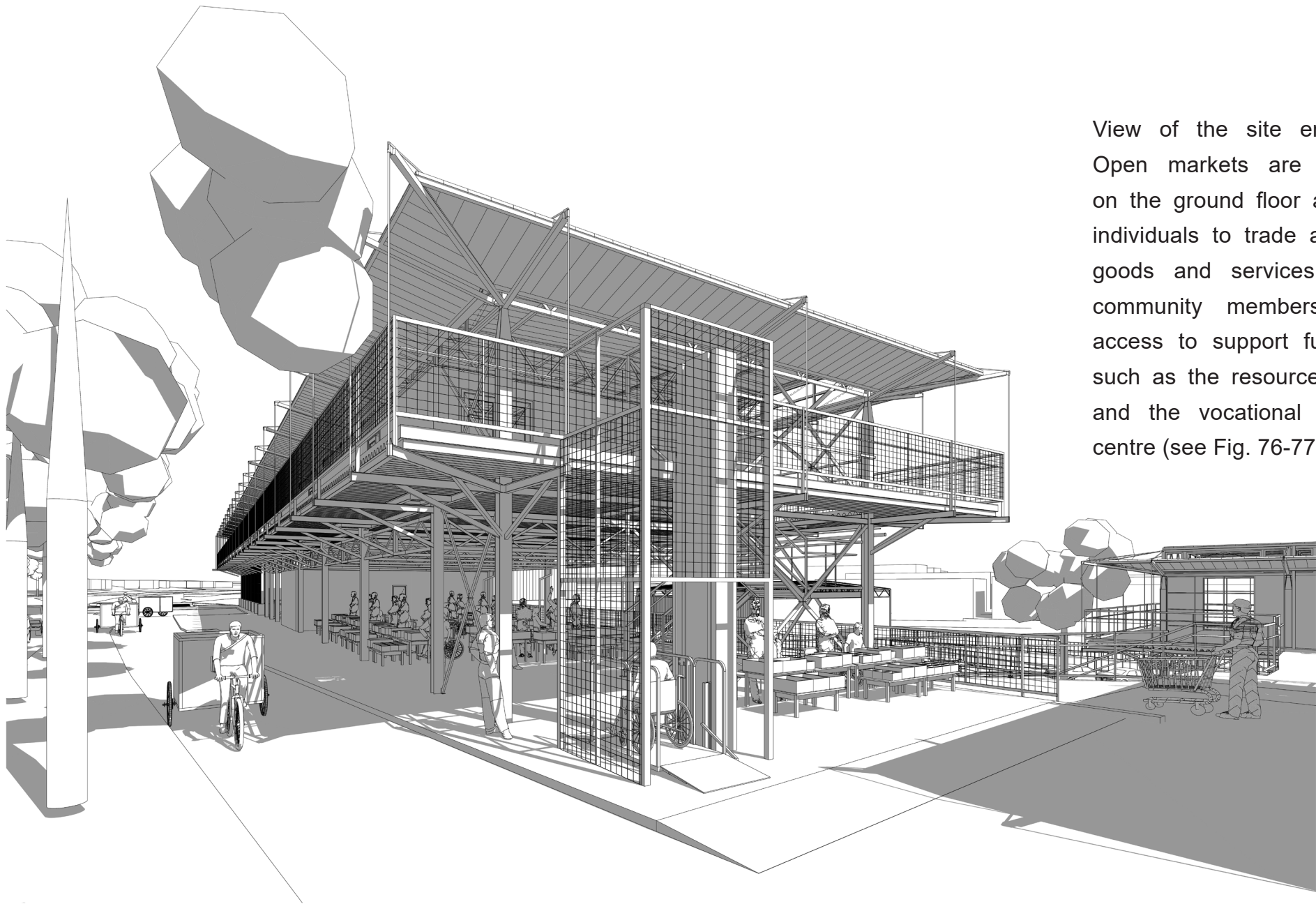


Figure 76 View of bridge transition between phases



View of the site entrance: Open markets are located on the ground floor allowing individuals to trade and sell goods and services. Local community members have access to support functions such as the resource centre and the vocational training centre (see Fig. 76-77).

Figure 77 View of site entrance

10. Technical documentation

10.1 Detailed view of structural system

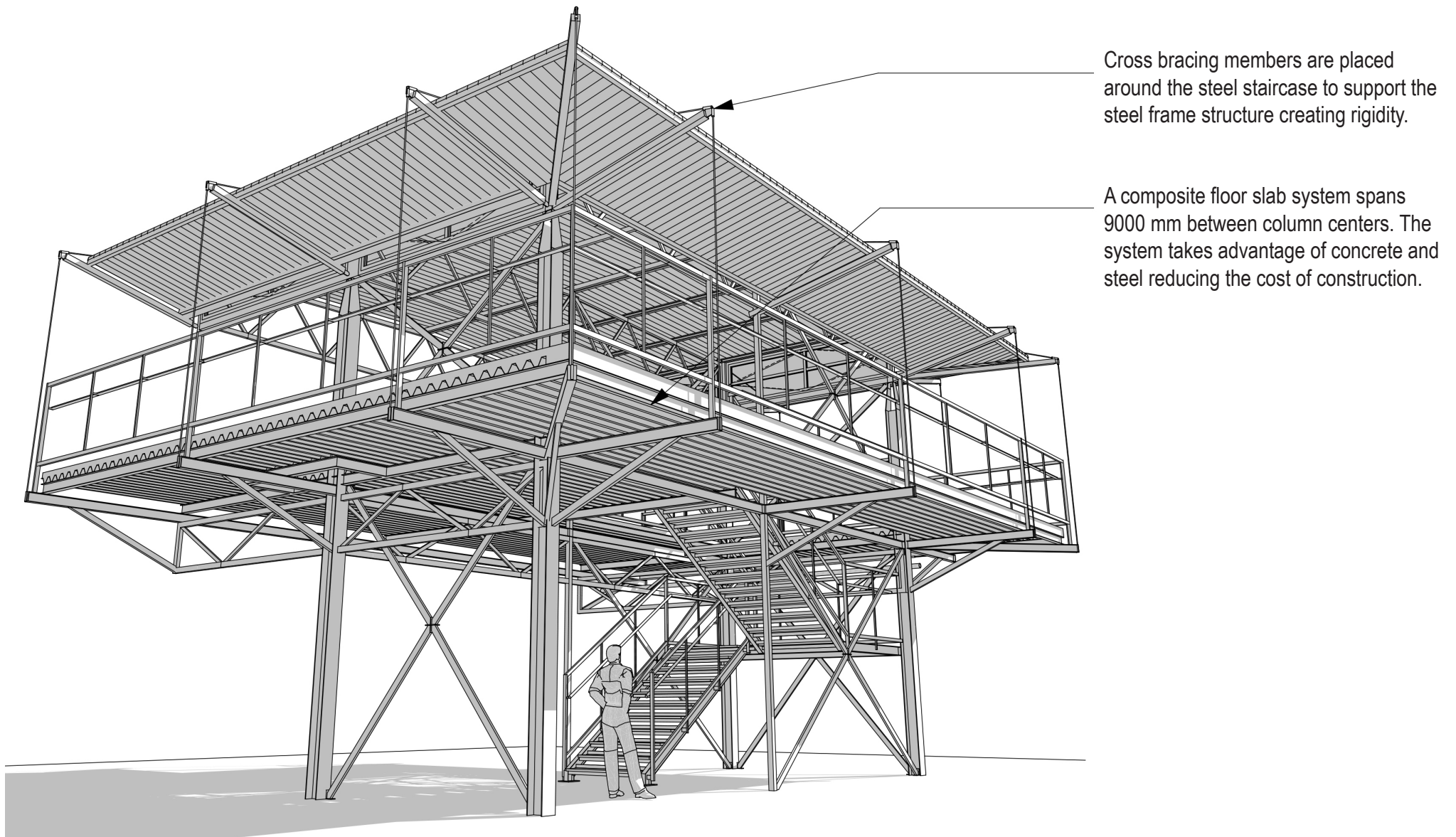


Figure 78 Detailed structural system

10.2 Detail 1

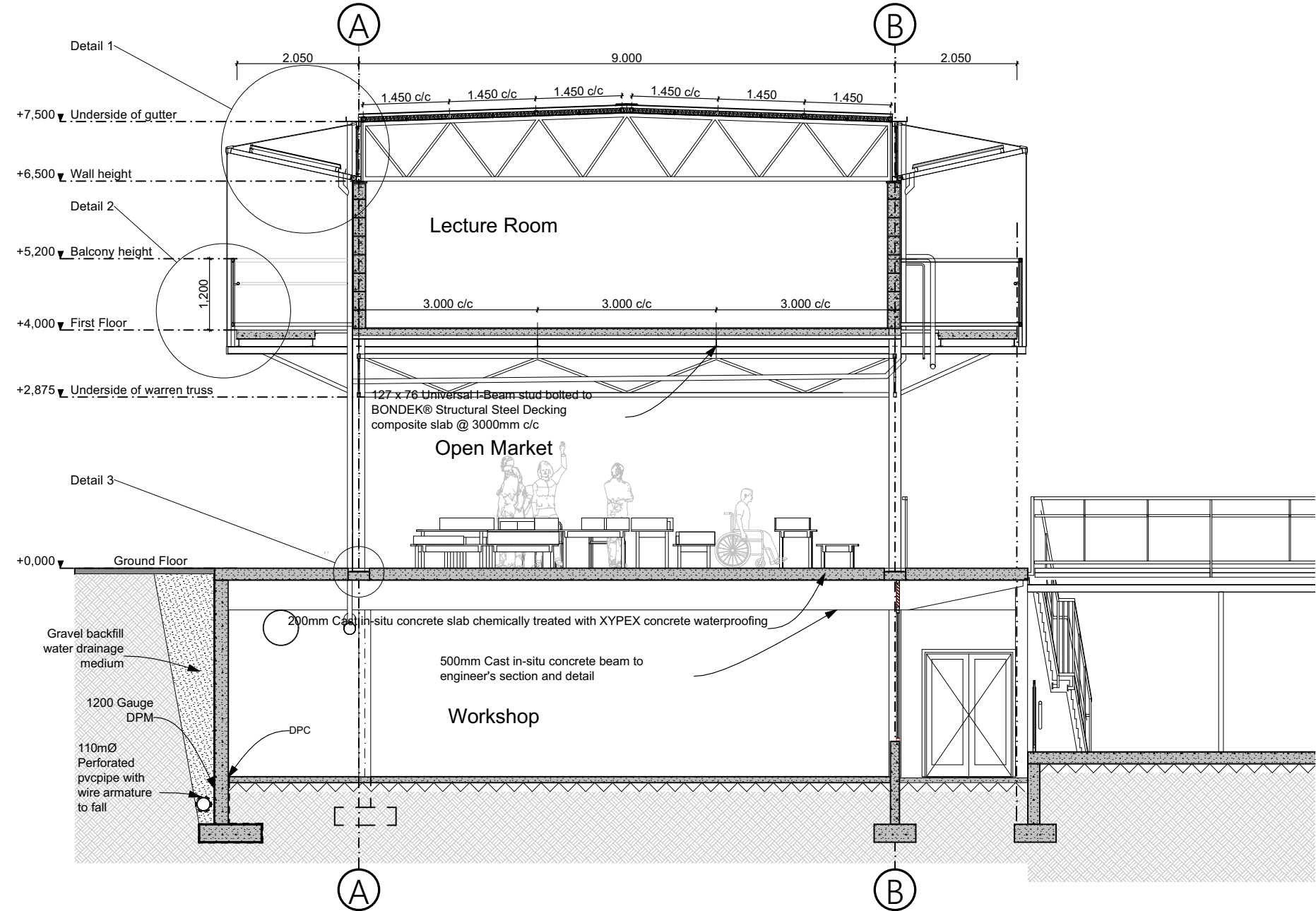


Figure 79 Section detail

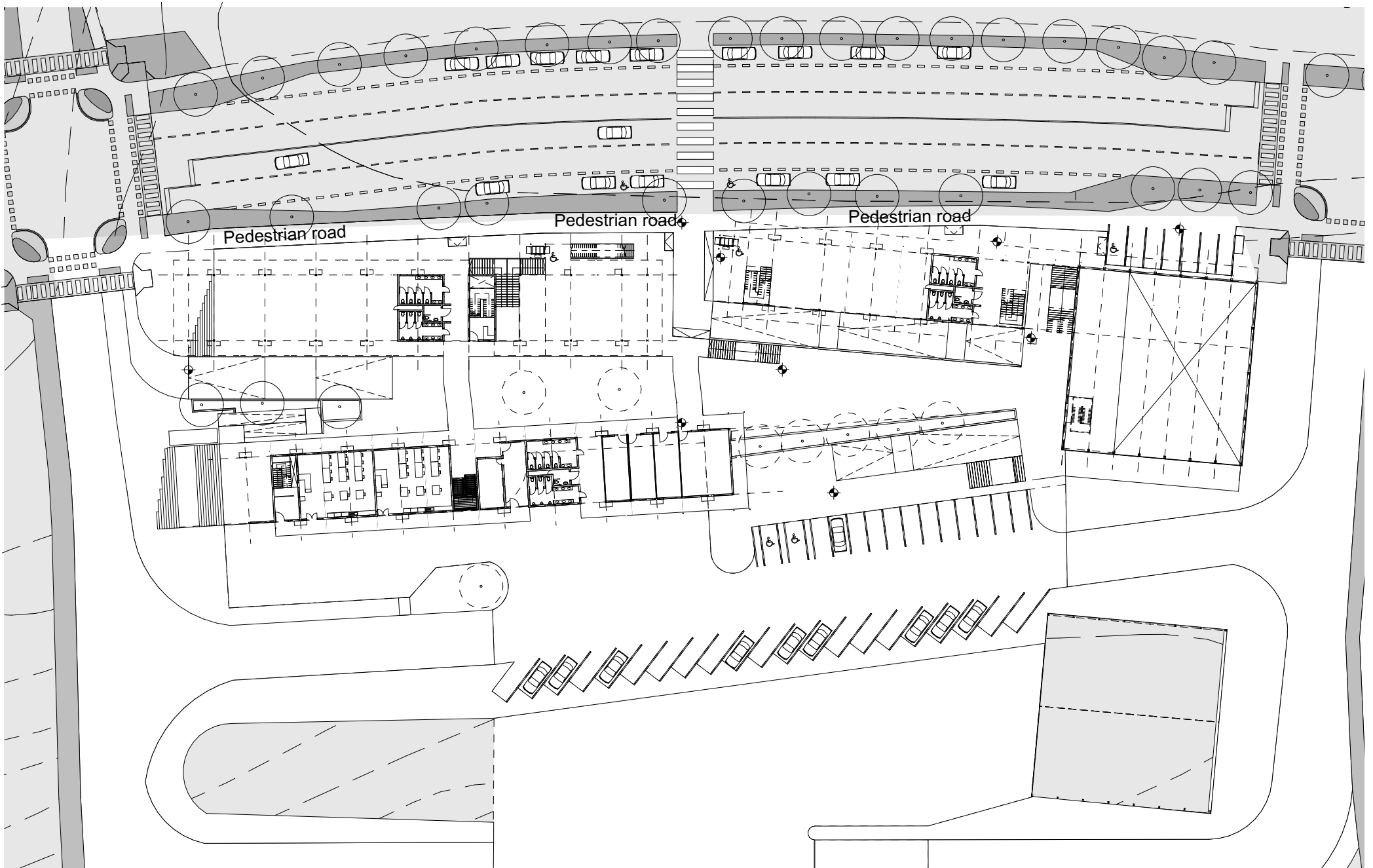


Figure 80 Detail 1 scale 1:10

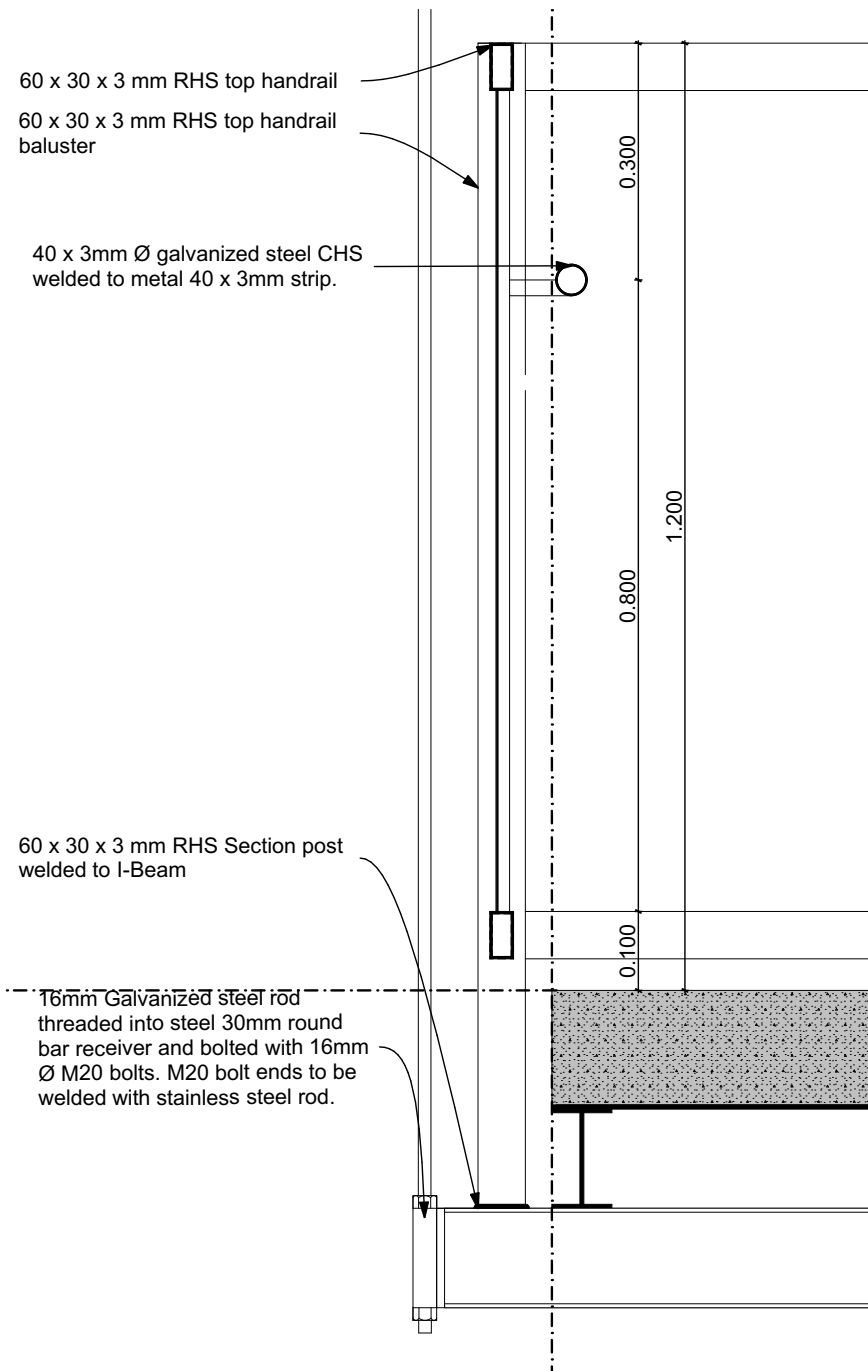


Figure 81 Detail 2 scale 1:10

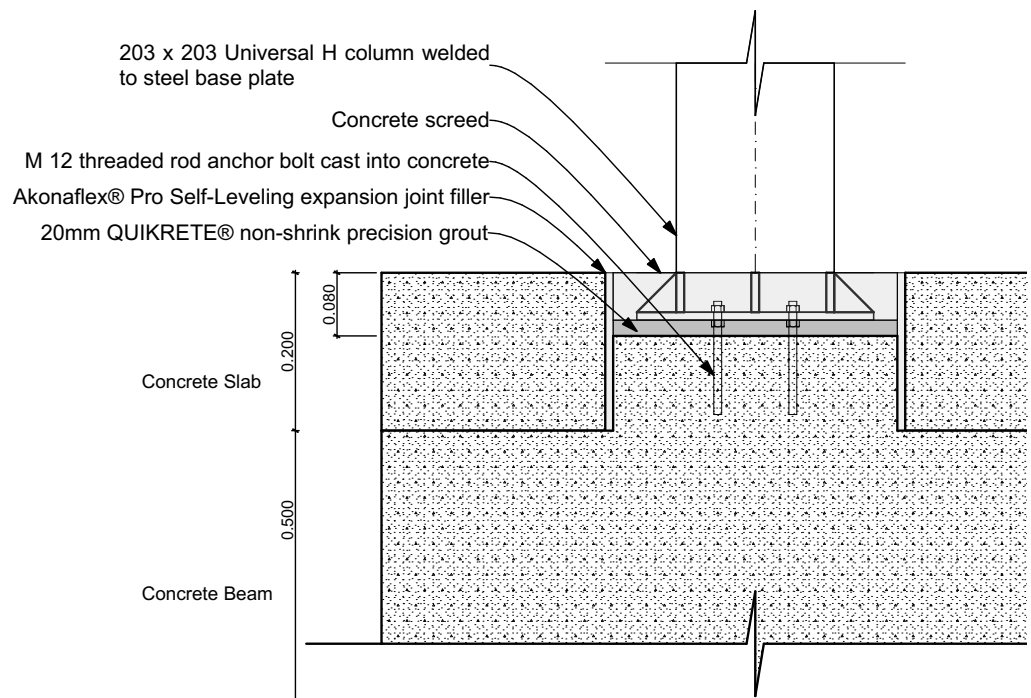


Figure 82 Detail 3 scale 1:10

10.3 Colour renderings



Figure 83 View 1: Main entrance facing towards phase 2 vocational training center



Figure 84 View 2: Side entrance

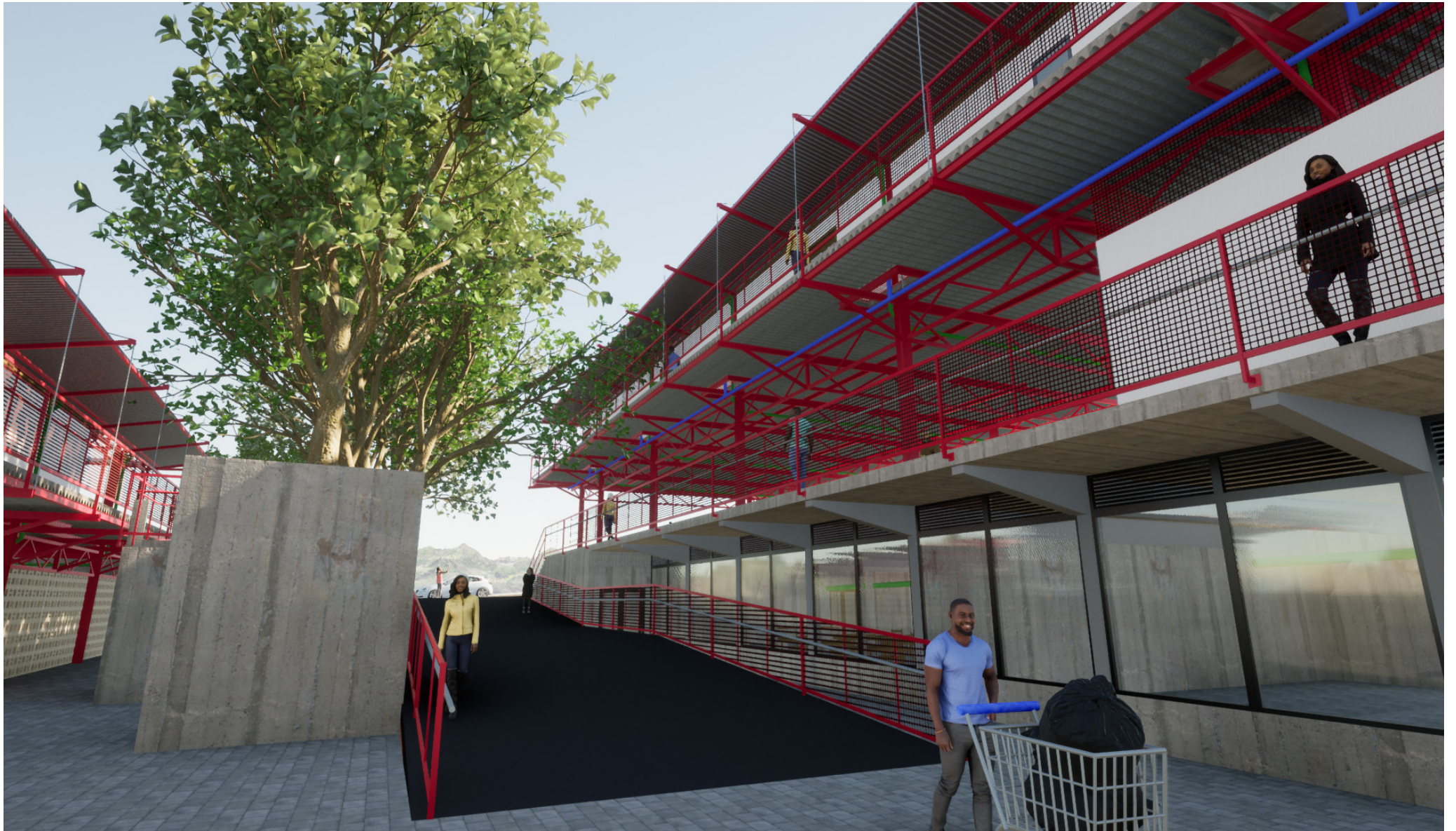


Figure 85 View 3: Internal courtyard



Figure 86 View 4: Automobile repair workshop



Figure 87 View 5: Main entrance



Figure 88 View 6: Main ramp leading towards Material Recovery Facility

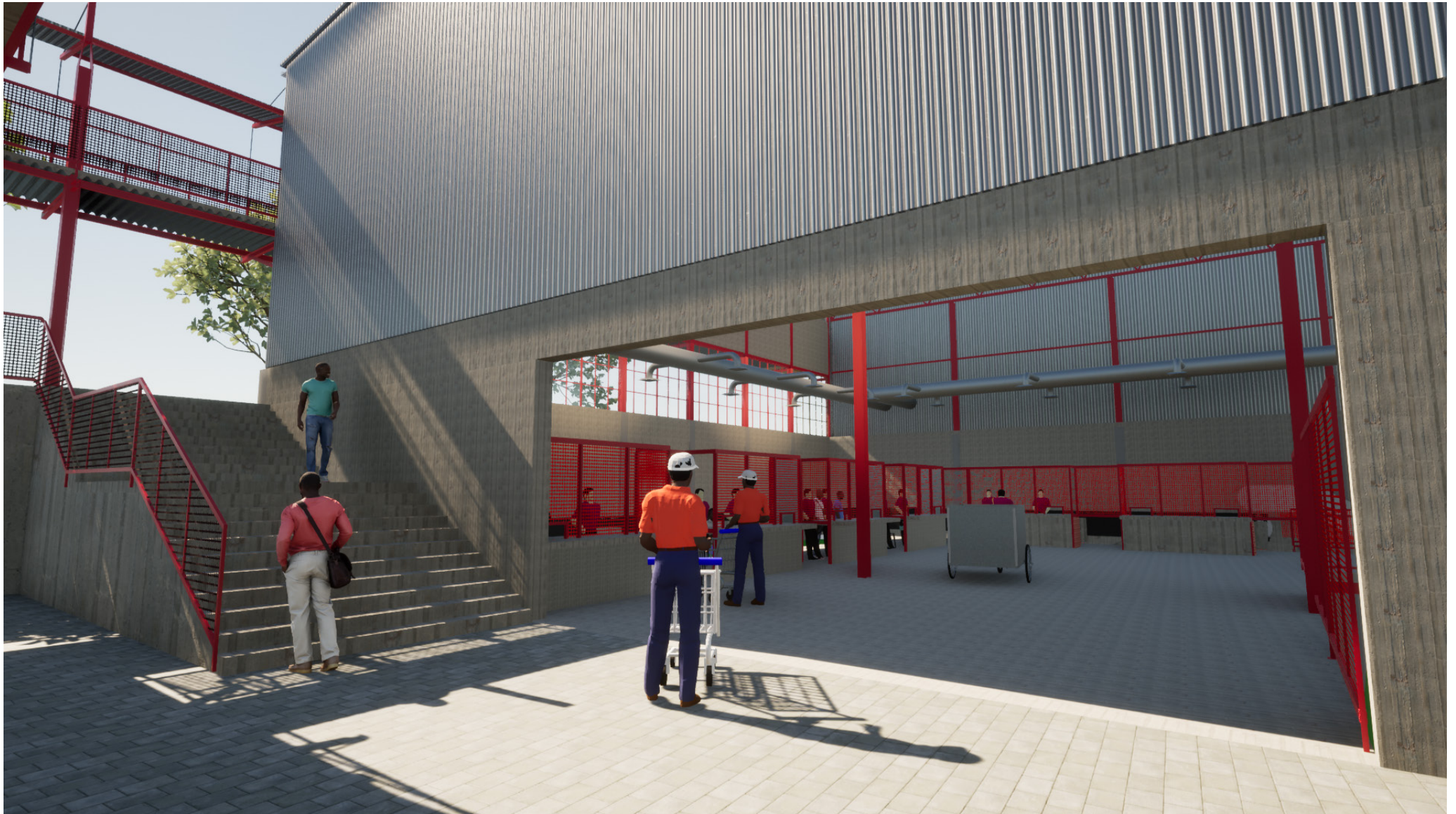


Figure 89 View 7: Main entrance of Material Recovery Facility



Figure 90 View 8: Internal courtyard view with bridge connection between floors

11. Conclusion

The city can be understood as a shared space where individuals or entities, such as local community members living in Havana and a private waste management operator (in this case Rent-A-Drum), have the potential to collaborate through spatial agency (waste management). Spatial agency is not contained in a project's specific functions but rather in their interrelationships that adapt and evolve over time. Creating these opportunities for mutual support adaptation and change was achieved through understanding different urban scales, practices and operators that govern them. These range from informal small-scale actors to large institutions and private companies that have operational capacity to stimulate change and development. The project's problem statement highlighted the need to integrate waste management as a key issue. Maximising spatial agency to resolve the waste issue required a lot of thought and consideration at the urban, socio-economic and technical architectural level. The site selection at the city's periphery was informed by how commodities flow through the city at different scales. The architectural language used throughout the building design emphasises interaction and

“While the power of each participant might be limited, the conjunction of many individuals with limited power can make up a substantial force” (Awan, Schneider, & Till, 2011, p. 77)

collaboration using material and spatial arrangements to support the mobility and efficiency of existing functions that are present within the Monte Christo corridor. An industrial architectural design language was used, highlighting the interdependencies between the different actors and activities within the building. The intervention ultimately strengthens livelihoods of marginalised residents through the creation of spatial agency that links their essentially survivalist operations to large scale economic system.

12. References APA 7th edition

- Awan, N., Schneider, T., & Till, J. (2011). *Spatial agency: Other ways of doing architecture*. New York: Routledge.
- Charman, A., Govender, T., & Tonkin, C. (2017). Transformative leisure economies: Eveline Corridor, Katutura, Windhoek. Johannesburg: Sustainable Livelihoods Foundation and UrbanWorks Architecture and Urbanism. doi:10.13140/RG.2.2.17245.61929
- Ezeah, C., Fazakerley, J. A., & Roberts, C. L. (2013). Emerging trends in informal sector recycling in developing and transition countries. *Waste Management*, 33(11), 2509-2519. doi:10.1016/j.wasman.2013.06.020
- Heidersbach, F., & Strompen, F. (Eds.). (2022, January 19). Sustainable Urban Transport Master Plan. Retrieved from windhoekcc.org: http://www.windhoekcc.org.na/documents/SUTMP_Final%20Main%20Report%202013%20v1.pdf
- Gunsilius, E. (2021, April 17). The World Bank. Retrieved June 22, 2022, from The World Bank Website: <https://ppp.worldbank.org/public-private-partnership/library/role-informal-sector-solid-waste-management-and-enabling-conditions-its-integration>
- Karuaihe, S., & Wandschneider, P. (2018). Limited access to services for the urban poor in Windhoek Namibia. *Development Southern Africa*, 35(1), 1-14. doi:10.1080/0376835X.2018.1475219
- Kaza, S., Yao, L., Bhada-Tata, P., & Van Woerden, F. (2018). *What a Waste 2.0: A global snapshot of solid waste management to 2050*. Washington, DC: World Bank. doi:10.1596/978-1-4648-1329-0.
- Ndum, A. E. (2013). Bottom-up approach to sustainable solid waste management in African countries. Cottbus: Brandenburg University of Technology.

Ojeda-Benitez, S., Armijo-de-Vega, C., & Ramirez-Barreto, M. (2002). Formal and informal recovery of recyclables in Mexicali, Mexico: *Resource, Conservation and Recycling*, 34(4), 273-288. doi:10.1016/S0921-3449(01)00105-7.

Schioldborg, A. A. (2014). *Livelihood impacts of solid waste management in informal settlements of Windhoek, Namibia*. University of Agder, Faculty of Economics and Social Sciences. Agder: University of Agder.

Simatele, D. M., Dlamini, S., & Kubanza, N. S. (2017). From informality to formality: Perspectives on the challenges of integrating solid waste management into the urban development and planning policy in Johannesburg, South Africa. 63, 122-130. doi:10.1016/j.habitatint.2017.03.018

Wilson, D. C., & Cheesman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat international*, 30(4), 797-808. doi:10.1016/j.habitatint.2005.09.005

13. List of Figures

Note: All Figures are by the author unless otherwise indicated.

Figure 1 Northern city periphery.	4
Figure 2 Waste management cycle illustrating waste picker relationship with house- holds, industry and transfer station. Source: Ojeda-Benites et al (2008).	7
Figure 3 Urban population density, residents per hectare (Redrawn by author based on SUTMP report map pg. 27). Source: Heidersbach & Strompen (2022).	14
Figure 4 City average income NAD per month (Redrawn by author based on SUTMP report map pg. 28). Source: Heidersbach & Strompen (2022).	14
Figure 5 Urban zoning types (Redrawn by author based of SUTMP report map pg. 25). Source: Heidersbach & Strompen (2022).	16
Figure 6 Income demographic versus transportation modes (Redrawn by author based of SUTMP report graph pg. 36). Source: Heidersbach & Strompen (2022).	17
Figure 7 Transportation demographics (Redrawn by author based of SUTMP report graph pg. 36). Source: Heidersbach & Strompen (2022).	17
Figure 8 Nolli map of northern periphery and Monte Christo corridor	18
Figure 9 Traders selling wide variety of foodstuffs and domestic supplies	20
Figure 10 Overview of informal spatial agency and economic trade	20
Figure 11 Monte Christo 4-way market 10 am and 3 pm depicting low operational hours	22
Figure 12 Monte Christo 4-way market 8 am and 5 pm depicting high operational hours	23
Figure 13 Stop N Shop informal traders. Refer to C in Fig 14.	24
Figure 14 Stop N Shop Wholesale analysis.	26
Figure 15 View of Stop N Shop Wholesale. Refer to A in Fig 14	27
Figure 16 Sense of space in relation to the waste crises	28
Figure 17 Burning of waste in Havana riverbed	29
Figure 18 Map illustrating contaminated sites along Monte Christo corridor	30
Figure 19 Monte Christo 4-way market contaminated site	31
Figure 20 Burning waste in skip container.	31
Figure 21 Havana 4-way waste collection point with contaminated water	31
Figure 22 Local community members specialising in glass bottle collection in Hakahana	32
Figure 23 Bag of collected glass bottles.	32

Figure 24 Waste picker trolley	.34
Figure 25 Informal waste picker in the CBD.	.34
Figure 26 Overview of C+J Recyclers	.36
Figure 27 Waste picker unloading recyclables from shopping trolley	.37
Figure 28 Bag with presorted aluminum cans weighed on scale.	.37
Figure 29 Workers processing metal cans	.37
Figure 30 Overview of Rent-A-Drums material recovery facility	.38
Figure 31 Step 1.	.40
Figure 32 Step 2.	.40
Figure 33 Step 3.	.40
Figure 34 Step 4.	.40
Figure 35 Step 5.	.40
Figure 36 Step 6.	.40
Figure 37 Step 7.	.40
Figure 38 Step 8.	.40
Figure 39 Step 9.	.40
Figure 40 Step 10	.40
Figure 41 Interrelated map of actors and activities	.42
Figure 42 Site view of the Centre Pompidou. Source: https://www.atlasofplaces.com/architecture/centre-pompidou/#figure-2	.46
Figure 43 View of plaza. Source: https://www.atlasofplaces.com/architecture/centre-pompidou/#figure-23	.47
Figure 44 Cross section	.48
Figure 45 Long section	.48
Figure 46 Detailed cross section of the building floors, Pompidou Centre	.50

Figure 47 Site Diagram	.52
Figure 48 Site View angle map	.54
Figure 49 Site View A	.55
Figure 50 Site View B	.55
Figure 51 Site View C	.55
Figure 52 Consolidated site plan and spatial arrangement for the building's primary functions.	.56
Figure 53 Early massing model indicating spatial form and arrangement on site.	.57
Figure 54 Circulation pathways with highlighted pedestrian movement along Monte Christo corridor	.58
Figure 55 Highlighting the sorting facility as the major anchor/ point of interest	.59
Figure 56 Concept of Material Recovery Facility interface and operations diagram	.60
Figure 57 Early concept sketch ideas	.61
Figure 58 Overview of socio-economic activity integrated in spatial typology.	.62
Figure 59 Conceptual modular structure	.64
Figure 60 Isometric view Phase 1 development	.65
Figure 61 Isometric view Phase 2 development.	.66
Figure 62 Isometric view Phase 3 development.	.67
Figure 63 Ground Floor	.68
Figure 64 Lower Floor.	.70
Figure 65 First Floor.	.72
Figure 66 Long Section B	.74
Figure 67 Short Section C.	.76
Figure 68 Short Section D.	.78
Figure 69 Perspective of project from Monte Christo corridor.	.80

Figure 70 Ramp leading to Material Recovery Facility	.82
Figure 71 Interior view of MRF 1	.84
Figure 72 Interior view of MRF 2	.85
Figure 73 Section B not to scale.	.86
Figure 74 Machine floor plan scale 1:500	.87
Figure 75 Interior view of corridor	.88
Figure 76 View of bridge transition between phases	.90
Figure 77 View of site entrance	.91
Figure 78 Detailed structural system	.92
Figure 79 Section detail	.93
Figure 80 Detail 1 scale 1:10	.94
Figure 81 Detail 2 scale 1:10	.95
Figure 82 Detail 3 scale 1:10	.95
Figure 83 View 1: Main entrance facing towards phase 2 vocational training center	.96
Figure 84 View 2: Side entrance	.97
Figure 85 View 3: Internal courtyard	.98
Figure 86 View 4: Automobile repair workshop	.99
Figure 87 View 5: Main entrance	100
Figure 88 View 6: Main ramp leading towards Material Recovery Facility	101
Figure 89 View 7: Main entrance of Material Recovery Facility	102
Figure 90 View 8: Internal courtyard view with bridge connection between floors	103

14. Appendix A: Interview with Rent-A-Drum

Good morning, Mr Reinhardt thank you for having this interview with me. My name is Harry van Schouwenburg and I am a Masters student at NUST. I am conducting research for my mini-thesis about sustainable waste management. My thesis topic is integrated solid waste management towards strengthening Havana township livelihoods by the valorisation of waste, basically adding value to recycling and adding value to waste and the livelihoods of informal communities.

I have a series of question for you:

1. Can you tell me about your position at Rent-A-Drum and how many years you have worked as the facility manager?

Abraham Reinhardt: Yes I am the recycling manager for Rent-A-Drum and I have been working for the past 6 years as the facility manager. Before that I was the operation manager.

2. What type of materials recovery facility is this? Is it clean or dirty and do you wash recyclable materials?

Abraham Reinhardt: No it's a dry facility so we only take in dry recyclables no wet waste or any organic waste or any general waste. All we do is we only sort and bale the different commodities ... we don't do any washing of any materials.

3. What materials do you sort and process?

Abraham Reinhardt: We do sorting on 22 types of commodities. With plastic alone it is about 11 different plastics and then its just the normal glass carton boxes white paper. And then we also do RDF. RDF stands for refuse derived fuel. Which is an alternative derived fuel for Ohorongo cement instead of them using charcoal or coal or woodchips they also use our shredded waste. Some of those products are contaminated recyclables which you can't use for recycling purposes but they can still be used for RDF.

4. Can you tell me about the material recovery process from the arrival to the baling and transportation? I guess it is rather extensive.

Abraham Reinhardt: I can just explain it quickly to you. Our own trucks collect recyclables of which the clear bag is also a big part as you know; we put these bags at households and we do collect them the same day as the municipality when the municipality is cleaning the green bin for instance. All those materials are being collected by our vehicles and brought to the plant. So we have different sections in the plant. We have a paper section and then we have a confidential paper shredding area, and then you have your carton box and plastic area and then you also have your clear bag side.

5. Are there any local manufactures you supply with recyclables?

Abraham Reinhardt: Mostly 90 percent go to South Africa. There is only one type of plastic that is clear plastic which goes to Okahandja to Zambia polymer recyclers which is the factory for plastic packaging. And then we are also transporting ungranulated fish crates and west bank blue plastic from Walvis Bay to a recycler in Rundu (Kavango Pipes). Those are the only two local recyclers.

6. Basically I am also designing a material recovery facility and I wanted to know the maximum slope that the conveyor belt can operate so that the waste does not trickle down.

Abraham Reinhardt: Your conveyor belt is designed in such a way that at every meter from each other there is an angle iron beam bolted onto the conveyor so that prevents your waste from going back on the conveyor. If your conveyor has an incline it is about 45 degrees so it takes all the waste with due to your angle iron partition on top.

7. How has the Covid 19 pandemic impacted the material recovery facility?

Abraham Reinhardt: Yes, it had quite a big impact due to the fact that businesses slows down. And mostly all our carton boxes and plastics are coming from businesses so its more packing material,

so we had quite a huge decline in the supplying of or receiving recyclables. Its picking up a little bit at this stage but I think it's still going to take some time.

8. How many workers do you employ and what is the minimum wage of a waste sorter?

Abraham Reinhardt: At the Windhoek plant we employ a hundred people. We are working in two different shifts, it's about 50 people per shift. You have a day shift and on night shift due to volumes otherwise, you will not be able to sort all the recyclables that came in a period of one week. That is the reason why you have to run a night shift as well. The minimum wage is for a cleaner due to the fact that you are working with waste. You have to make sure the space is properly cleaned and that is more or less on an average salary of N\$2 500.

9. How much do waste sorters earn?

Abraham Reinhardt: It depends because all our people are on levels, so a cleaner is for instance on level one, a general worker is on level 2 and you have your quality control on level 3. Your operators are on level 5 your forklift operators on level 6 and 7 and your team leader is also on level 7. So, for every level there is a different salary.

10. That is interesting to note I am sure you have specialised licenses to operate machines and the maintenance of them?.

Abraham Reinhardt: Just for the forklifts. Your forklift drivers need to renew their forklift licenses every second year. And for the machines you just take the operators, and you just train them give them proper training and of course everything is being documented because we are an iso registered company for health and safety (definition by Google ISO-certified companies are independent, non-governmental, international organisations that develop standards to ensure the quality, safety and efficiency of products, services and systems)

11. I wanted to ask; does Rent-A-Drum engage with informal waste pickers?

Abraham Reinhardt: Yes, we do. We call them buy-back centres. We have individual people collecting recyclables preferably it should be sorted before they bring them over here otherwise, they will get a lower price for mixed recyclables which mean that we still have to do the sorting. So, if they do the sorting already on their part they are paid for recyclables as per commodity. So your sorted clear plastic bottles will be sorted; your green one side; your brown one side;

just to give you an example. What I mean with sorting is that it is the same with cans. Your aluminium cans must be separated from your metal food cans or your upc steel cans.

Abraham Reinhardt: In Windhoek, we only have individual people who are collecting recyclables by themselves. They bring it with their vehicles. We only pay them once a month of course with a record system on our way bridge scale where we keep a record of who brings in what. First, they need to register with us at a buy-back centre and we need to get all their personal details or company details and of course, their bank details as we pay them once per month into the bank account. We don't keep cash on site it is too risky.

