SUSTAINABLE DESIGN APPLIED TO LOW INCOME COMMUNITIES IN DEVELOPING COUNTRIES: THE EXAMPLE OF PINTASSILGO COMMUNITY - SANTO ANDRE, BRAZIL

by

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Abstract

The overall goal of this thesis was to explore sustainable design principles and its applicability to low income communities situated in environmentally sensitive areas, focusing on the case of developing countries. Guidelines were established considering typical problems of those communities and than a case study was developed, applying the proposed guidelines to a real case situation at Pintassilgo Community, in Santo André, Brazil.

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Acknowledgements

In the memory of my Dad

This thesis is about ways to change lives for better, especially lives of those who need the most, people for whom the most basic needs are not provided. The most important person leading me to act in changing this situation was my Dad, always caring and helping as much as he could, and showing us how wonderful it is to be able to make someone's life better.

I would like to thank Don, Erika and Patrick for their help in developing the thesis and getting as close as I could to recommendations applicable to developing countries situation, and their immense knowledge on the subject.

I would also like to thank my family, my mom for all her loving and believing; my dearest Gabriel, who were always there for me; and my brothers for their support and friendship.

1. Introduction

This thesis focuses on the interface between low income informal settlements in Brazil located in environmentally sensitive areas, with a case study in a watershed area and sustainable design.

The problem of informal settlements is very common in Brazil, starting in the late 60's with migration to urban centers and non-planned growth, leading to crises in habitation as well as growth of a new form of occupation called favelas. Favelas are informal and illegal communities, commonly not served by the most basic services, facilities and infrastructure.

Due to the uncontrolled growth, lack of infrastructure and location in environmentally sensitive areas, these communities have a detriment effect on the environment, causing impacts in short and long terms. Developing a more sustainable design for these communities is therefore imperative to reduce environmental impact and at the same time, to provide better life conditions for the communities.

This thesis will focus on design issues, proposing more sustainable alternatives for favelas in Brazil. Although the design recommendations proposed in this work can make a significant improve in these communities, it is important to recognize that the success in long term can only be achieved by constant participation of public agencies, the community where the change will be implemented and the society as a whole.

2. Thesis Goal

The overall goal of this thesis is to explore planning and design alternatives for building a more sustainable community for low-income communities in environmentally sensitive areas.

3. Thesis Objectives

- ☐ to investigate the case of a charrette developed for the low-income community of Pintassilgo, Santo André, Brazil;
- ☐ to establish a basic guideline of principles applicable to low-income settlements in environmentally sensitive areas;
- ☐ to develop a proposal for Pintassilgo neighborhood, based on the charrette experience and incorporating new ideas.

4. Conceptual Foundations and Premises

4.1. Sustainable Community Design[1]

The concept of sustainable design in human developments has come to the forefront in the last 30 years. It "recognizes that human civilization is an integral part of the natural world and that nature must be preserved and perpetuated if the human community is to sustain itself indefinitely. Sustainable design is the philosophy that human development should exemplify the principles of conservation, and encourage the application of those principles in our daily lives."[2]

The concept of sustainable design in human developments should come together with the concept of bioregionalism - the idea that all life is established and maintained on a community basis and that all these distinctive communities have mutually supporting life systems that are generally self-sustaining. Therefore, the concept of sustainable design proposes that future technologies must function primarily within bioregional patterns and scales. They must maintain biological diversity and environmental integrity, contribute to the health of air, water, and soils, incorporate design and construction that reflect bioregional conditions, and reduce the impacts of human use.

Contemporary cities have a great impact on the natural system and effects from that can be seen all over the world. Soil erosion, groundwater contamination, acid rain, and other industrial pollutants are damaging the health of our natural system. Planners and designers must be aware of the impacts that the present way of developing cities is causing. The concept of sustainable design suggests a more holistic, ecologically based approach, in order to create projects that do not alter or impact but instead help repair and restore existing site systems.

It is still not possible to assure that urban environments can be completely sustainable. The way we build cities and use them is commonly opposed to what is understood as passive to exist in a long term, but there are some measurements that can be taken to move us closer to being sustainable. Some strategies towards a sustainable site design include:

- ☐ Recognition of context
- ☐ Treatment of landscapes as interdependent and interconnected
- ☐ Integration of the Native Landscape with Development
- ☐ Promotion of Biodiversity
- ☐ Reuse of already disturbed areas
- ☐ Making a Habit of Restoration

The movement towards sustainability should also include aspects such as urban form, transport, buildings, energy supply, landscape, and all other aspects related to communities and city design. It should involve making cities more suitable for people, creating environments for pedestrians, cyclist and public transport instead of cars.

In this context, this thesis will focus on short term actions and design solutions in order to develop communities oriented towards the sustainable design ideal. Those actions should also create a situation or opportunity that will facilitate changes to long-term sustainability.

4.2. Low-Income Communities situated in environmentally sensitive areas in Brazil

The focus of this thesis is on low-income communities illegally occupying environmentally sensitive areas in Brazil. Those communities in Brazil are called "favelas".

Their formation started in the 70's when migrants from other cities and from rural areas moved into bigger cities looking for better opportunities in life. The concentration of industries in these cities increased job offers, attracting especially smaller rural workers, tired of not having support from the Government. This migration is still happening today, but in smaller rates.

When these families arrived at their destination they could not afford to pay rents or purchase homes, they would commonly have no savings and even when they found a job, they would be extremely underpaid.

The lack of action from the Government at that time led them to move to non-occupied areas and build their houses themselves. And that's what they did. These occupations were commonly on protected areas or other kinds of environmentally sensitive areas, causing damage to the environment and frequently hazardous conditions for the new occupants.

Due to the illegal status of these occupations they would commonly have poor or no infrastructure, poor accessibility and problems of poverty, violence and the presence of drug dealers. Safety is also a serious issue. Although problems like violence and drug dealers affect the whole city, it's usually the people who live in these neighborhoods that suffer the most.

Solutions for this problem can only be achieved in the long term but short term actions can be taken to reduce some of the urgent needs of those communities and also to empower the community for the bigger change.

Governmental agencies have the responsibility to help and direct this change, providing infrastructure, community facilities and also providing solutions regarding the problem of ownership of the land.

The environmental issue should also be addressed. Communities should reduce their impact on the environment as much as possible, and in cases of danger to the community or danger of permanent damage on the ecological equilibrium of the area, relocation should also be considered. Less costly solutions should be taken in order to allow actions in a broader spectrum and also guaranteeing affordability for present residents.

Finally, actions should be taken to allow reduction of migration. That should include incentives for small farmers and also creation of employment in less developed areas.

Although those problems are key in solving the problem in a long term, this thesis will focus only on design recommendations for building and restoring low-income communities in a more sustainable way.

5. Site Planning and Development Guidelines for Sustainable Community Design in Environmentally Sensitive Areas

The intent of this section is to combine the concept of sustainable community design and existing guidelines in the context of "favelas" in Brazil. Although the principles are the same, there are some peculiarities of the favela context that deserve special recommendations in order to achieve a more sustainable situation.

The purpose of this thesis is to develop a set of guidelines for this special condition of favelas in Brazil, taking the existent guidelines and adapting them to those special conditions.

Among the differentials to be considered are: the problem of poverty that require less costly solutions; the problem of ownership of the land, leading to the issue of control of who is responsible and taking control of what; the absence of community facilities and infrastructure, such as health centers, schools, sewage treatment, water supply and so on; the problem of safety and territory, especially the issue of control from drug dealers; the problem of occupation and growth control; the problem of erosion and environmental damage; and the problem of spreading diseases due to presence of standing water and lack of sewage infrastructure and treatment.

The guidelines are focusing on principles and guidelines especially for new communities, in the case of future developments or total relocation of existing communities. It is important to note that in the case of existing communities, urbanization and restoration should consider existing houses and features, with the intent to maintain as much as possible of the existing structure, when safety and environmental considerations are favorable.

The reason for the focus on new communities was the intent to provide a basic start for designing principles and guidelines, considering that each case, context and environment would require a different range of solutions and recommendations. In that sense, the idea was to establish high standards, considering the reality of low income communities in developing countries that should be taken and adapted, considering each scenario.

The principles and guidelines were divided into categories, for practical reasons. It's important to note that a lot of the themes are interconnected and interrelated, and idealistically they should be integrated. This subdivision was intended to facilitate the understanding regarding the different aspects taken into consideration.

5.1. Community Form

The form of the Community should take into consideration the site's environment and ecology, based on a careful analysis in order to preserve and enhance natural, historical and cultural aspects of the community. Therefore, the site selection is a key decision in allowing the construction of more sustainable communities. The final form and configuration of the project should be a reflection of the site potentialities and restrictions of the environment.

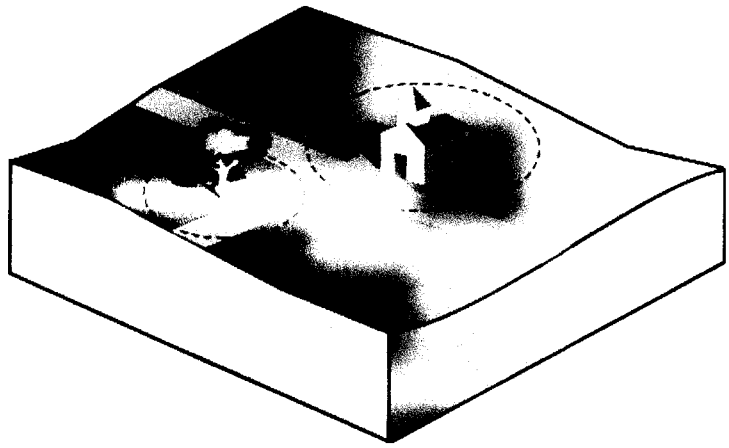


Figure 1 - Existent site's history, culture and archeological values should be studied and reveled with the design.

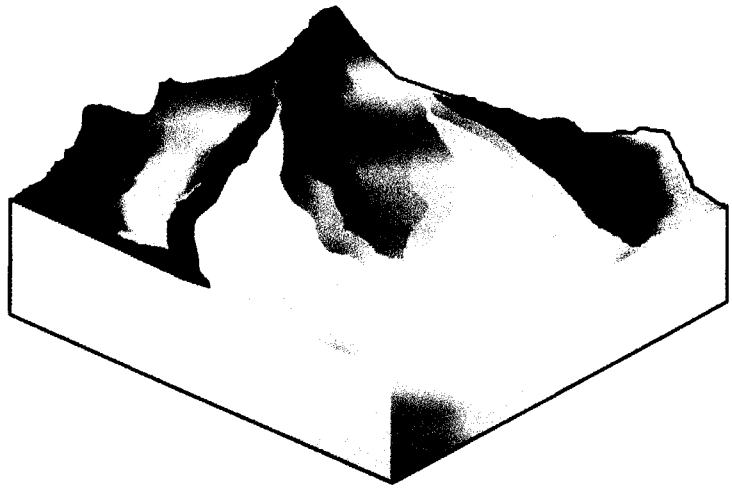


Figure 2 - Natural features of the site should be protected and enhanced. The visual aesthetic should also contribute to the community's physical quality.

5.1.1. Site Selection

a)For new developments:

☐ **Develop a careful study of the site's suitability for new developments:** The suitability analysis should include the site and its region, evaluating both natural and cultural aspects. Based on McHarg's[3] methodology for analysis, some of the aspects that should be taken into account are:

- **Culture, history and archeology:** It is very important to evaluate archeological, historical and cultural aspects of the site and to preserve and reveal those aspects through the design. (fig. 1)
- **Access to a potable water supply:** Evaluate the sources of water, quantity and quality. Ensure that the new demand will be compatible with the regional ecosystem's ability to recharge its aquifer and not have a detrimental effect on the existing water supply.
- **Access to utilities and energy resources:** Evaluate opportunities to use the site's natural renewable resources, i.e. solar, hydro, or geothermal energy. Explore common utility corridors in order to minimize disruption to the environment.
- **Possibility of extending infrastructure to the site:** Evaluate proximity to other communities and existing infrastructure, as well as its capacity for expansion and growth on demand.
- **Proximity and extent of transportation infrastructure:** Implementation of transportation infrastructure should be minimized as much as possible. Design solutions should promote the reduction of automobile use.
- **Careful evaluation of the natural features of the site, including soil, geology, topography, vegetation and wildlife:** The physical landscape can orient design solutions. Natural features can be a strong element in improving the visual quality of the community. Watershed, native vegetation and wildlife should

be preserved and enhanced. Biodiversity should be promoted as well. The development should also be channeled into already disturbed areas when possible. Previously disturbed areas should be restored and recycled when possible; the layout should seek the minimum impact on local environment;(fig. 2)

■ **Evaluation of slope conditions and viability of occupation:** Steep slopes should be avoided for development. It's recommended that no occupation should take place in slopes steeper than 45% of inclination; occupation should be restricted in slopes ranging from 30 to 45%; and the development should concentrate in slopes of 30% of inclination or lower, when environmental conditions allow;

■ **Evaluation of local climate:** Understanding local climate is fundamental for designing communities. Aspects as intensity and frequency of rains, humidity and winds should be considered;

■ **Study of the regional context including nearby communities:** Analyze the context of the site, both regional and local. The economic base of the region, the population, culture, and vernacular aspects of the area, including neighboring communities and take all of those aspects into consideration when designing the community;

☐ Once this information is gathered and evaluated, decide whether the site is suitable for the development. If so, design the most sustainable strategy for such a development.

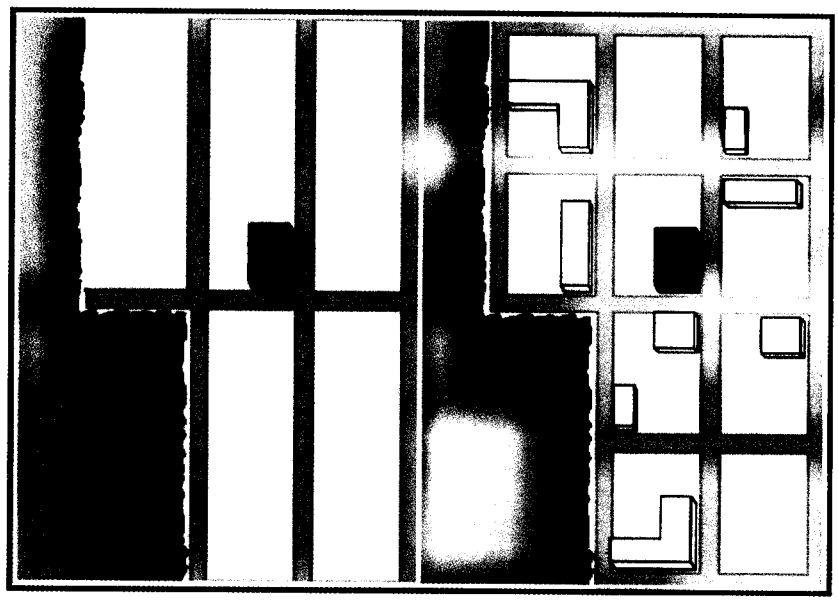


Figure 3 - Existing infrastructure (left) should be taken into consideration in the new design (right).

b) For existing communities:

☐ Analyze site for the same aspects listed for new communities;

☐ Encourage community involvement from the beginning of the study and through the whole process;

☐ Evaluate site's capacity to accommodate further growth; if there is necessity to control further growth, use design and policies to contain expansion;

☐ Maintain existent structures and buildings as much as possible;

☐ Incorporate existing uses and infrastructure;

☐ Restore and enhance degraded environment;

☐ Implement changes in steps.

5.1.2. Configuration / Patterns

a)Site's environment and ecology:

☐ Restore, recycle and enhance previously disturbed areas;

☐ Reveal natural features of the land in the design;

☐ Preserve and enhance watershed, native vegetation and wildlife;

☐ Promote biodiversity;

☐ Channel new development into already disturbed areas, when possible.

b)Block pattern / urban form:

☐ Seek efficiency by the urban form;

☐ Minimize costs by the concentration of infrastructure;

☐ Improve circulation; centralize infrastructure; control sprawl; promote safety and cost reduction through urban form. A grid structure usually works better to provide these results. Linear structure is usually less efficient and more costly; (fig. 4, 5)

☐ Allow flexible use; promote diversity;

☐ Establish minimum density to maintain a cost-effective

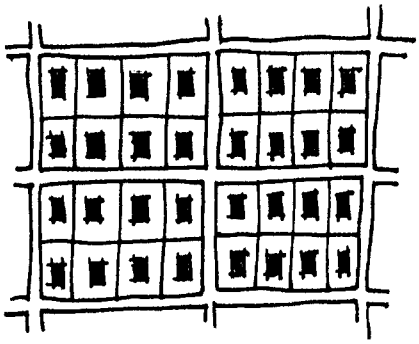


Figure 4 - The grid principle should be adapted to the site's environment and ecology with a careful site analysis.

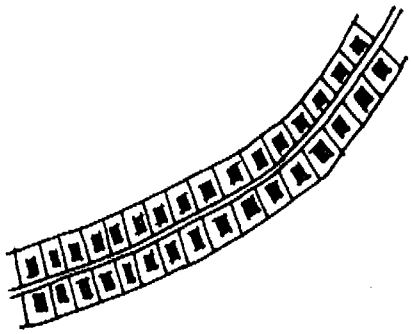


Figure 5 - Linear growth, typical in rural areas and some low-income communities. This type of urban growth should be avoided.

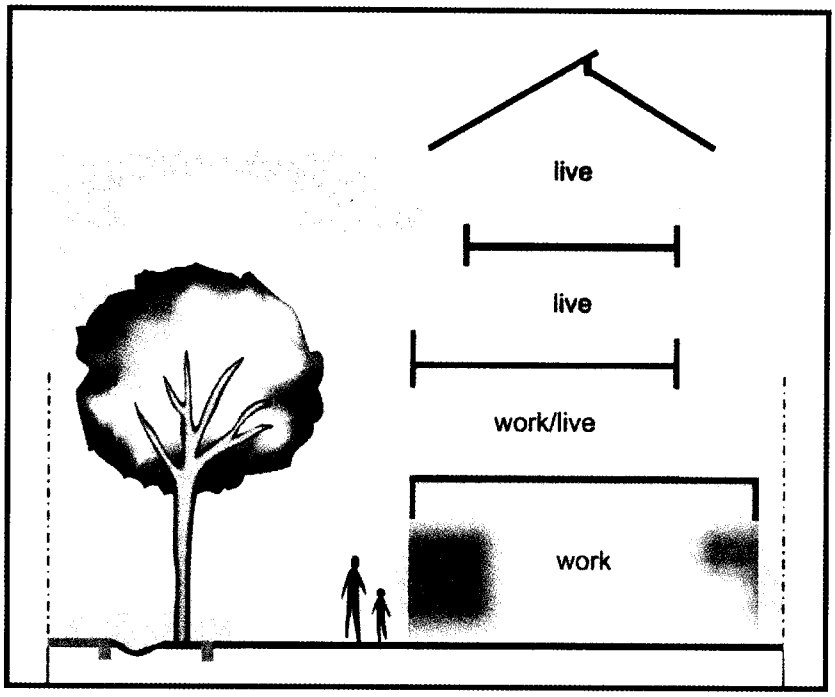


Figure 6 - Cross section illustrating live-work alternative.

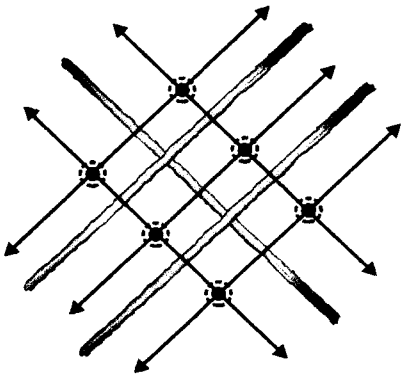


Figure 7 - Neighborhood centers combined with the green infrastructure network, ensuring a high-value ecological and social community.

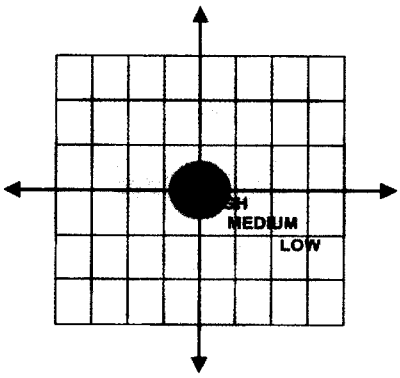


Figure 8 - Density concentrating on the center point, decreasing as the distance from the center increases.

relation; vary density within the community;

☐ Promote different characters for units; mixing lot sizes and housing. Provide different types of housing, services and employment;

☐ Provide transit and other activities of daily life within a walkable distance;

☐ Encourage the combination of working spaces and residential spaces in the same building; this action can reduce costs and also work as a transition between residential areas and higher density areas;(fig. 6)

☐ Create centers. They should provide services, work opportunities, recreation, meeting places, commerce, and green spaces; centers should also concentrate more density. Considering the 5 minute walk radius as a comfortable distance for walking to get to community facilities, an average size for communities would be between 16 hectares and 40 hectares. The center should concentrate more density, since this is where the commerce, services and jobs would also be concentrated. This should be a focal point, attracting the whole community. (fig. 7, 8)

5.1.3. Edges / Adjacent Relations

☐ Establish and design main axis to attend the demand and allow constant circulation and interaction between the community and the region;

☐ Provide a common meeting ground linking the existing community and the new one[4],

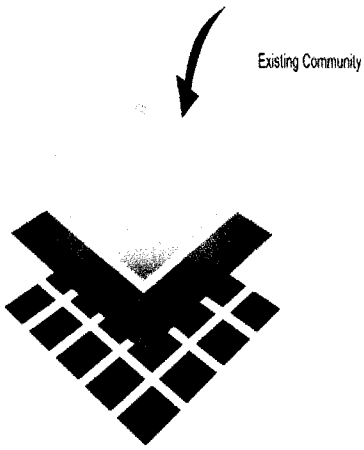


Figure 9 - Common meeting ground linking both communities.

establishing a shared area for both communities; (fig. 9)

☐ Provide an efficient and safe circulation network to encourage alternatives to vehicle use;

☐ Provide public transportation widely and efficiently within a walkable distance from all units;

☐ Provide safe and interconnected walkways and bikeways.

5.2. Community Components

5.2.1 Circulation

a)Network

☐ Integrate access. All types of roads must contribute to the community's circulation network;

☐ Use shape to direct the placement of an interconnected street network;

☐ Design street network to dilute the traffic, with multiple connections and relatively direct routes;

☐ **Promote public transportation; the service should be efficient, attending the community demand;**

☐ Promote use of bicycles, integrating bike lanes to the transportation system and guaranteeing the user's safety. Providing a good public transportation system as well as providing pleasant and safe walkways and bikeways can help reduce the automobile use and create a more vibrant community.

b)Design

☐ Use the shape of the land to direct the placement of the street network. Disturbance within the site can be reduced by narrowing the streets and also sloping the boulevards. This will decrease the amount of cut and fill required;[5]

☐ Design streets to be as narrow as possible;

☐ Use traffic calming measures when appropriated;

☐ Design attractive sidewalks in sufficient numbers;

☐ **Guarantee strong relationship between public and private spaces ("Eyes on the Street"), improving safety but not compromising privacy;** (fig. 10)

☐ Consider human scale in the size of streets and setbacks, in order to invite public use;

☐ Promote mixing uses in order to decrease the necessity of larger dislocations;

☐ Promote pedestrian use of streets, making them more attractive, comfortable, convenient and safe. A street with more intense traffic should have a buffer (like a line of trees) to decrease the negative impact on the sidewalks. Choice of sun or shade is also good to promote walking within the neighborhood.

c)Ecology

☐ Seek efficiency and reduction of environmental impacts through street design;

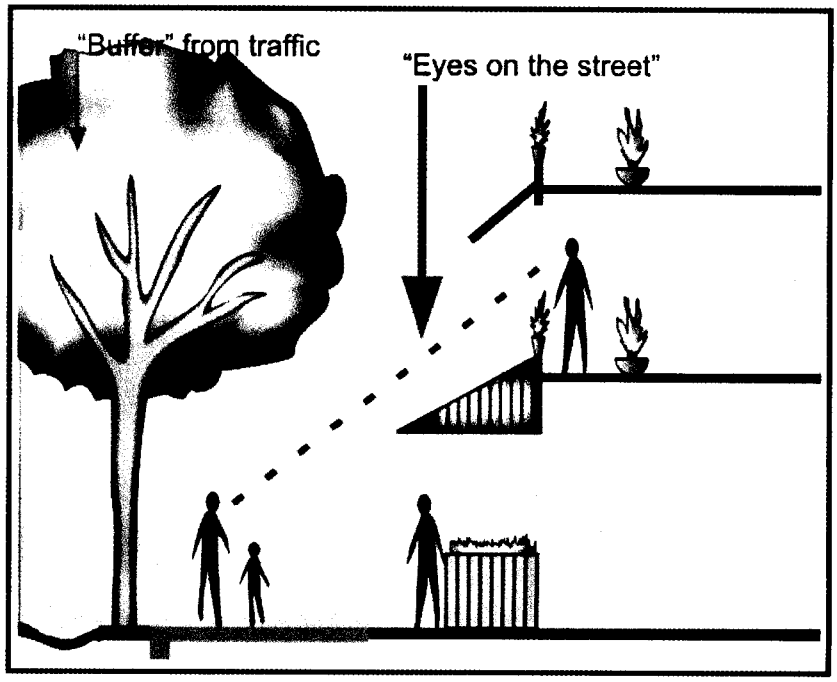


Figure 10 - "Eyes on the Street".

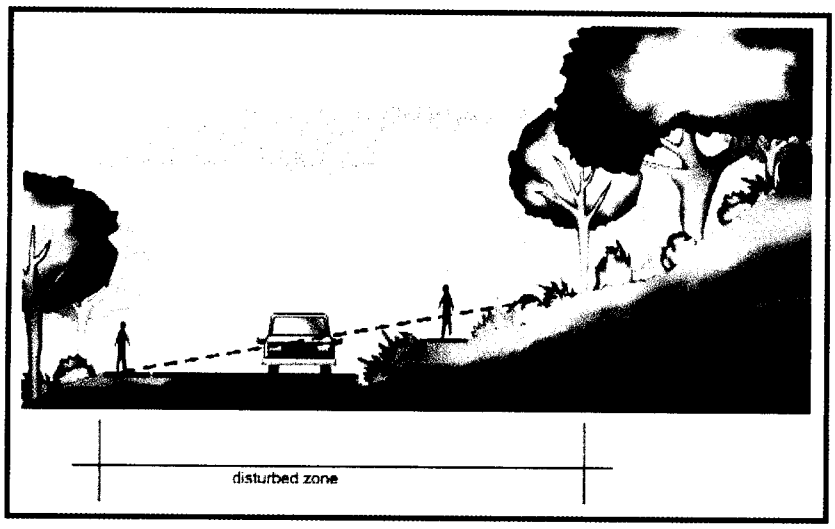


Figure 11 - Reducing zone of disturbance. Narrowing the streets and sloping the boulevards.

☐ Align streets in a way to give buildings energy efficient orientations;

☐ Use alternative paving to reduce the use of impervious surfaces; promote use of swales to increase permeability; to direct and infiltrate stormwater;

☐ Reduce disturbance by narrowing streets and also sloping the boulevards[6]; (fig. 11)

☐ Create linear gardens along the streets;

☐ Select species of trees considering rainfall characteristics, soil condition, and native forest species[7] ;

☐ Vary species used along the community in order to create more diversity in colors, textures, and shapes.

d)Street Typologies

☐ Main Street: (fig. 12)

■ Provide connection from the community to the surrounding communities and the Region;

■ Include lanes for public transportation; they should have priority on these streets;

■ Increase density along main streets;

■ Concentrate commercial activities;

■ Provide buffer from traffic for sidewalks;(fig.13)

■ **Provide efficient lighten-**

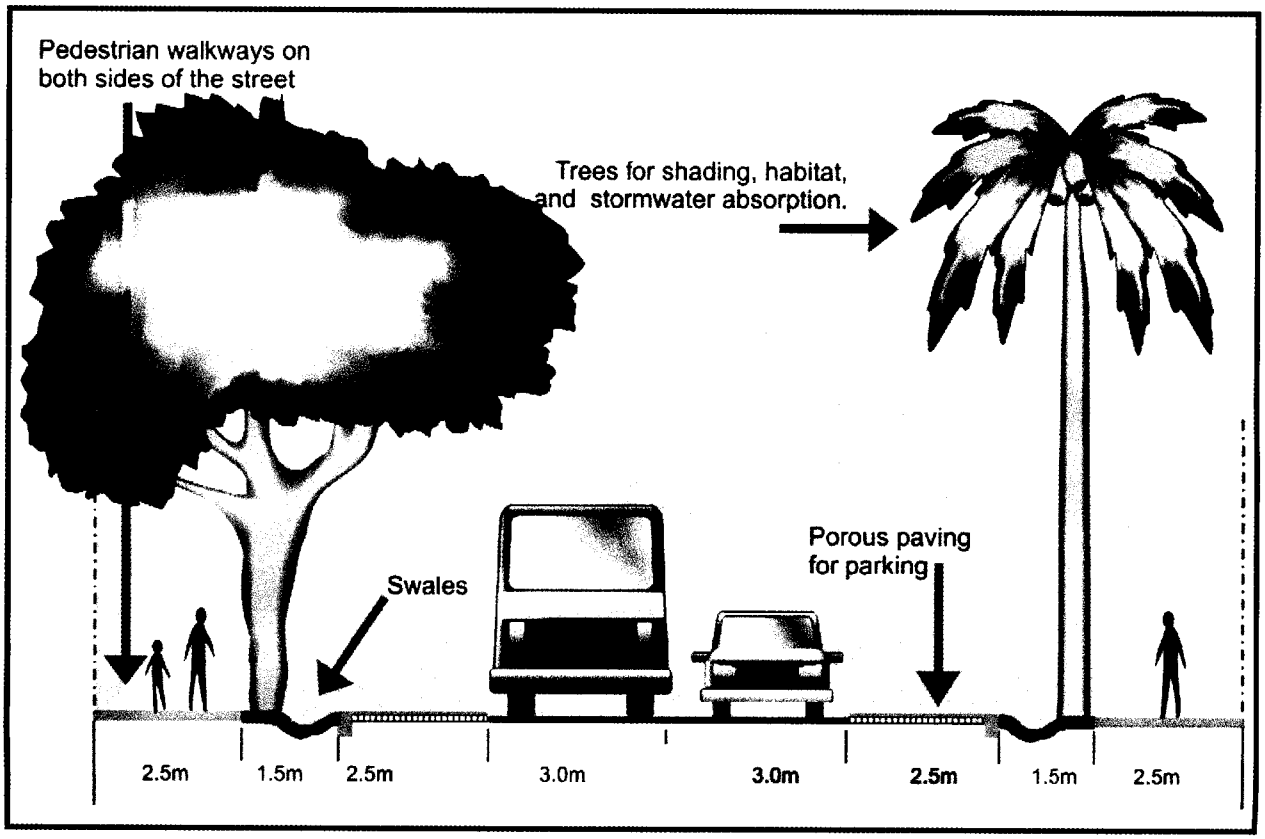


Figure 12 - Example of main street.

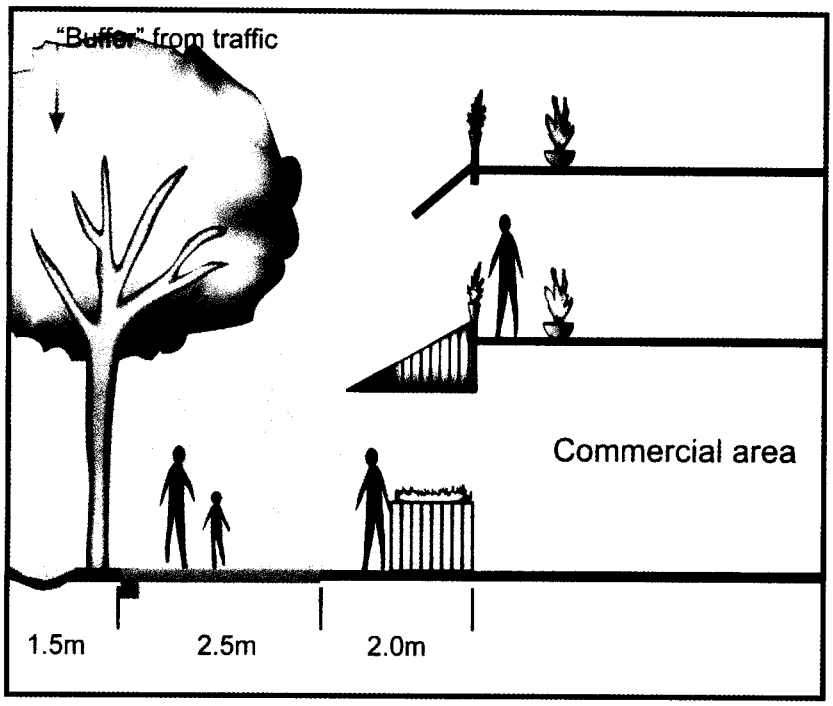


Figure 13 - Interface commerce and sidewalk.

ing to promote night use and increase safety;

- Provide additional parking lots behind the buildings, when necessary;
- Include a large number of trees on the parking lots;
- Use permeable pavement to reduce and treat stormwater runoff;
- Promote use of shared parking areas. They allow the reduction of the amount of land dedicated to surface parking.[8]

☐ Collector Street: (fig. 14)

- Provide access to the major streets as well as to the minor local streets, collecting and distributing the flow.

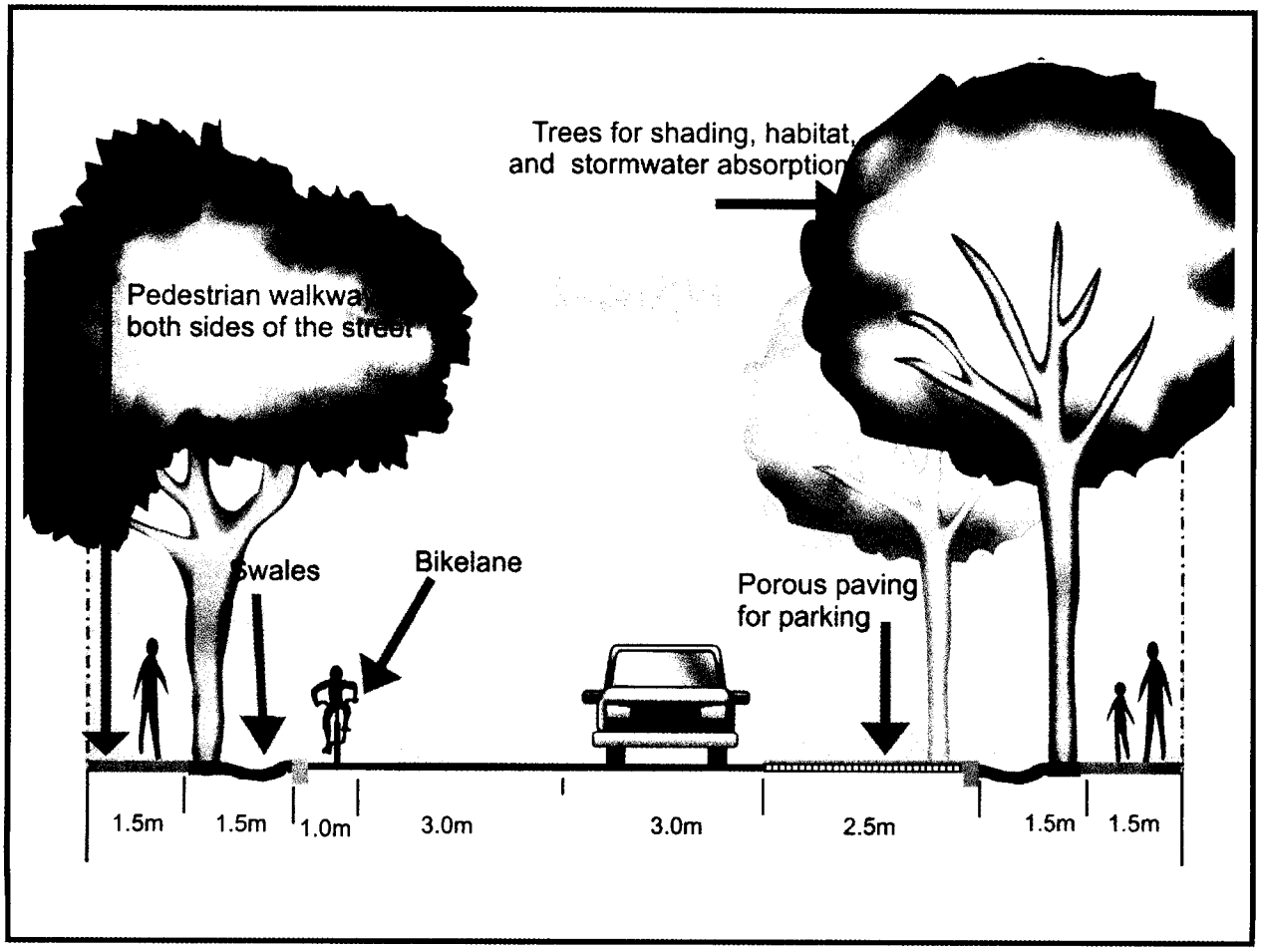


Figure 14 - Collector Street.

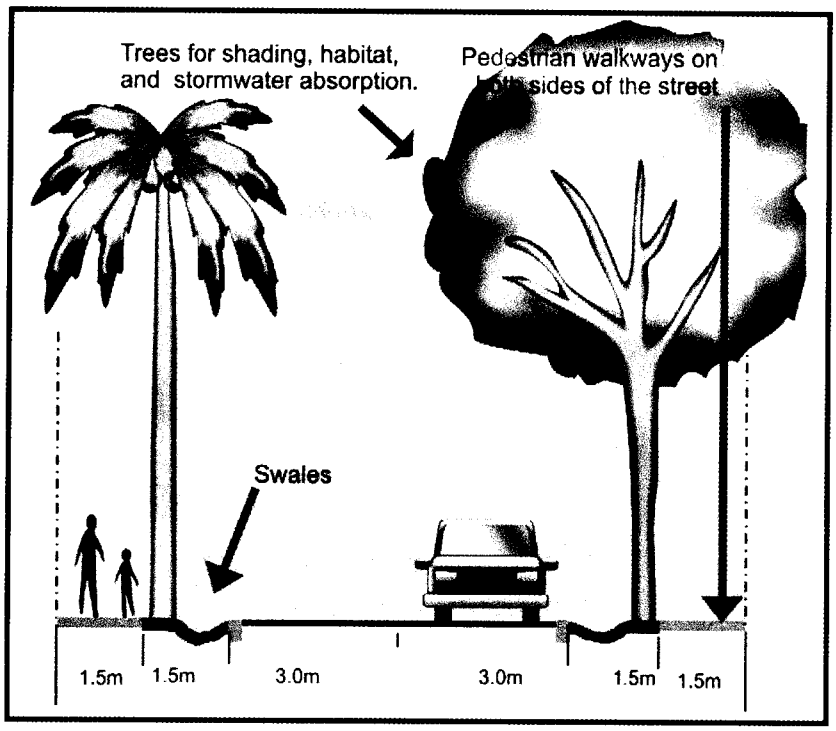


Figure 15 - One example of Local Street.

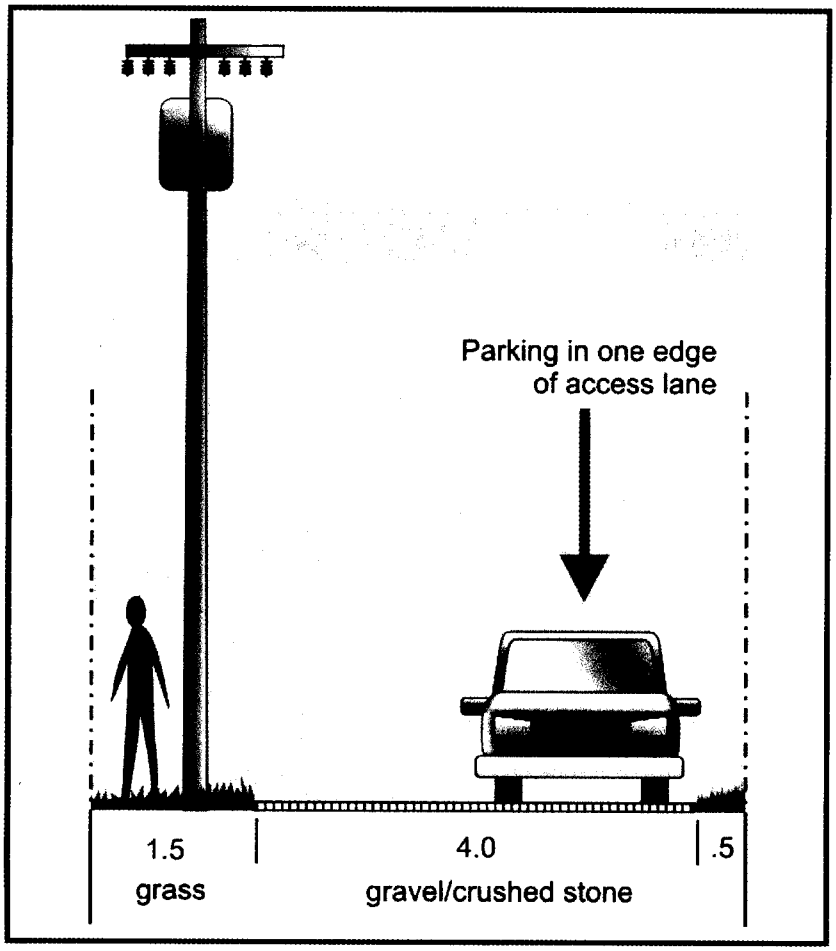


Figure 16 - Example of Access Street.

☐ Local Street: (fig. 15)

- Design local access as narrow as possible, accommodating local demand but also discouraging the constant use of cars;
- Local streets should be quiet and safe.

☐ Access Lane: (fig. 16)

- Provide access for parking and services for the local residents;
- Use pervious surface, such as gravel or crushed stone;
- Use 20 centimeter deep crushed stone pavement in order to increase stormwater infiltration. This system allows more accessibility within the community, working as a service area.[9]

☐ Greenways and Bikeways: (fig. 17)

- Work as a corridor, providing recreation, circulation, stormwater management, and habitat opportunities within the community;
- Locate greenways also near riparian and other sensitive areas, assuring a minimum of 15 meters of distance from the bank to maintain continuous tree cover;
- Provide tree cover widely to help habitat preservation and prevent sun exposure to overheat the stream water;
- Allow cyclists on the edge of riparian buffers;
- Create pedestrian crossing through buildings to increase connectivity;
- Use lightening and visibility to increase safety.

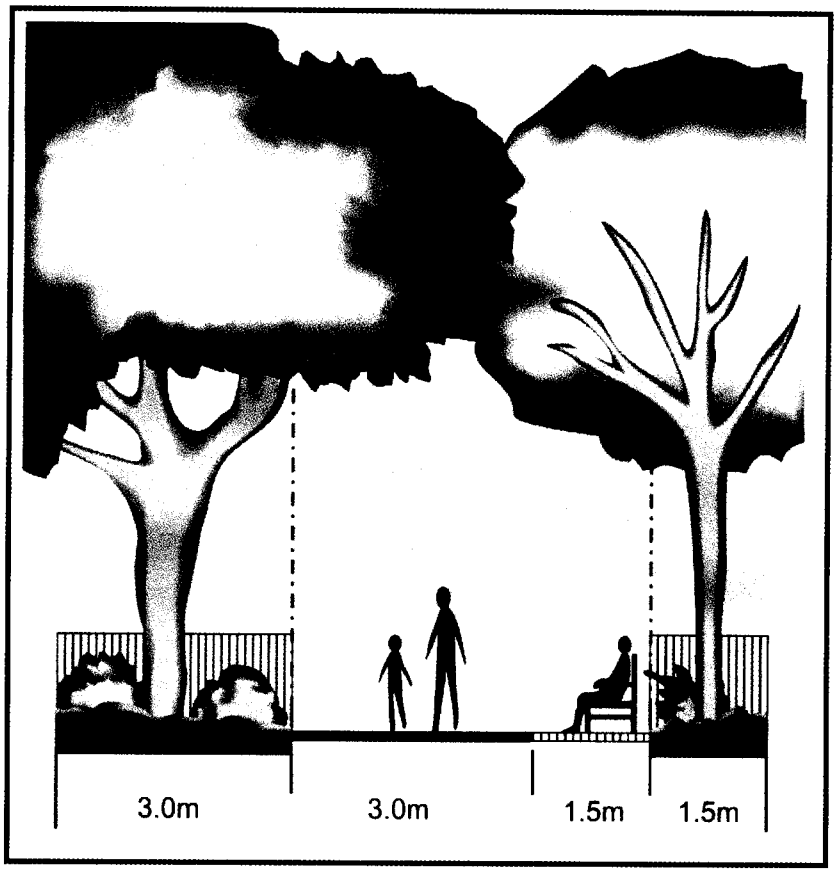


Figure 17 -Pedestrian crossing - mid-block connections.

5.2.2. Open Space, Habitat, Parks and Urban Agriculture

a) Open Space

☐ Provide spaces for public uses, including recreational activities, educational and general community activities;

☐ Create a pleasant environment, aesthetically and physically, providing for example climate protection for buildings and outdoor space;

☐ Create a network within the whole community to reduce negative impacts of urban development and improve recreational and aesthetic qualities of the area;

☐ Provide mid-block conections to improve accessibility; (fig.17)

☐ Provide access to open spaces, allowing a more public edge, improving safety and growth control.

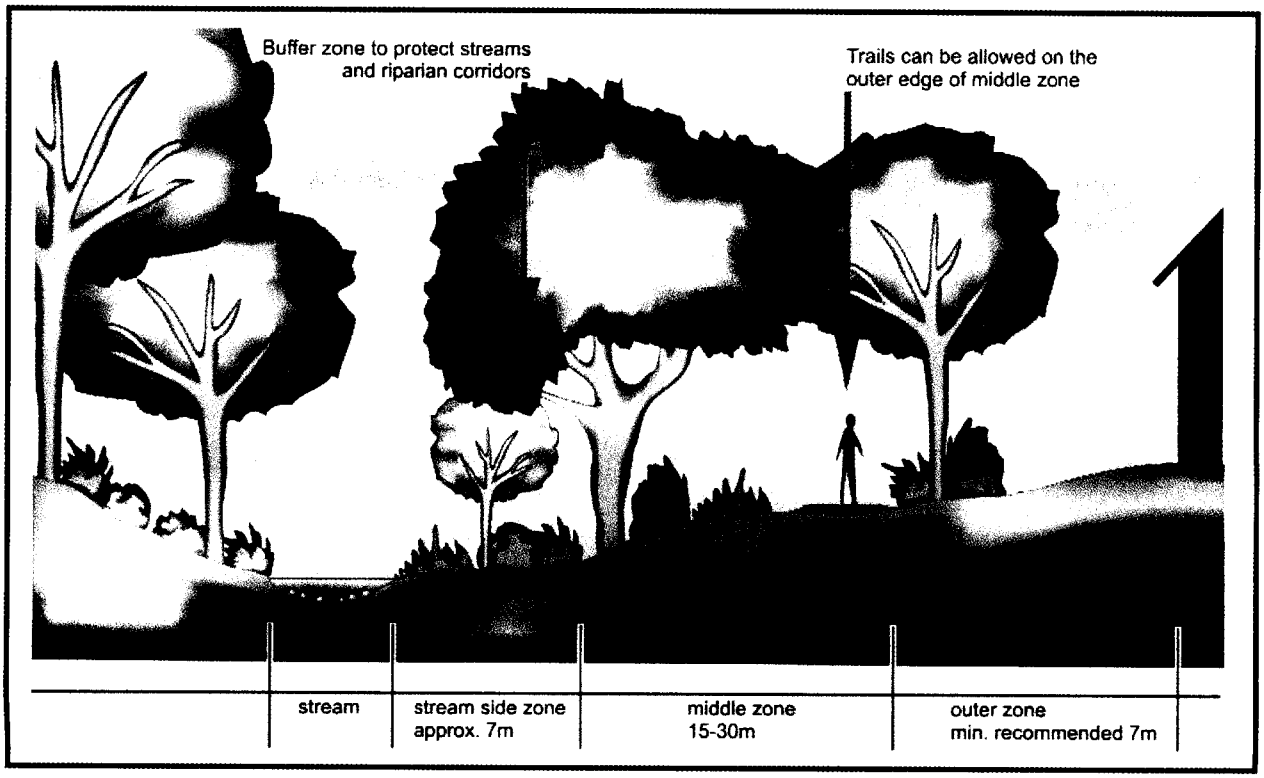


Figure 18 - Riparian protection zone.

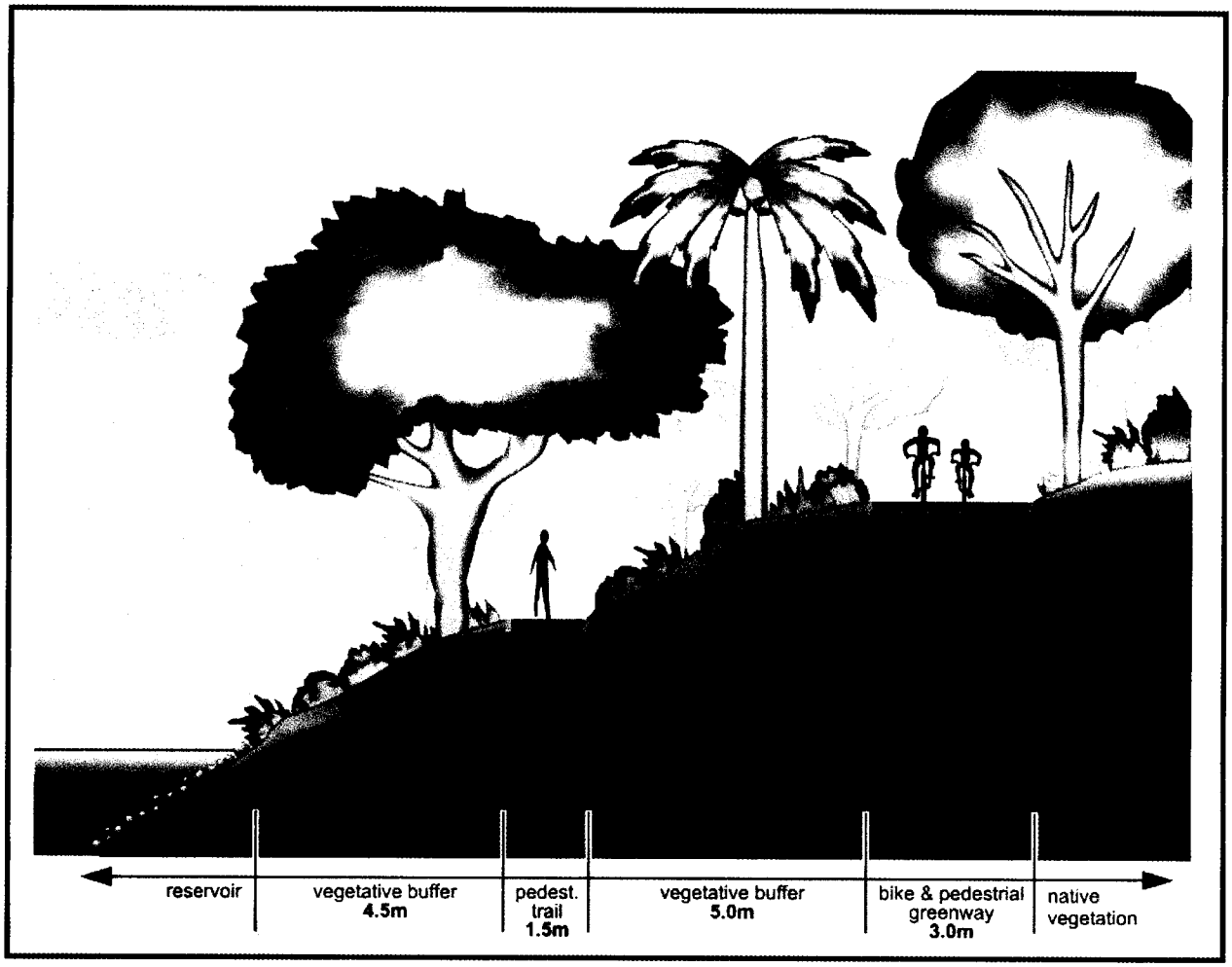


Figure 19 - Reservoir edge.

b) Habitat

☐ Protect and promote the use of native plant species. Non-native plants used only if they can co-exist with local environment;

☐ Use natural predators and other alternative solutions for the control of pests;

☐ Promote habitat enhancement;

☐ Preserve riparian areas, with restricted access and uses. (fig. 18,19)

c) Parks

☐ Attract and include every and all members of the community;

☐ Provide different options of recreational activities;

☐ Locate parks close to school sites and the community center;

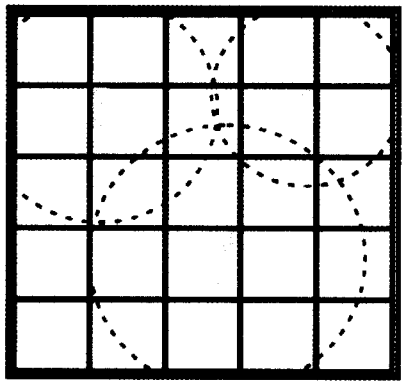


Figure 20 - Locating strategically bigger and smaller parks within the community to provide recreational alternatives in a reasonable distance from every unit.

☐ Promote xeriscaping or other water efficient landscaping for a more efficient consumption of water;

☐ Provide tree canopy widely, covering at least 50% of the park site. Urban forests help compensate for the loss of original forests, improving habitat and also helping the replication of hydrological function, disturbed by urban development;

☐ Provide different kinds of parks (fig.20)- smaller parks provide opportunity for meeting places and more passive recreation, while bigger parks can provide active recreation fields and other opportunities for more diversified types of

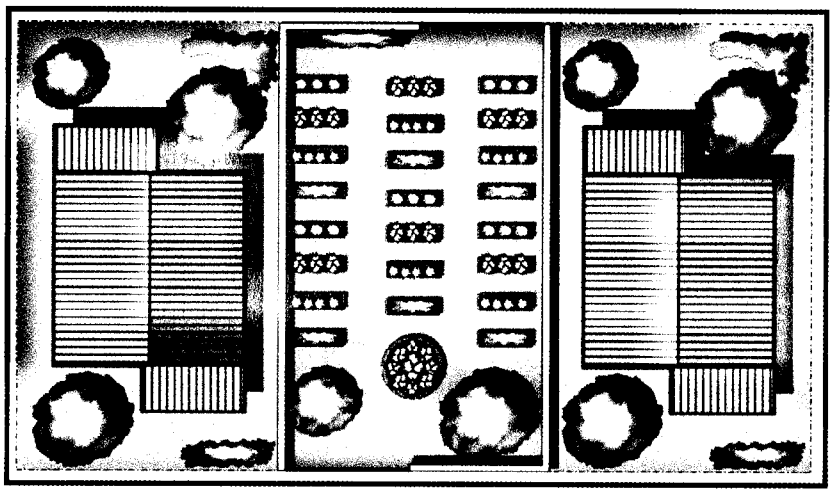


Figure 21- Community Garden providing opportunities for urban agriculture.

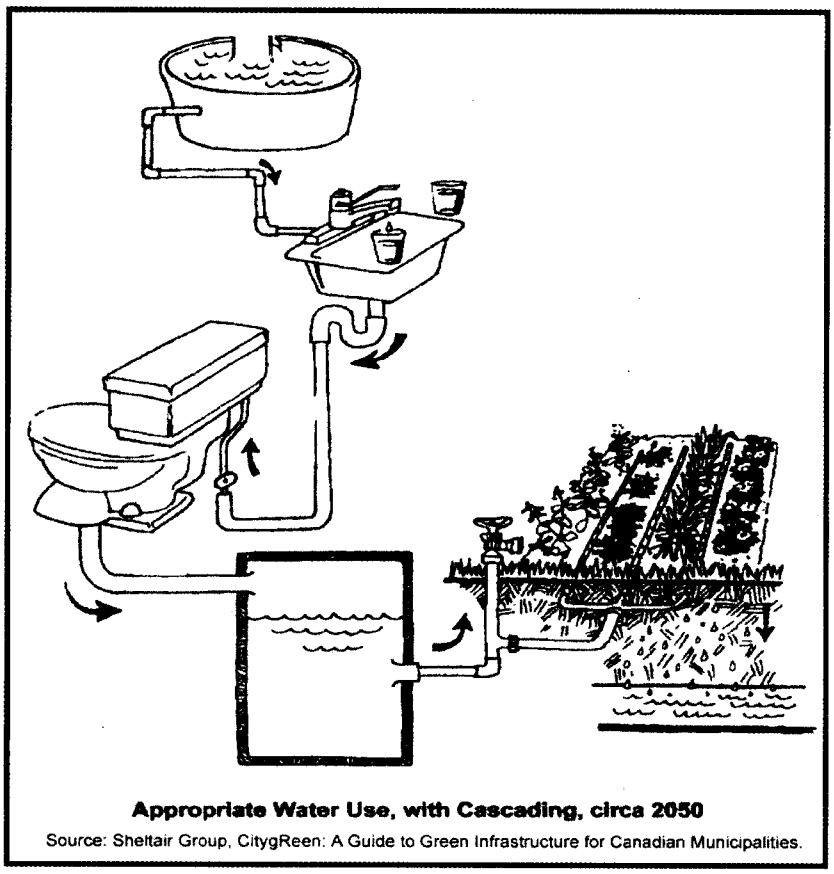


Figure 22 - Cascading water use. Source: Sheltair Group. CityGreen: A Guide to Green Infrastructure for Canadian Municipalities.

recreation. It is recommended to locate smaller parks within a 3 minute walk from every unit and bigger parks within a 7 minute walk from every unit.[10]

☐ **Provide public access to open spaces, preferably by using streets and promoting use of the edge of preservation areas, designing parks or other recreational activities, helping control urban sprawl on the reservoir side of the street.** (fig. 19)

d)Urban Agriculture

☐ Promote urban agriculture within the community. Urban agriculture promotes self-reliance, community engagement, and local economy, while reducing environmentally harmful farming practices; (fig. 21)

☐ Provide different alternatives for urban agriculture. It can be done individually, in small packets on the backyard or in bigger structures, like a community garden;

☐ Explore bio-intensive miniaturized agriculture;

☐ Promote organic fertilizers.

5.2.3. Water

☐ Seek protection and preservation of the watershed

a) Supply[11]

☐ Match the quality of the water to the end use, cascading supply is also recommended. High quality potable water should be used only for top-grade drinking water. Other functions, such as toilet flushing, landscape irrigation, clothes washing, and so on, can be fulfilled using non-potable water such as grey-water; (fig. 22)

☐ Optimize investments between increased water supply and water-efficient technologies. Those investments could be, for example, low flow fixtures, water efficient appliances, and drought resistant gardening. These measurements can reduce

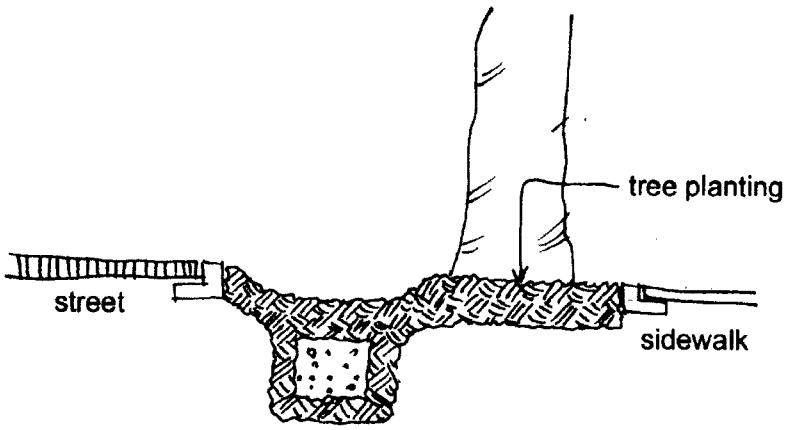


Figure 23 - Swales work as infiltration devices and also direct excess water to retention zones, in the case of bigger storms.

significantly water consumption;

☐ Load management should be encouraged. It could include on-site storage of water in cisterns, as well as behavioral modification through metering, rate structures, water bans and so on;

☐ Use cisterns at the building site to store water captured from roofs, and to provide occupants with a source of water for toilet flushing, irrigation and - with filtration - drinking and washing;

☐ **Cisterns should be protected with a cover or a net to avoid mosquito reproductions and therefore disease spread;**

☐ Promote two-pipe systems allowing access to reclaimed water (treated wastewater, meeting or exceeding drinking water standards) and potable water using only one system. The reclaimed water can be generated from wastewater, at the neighborhood scale, and looped back into buildings in a separate piping system for all non-potable uses.

b) Stormwater

☐ Manage all stormwater on site;

☐ Reduce negative impacts of urbanization controlling water flow;

☐ Choose specific practices for the type of remediation needed and also according to the natural characteristics of the site. Sedimentation devices, for example, work better for breaking down course particulate, while marshes and wetlands are more efficient in treating finer particulate. A complete and comprehensive system can be achieved by a combination of measures;[12]

☐ Promote use of swales and permeable paving along streets; (fig.23)

☐ Eliminate most of the stormwater pipe. The water should be slowed down and infiltrated, or directed to infiltration ponds; (fig. 24)

☐ Enhance natural flow. The site's ability to catch, hold and absorb water should also be improved;

☐ Minimize the use of concrete and asphalt paving;

☐ Promote use of alterna-

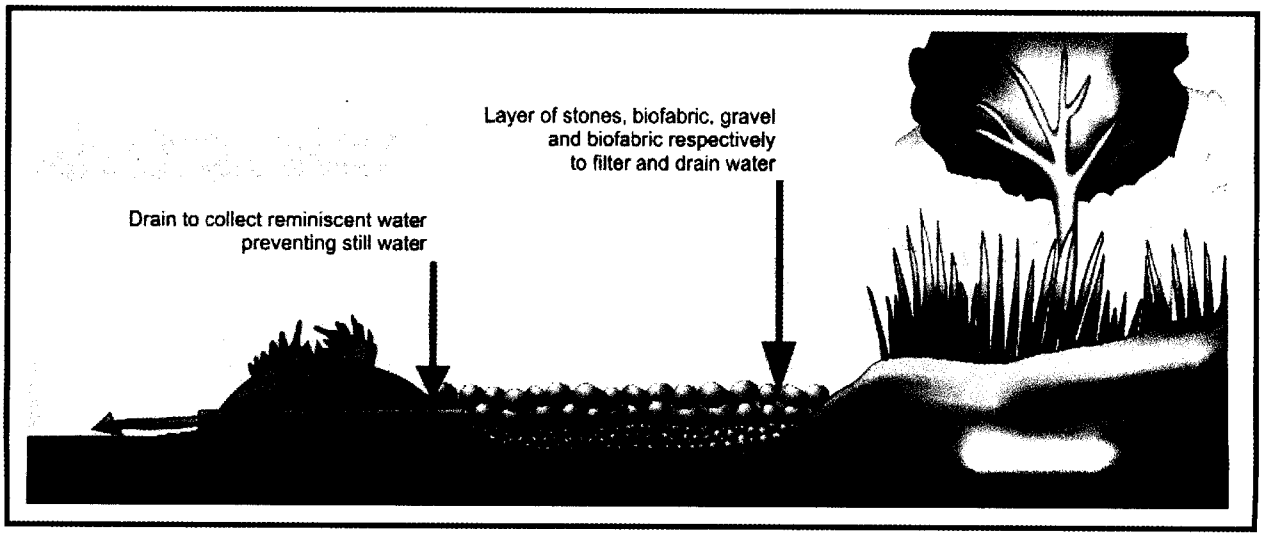


Figure 24 - Infiltration pond.

tive treatment to filter runoff. Some plants and micro-organisms can be used to filter out bacteria, toxins, and heavy metals out of the sewage runoff;

☐ Guide water to vegetated areas; depressions should be lined with sand, gravel and bigger stones and filled with water-harvesting plants to slow down water runoff and filter stormwater.[13]

☐ Distribute water back to the hydrological system;

☐ **Ensure that the water won't sit on the pond for longer periods, in order to avoid health problems like "dengue". This can be done by constructing the pond with a thick layer of aggregates that will allow the water to drain through the first layer and then to be filtered, without risk of diseases.**

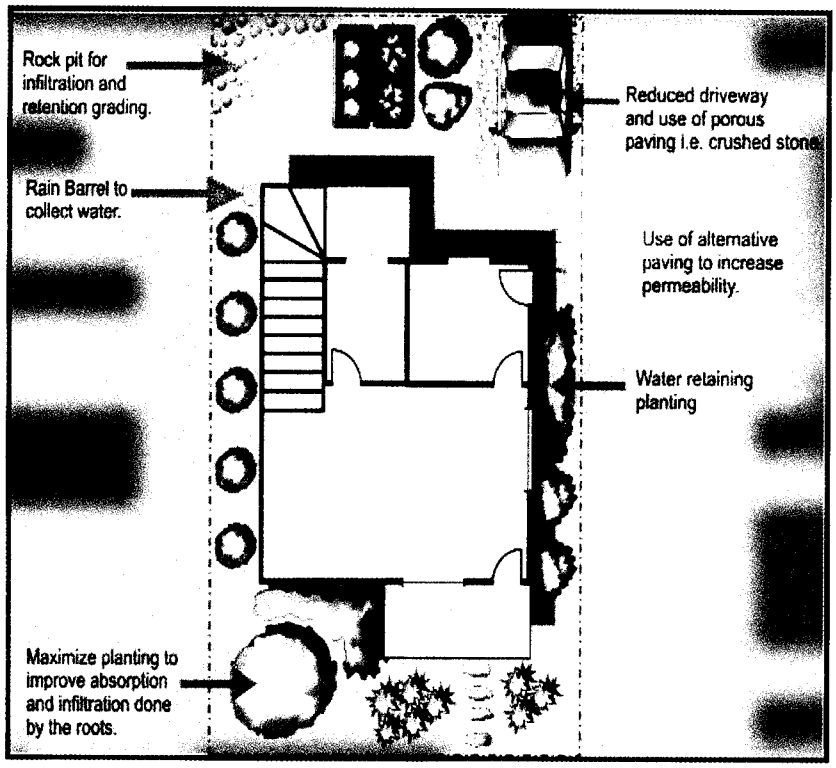


Figure 25 - Lot-scale recommendations.

☐ Lot-scale recommendations: (fig. 25)

■ Manage stormwater at this scale as much as possible. Use rock pits, retention grading, water retaining planting areas, and rain barrels;[14]

■ Collect rain water preferably from the roof and store in cisterns located on the roof, allowing distribution by gravity, reducing need for energy consumption. The water collected should be filtered and used for WC flushing, washing, and watering plants. [15]

☐ Block-scale recommendations: (fig. 26)

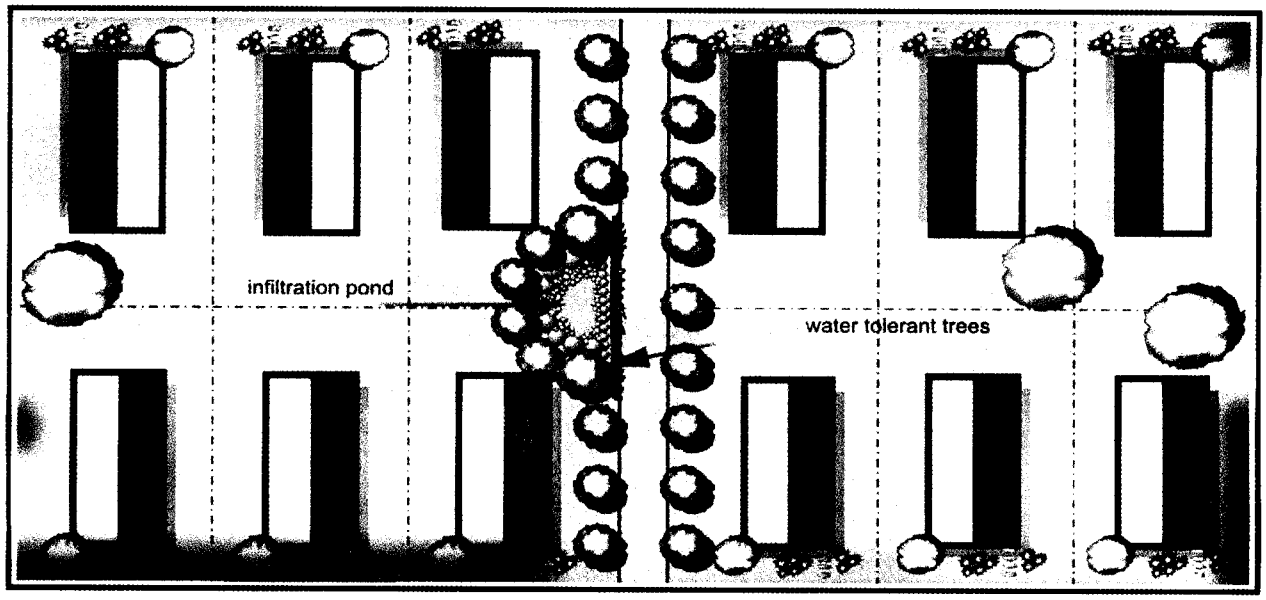


Figure 26 - Block-scale recommendations.

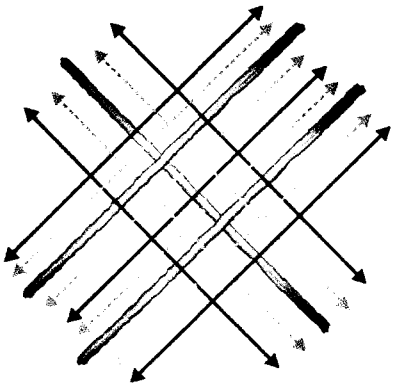


Figure 27 - Integrated green network.

- Design the middle of the block to function as a circulation area, with a semi-private character. The private area adjacent to that area should work as an integrated block-scale space to collect and filter runoff;
- The size of the infiltration tank should vary according to the demand, amount of rainfall and available area for collection surface;[16]
- Use water tolerant shading trees to help with slowing the flow of water, allowing more infiltration.

☐ Street-scale recommendations:

- Allow transportation and collection of stormwater;
- Interconnected street networks can also work as an interconnected stormwater network if used to capture, transport and infiltrate stormwater. (fig. 27)
- Promote the design of boulevards with swale and street trees to handle this scale of stormwater management demand. (fig. 28)

c) Streams and springs

☐ Preserve, protect and enhance environmental assets, including streams, and associated riparian zones, wetlands, forests, and other important areas for habitat;

☐ Use natural hazard areas as public or private conservation zones, when suitability allow;

☐ Allow use of trails on the outer edge of the middle zone. Trails help direct human activity to an appropriate location, and prevent negative human impact on the buffer ecosystem.[17] See fig. 18.

☐ Promote educational and incentive programs to assure the protection of those areas. Educational programs should be directed to inform the community on the importance and benefits of helping protect natural resources.

5.2.4 Community facilities and Social space

Informal settlements usually are not provided with community facilities. That is a result of their illegal status of occupation but also negligence of the State. The State has an obligation to provide those services to every citizen, including those who had no other choice in life than to live in favelas.

The presence of such facilities within the neighborhood has a huge effect in developing the community, empowering their inhabitants and leading them to a better life in both the short and long terms.

It is important to incorporate some community facilities, to decrease the necessity of dislocation to other communities and also to create a better sense of community. Other benefits include the creation of

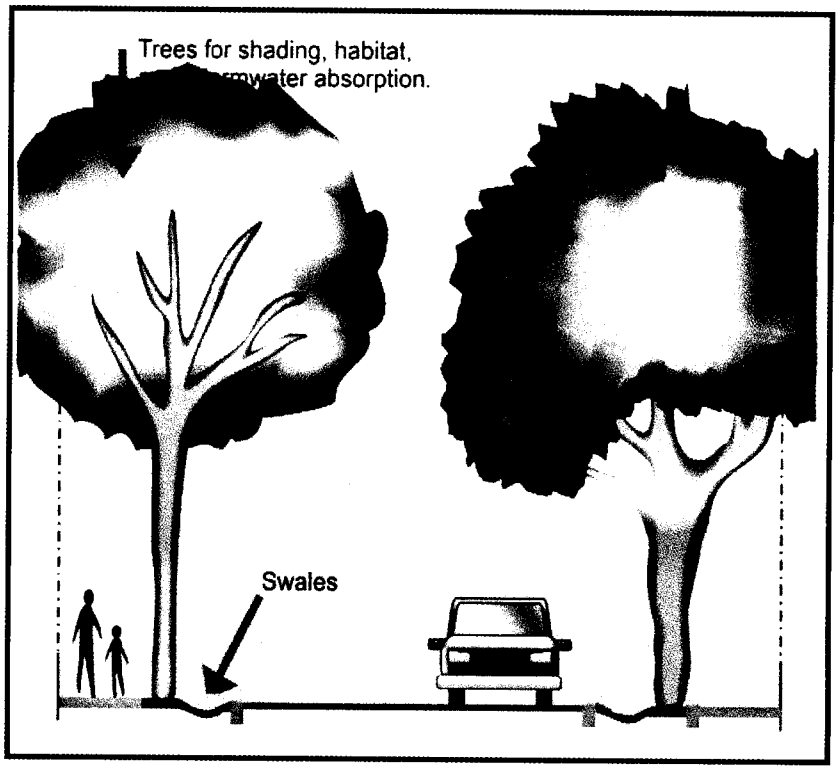


Figure 28 - Street-scale recommendations.

job opportunities inside the community and safety increases as a result of closer personal relations within the community. Some of the community facilities suggested includes:

☐ Day Care Centre:
■ Provide at least one Day Care Center for every 300-400m radius. Each centre should have at least 150m² of open space.

☐ Elementary School:
■ Provide one Elementary School for every 600-1000m radius. The school site should be integrated with open space, promoting integration in uses for both recreational and educational purposes. One example could be the development of a community garden coordinated by the school and students, and involving the community as well. Educational purposes can also be fulfilled by integrating natural systems management, for example a retention pond.
■ School sites should also be designed to be conductive to integrated continuing education classes, events like lectures, workshops, and general events involving the community should be promoted. They can take place in hours that the school is not operating, maximizing the utilization of public facilities and also improving community interaction.

☐ Second Grade School:
■ Provide one Second Grade School for every 5000m radius. This could imply one Second Grande School serving more than one community. Community activities, like sport events, should be promoted, as well as other activities that help get the community involved with school activities.

☐ Community Centre:
■ Provide one community centre for each community. This centre should be active and run by the community. The City should be an active partner, offering orientation, information and learning from the community as well. This centre would have a strong social and political role, helping members of the community, improving and defining priorities in public actions.

☐ Health Centre:
■ Provide at least one health centre for every 5000m radius. This centre should function not only as a treatment centre but as a prophylactic centre, with information for residents and family care. Idealistically, this could include the family doctor that could visit families at their home, where it would be easier to identify potential threats to health and genetic history, as well as to create a closer link between doctor and family.

☐ Police Station:
■ Provide a police unit in every 5000m radius. They should work actively with the community and should incorporate an educative aspect, replaced as much as possible from punitive actions.

☐ Recycling Centre:
■ One option for creating work opportunities within the community and education opportunities at the same time can be achieved for example from the creation of a recycling centre. This centre could operate in partnership with other companies and the City in order to provide ways of surviving competitively, and keeping at the same time the social role. This activity could also be linked to craft art made from recycled materials, engaging children and the schools in those activities. (See also Recycling on Waste Section)

☐ Commerce:
■ Provide 10 to 20% of area within the community dedicated to commercial area. This could include grocery stores, bakeries, bank agency, post office, restaurants, among others. The maximum distance of commerce and services from any dwelling unit within the community should be 400m.

☐ Institutional Area:
■ Provide at least 5% of area within the community dedicated to institutional area. This would add in the creation of job opportunities as well as strengthen the links between the community and public institutions.

5.2.5 Housing Typologies

a) General recommendations:

☐ **Design and build**

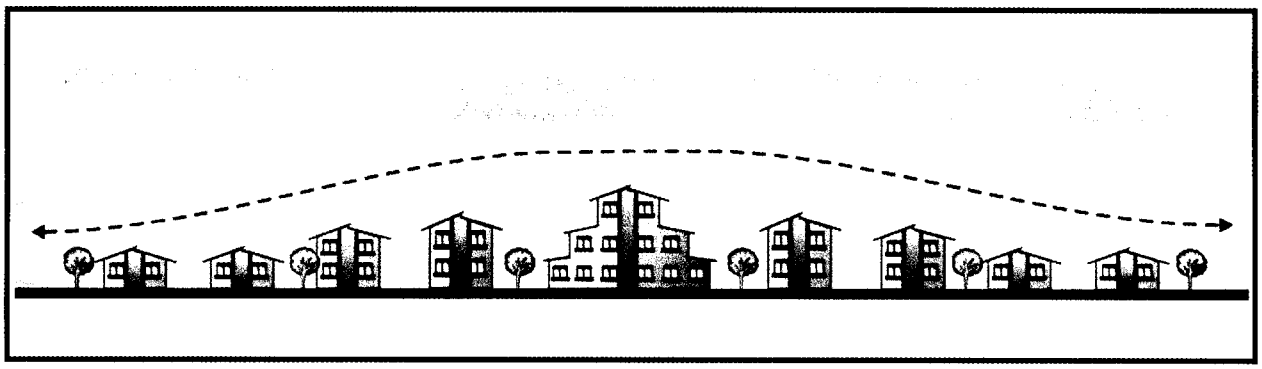


Figure 29 - Harmonious skyline.

housing to last as long as possible; maximize cost-effective site development and construction;

☐ Allow the location of the buildings to create outdoor spaces;

☐ **Improve private/public relationship and increase safety by locating buildings closer to streets;**

☐ **Keep safety in mind when designing. Clear property boundaries and increased public vs private relationship are some was of improving safety;**

☐ Promote diversity of housing and building typologies, as well as cluster development, promote mix of uses;

☐ Integrate skyline harmoniously with natural and built environment; (fig. 29)

☐ Situate higher-density housing preferably closer to parks or open spaces;

☐ Promote use of energy-saving features;

☐ **Provide green spaces within the housing units preferably as part of yards for individual units, facilitating the control and reducing maintenance costs for the City;**

☐ **Provide public access to other green areas, like parks**. (fig. 30)

☐ Recommendations for the yard:

■ Work as a sponge, absorbing the rain draining off roofs,

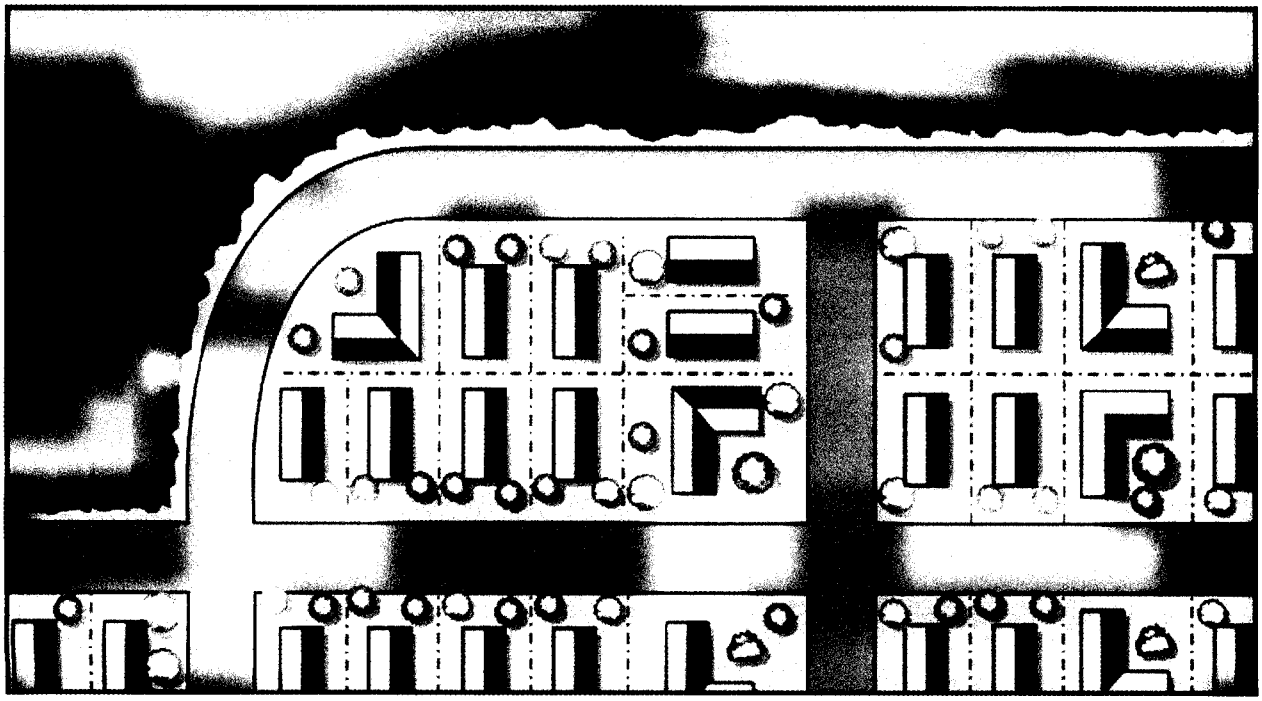


Figure 30 - Housing facing park or open spaces, increases safety, improves housing desirability. A public access should also be available.

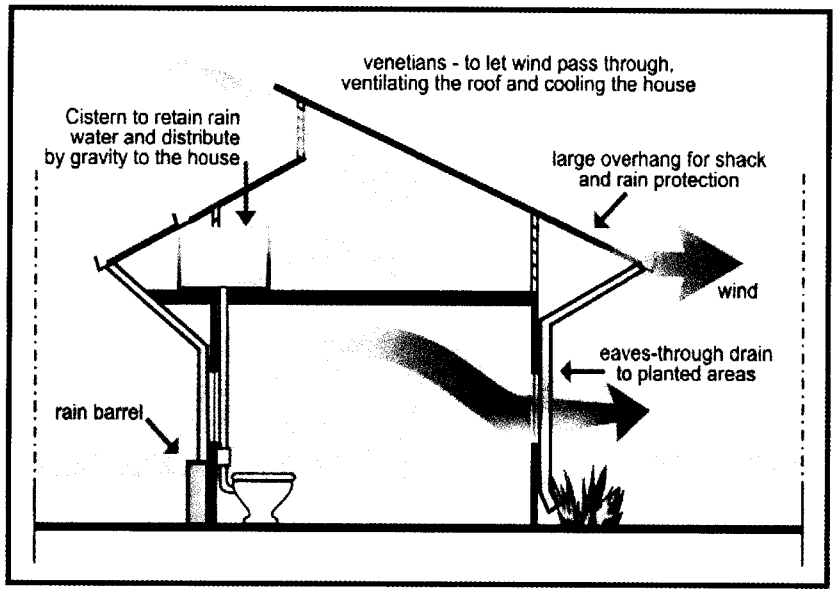


Figure 31 - Recommendations for the roof.

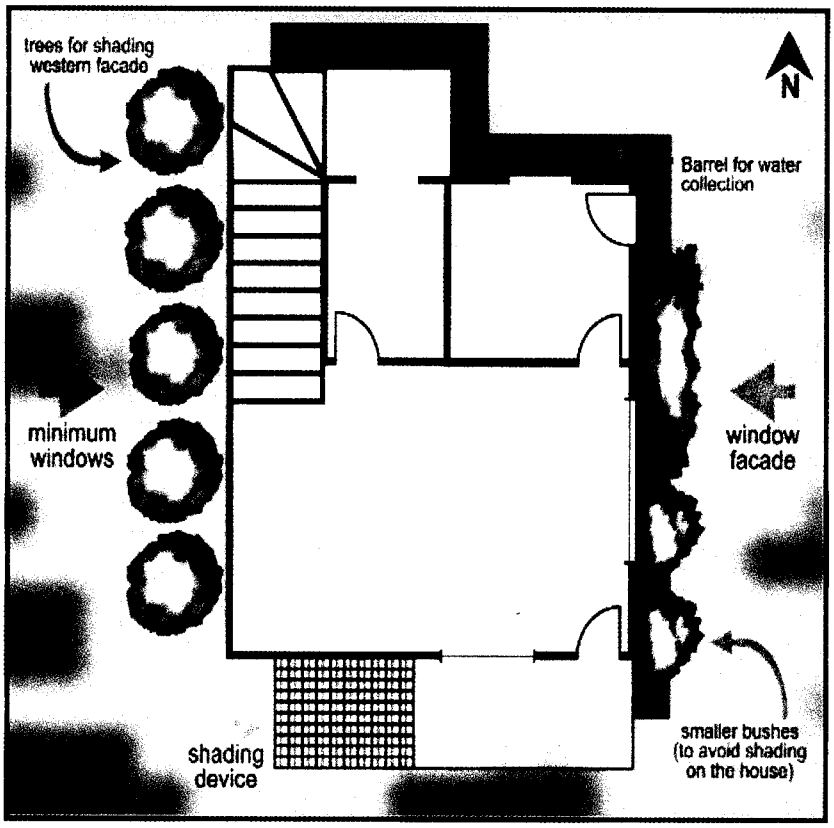


Figure 32 - Building orientation and design considering solar orientation and rain water collection.

parking areas, and pathways. **Rock pits and other devices should be used to avoid sitting water on the yard;**

- No more than 50% of the parcel should be covered with buildings and impervious surfaces. Pervious materials like crushed stone or some other type of porous pavement can be used in driveways and paths;
- All permeable areas should be designed to accept runoff. A concave lawn edged by gardens can collect and infiltrate stormwater on-site;
- Topsoil should be stockpiled during the development for redistribution; the resulting topsoil can be twice the original depth. Soil porosity must be maintained throughout construction and tested before occupation to prevent erosion problems;[18]
- **The edge of the property should be well established, with low walls, fences or plantings to facilitate control and increase safety;**
- **Protect the western façade from sun exposure. Use higher trees and other shading devices;**
- **Open east façade to incidence of morning sun and natural lighting inside the house. Lower trees and shrubs should be used;**
- Promote urban agriculture at the lot-scale. Smaller planting beds can be used.

☐ Recommendations for the roof: (fig. 31)

- **Promote use of pitched roof or similar to avoid addition of other floors, controlling the sprawl and unwanted densification. This type of roof also allows better circulation of air, especially if combined with venetians.**
- Collect rain water. A rooftop cistern can collect rainwater for irrigation, while water from the roof can be filtered for household use. Rain barrels attached to downspouts can provide water for

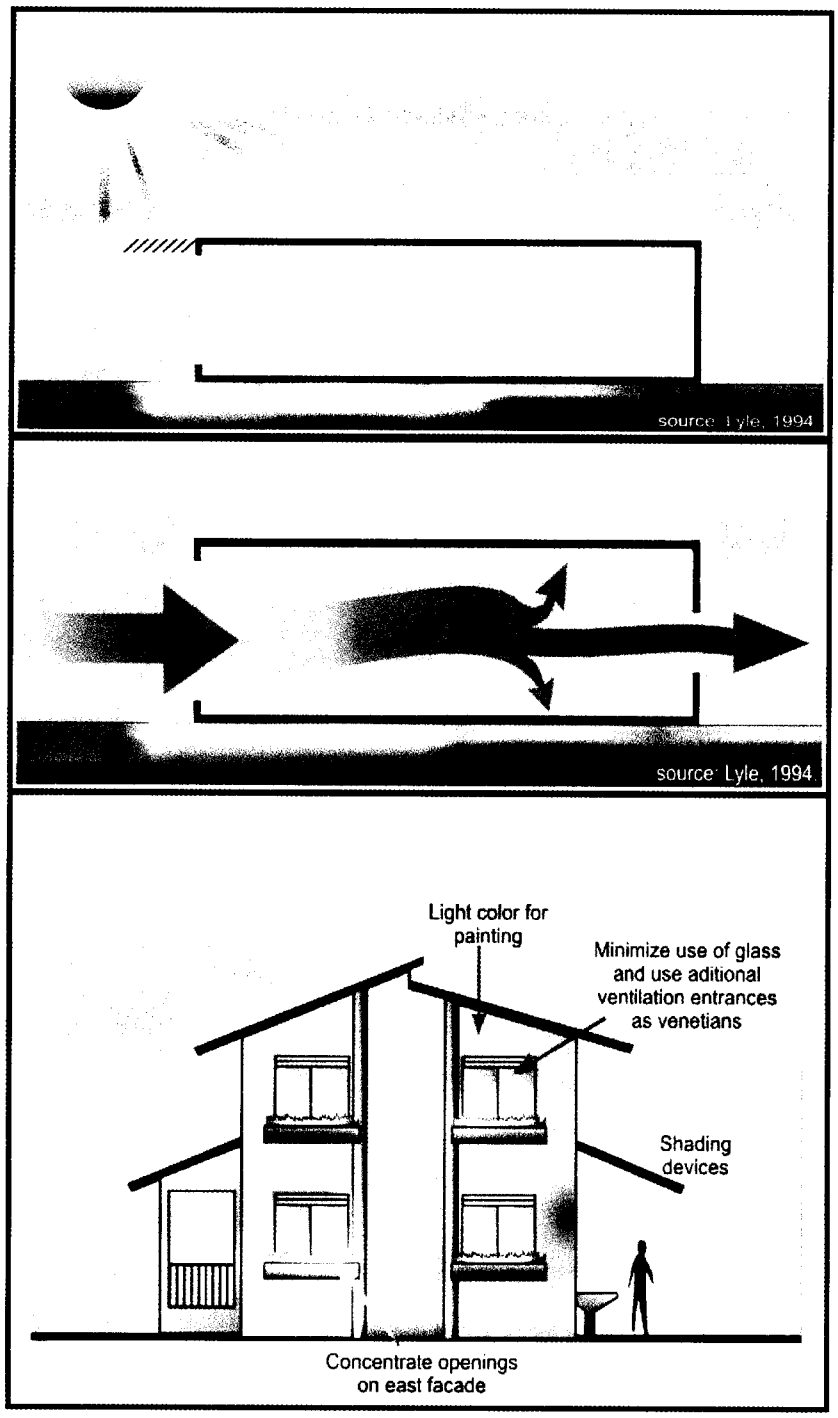


Figure 33 - Recommendations for the house. Design according to sun, wind orientation and local climate.

irrigation and remove water from storm drains.

☐ Recommendations for the house[19]: (fig 32,33)

■ **Take solar orientation into consideration when laying the buildings: Generally the best orientation is to set the longer side of buildings on an east-west axis, in order to maximize solar exposure. The year-round altitude and azimuth of the sun should be considered when designing exterior wall space, window sizing and placement, overhangs, and interior layout. Windows and shading devices can be placed strategically, in concert with the overhangs to minimize solar exposure in the summer and maximize in the winter; (fig. 33)**

■ **Shape buildings to be conscious of the wind: Buildings should be shaped to catch wind, while the interior should be laid out to efficiently circulate these breezes;**

■ **Use landscape to provide desired micro-climate for buildings: Landscape elements such as trees, plants and berms can protect buildings from solar gains and harsh winds. It is recommended to provide widely shaded west facades to reduce undesirable sun exposure. Design building to maximize east sun exposure and minimize west sun exposure;**

■ **Thermal mass / building materials: Thermal mass should be considered in cooling strategies. In general, the greater the mass of the exterior wall and roof, the greater the thermal transfer time between the exterior and the interior. This principle should be used in concert with the building's mechanical heating and cooling systems to achieve maximum energy efficiency.**

■ **Color: In general, light colored, reflective materials are preferable in hot climates, since they tend to reflect the heat rather than**

absorb it;

- **Windows: window type, size, and placement, have a huge effect on solar heat gains, passive cooling and natural lighting. These effects should be evaluated when deciding upon window types and placement. Windows allow too much heat gain in the summer and too much heat loss in the winter. However, some new technology materials have better insulation qualities than the regular ones, although the initial cost is still high but energy savings along the years might make it cost-effective;**
- **Shading devices: Roof overhangs, awnings, porches, blinds, and many other devices can be used to prevent unwanted solar heat gains. These devices should be placed carefully, according to the sun's altitude and azimuth.**

b) Layout and shape of the building

☐ Take advantage of natural daylight, ventilation and views;

☐ Situate the front setback between 3 to 5 meters, in order to create a pedestrian scale; (fig. 34)

☐ **Locate homes and stores close to the street, providing more "eyes on the street", making it safer and friendlier;**

☐ Provide semi-private spaces to make the transition between public and private spaces. This device also helps increasing safety in the community. Examples of semi private spaces include: balcony, porch, rooftop garden and courtyard. (fig. 35)

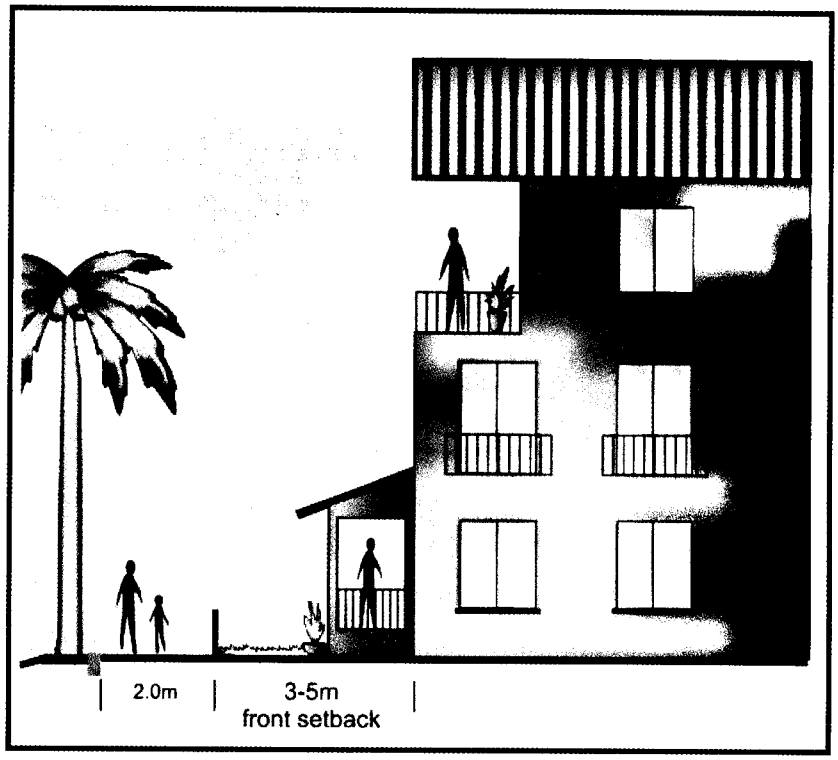


Figure 34 - Front setbacks shouldn't be bigger than 5 meters in order to improve the relationship between public and private spaces.

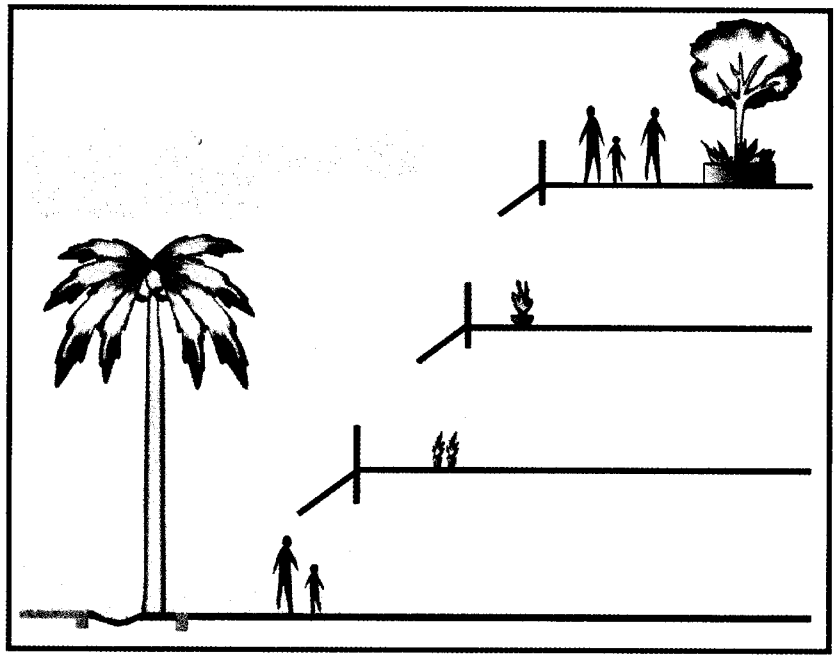


Figure 35 - Rooftop garden.

c) Cultural and regional identity

☐ Promote use of locally produced building materials;

☐ Use local labor whenever possible;

☐ Promote community involvement in building for

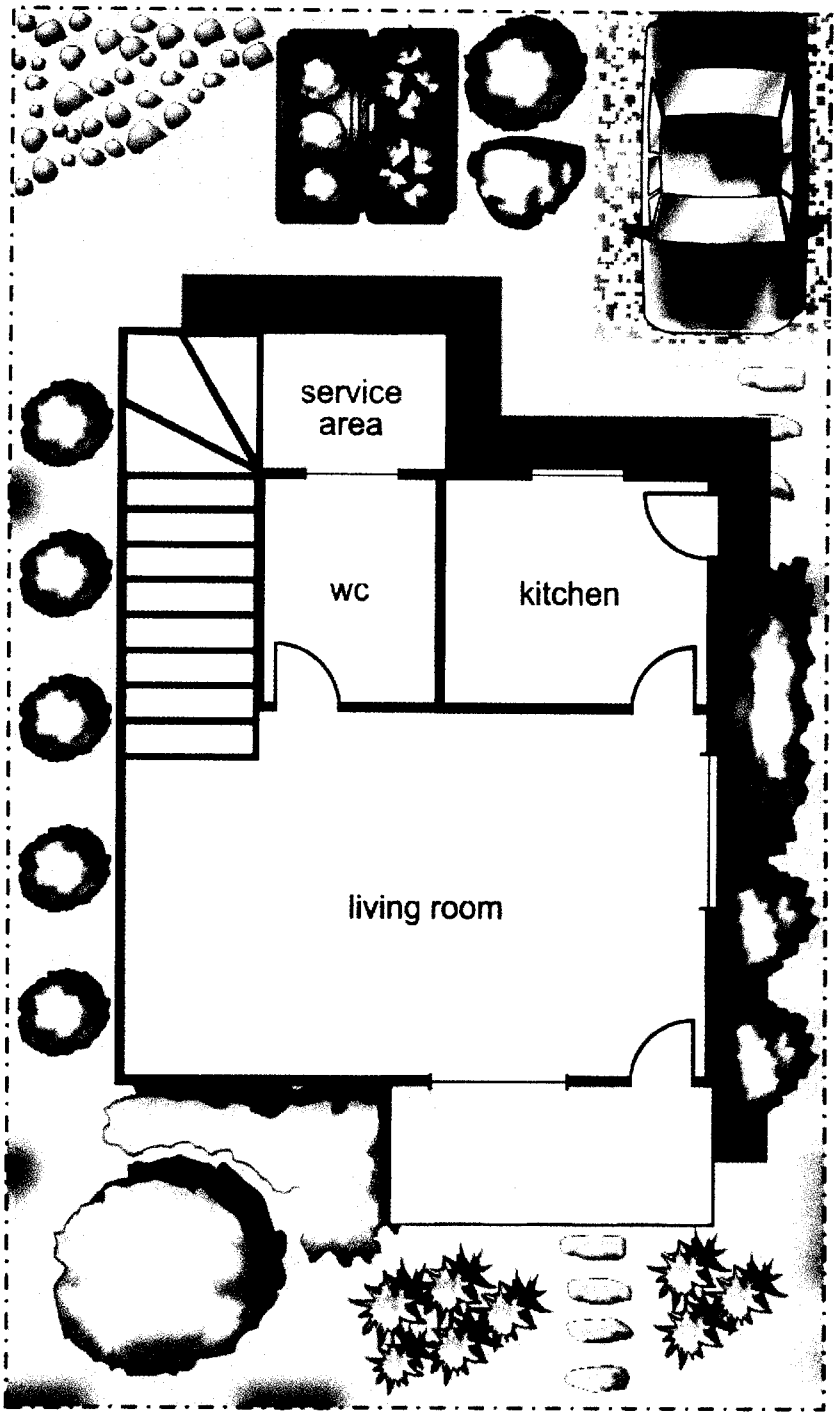


Figure 36 - Example of low density lot.

existing communities;

☐ Use architectural elements and features typical of the region and culture.

d) Materials

☐ Explore methods of recycling, retrofitting, and re-using buildings;

☐ Promote the use of materials which are either recyclable or re-usable. Recycling programs should be promoted in the construction site as well, in order to reduce the amount of solid waste accrued from construction;

☐ Promote used materials made of renewable or sustainable source as much as possible. Proximity of the source and the product to the building is also important to consider. Using materials from a closer source reduces transportation impacts, costs, and also helps regional economy;

☐ Consider embodied energy when choosing materials. Providing a more accurate cost of the building material;[20]

☐ Investigate the possibility of the material to create environmentally hazardous waste products or inordinate amounts of pollution - solid and air - and also how the company disposes of these wastes;

☐ Use preferably natural materials. Generally materials such as stone, lumber, and earth are less energy-intensive to produce, contribute less to the pollution of the environment and also present lower levels of toxicity;[21]

☐ Evaluate the cost of materials also by its durability, prefer longer lasting products, lower maintenance requirements;

☐ Reduce energy consumption by minimizing, reusing, and recycling construction and demolition waste.

e) Examples of housing typologies:

☐ Low Density (fig. 36)

■ **Single houses, even being more costly than denser types of occupation, should be provided, since it is usually the preferable type for the general population;**

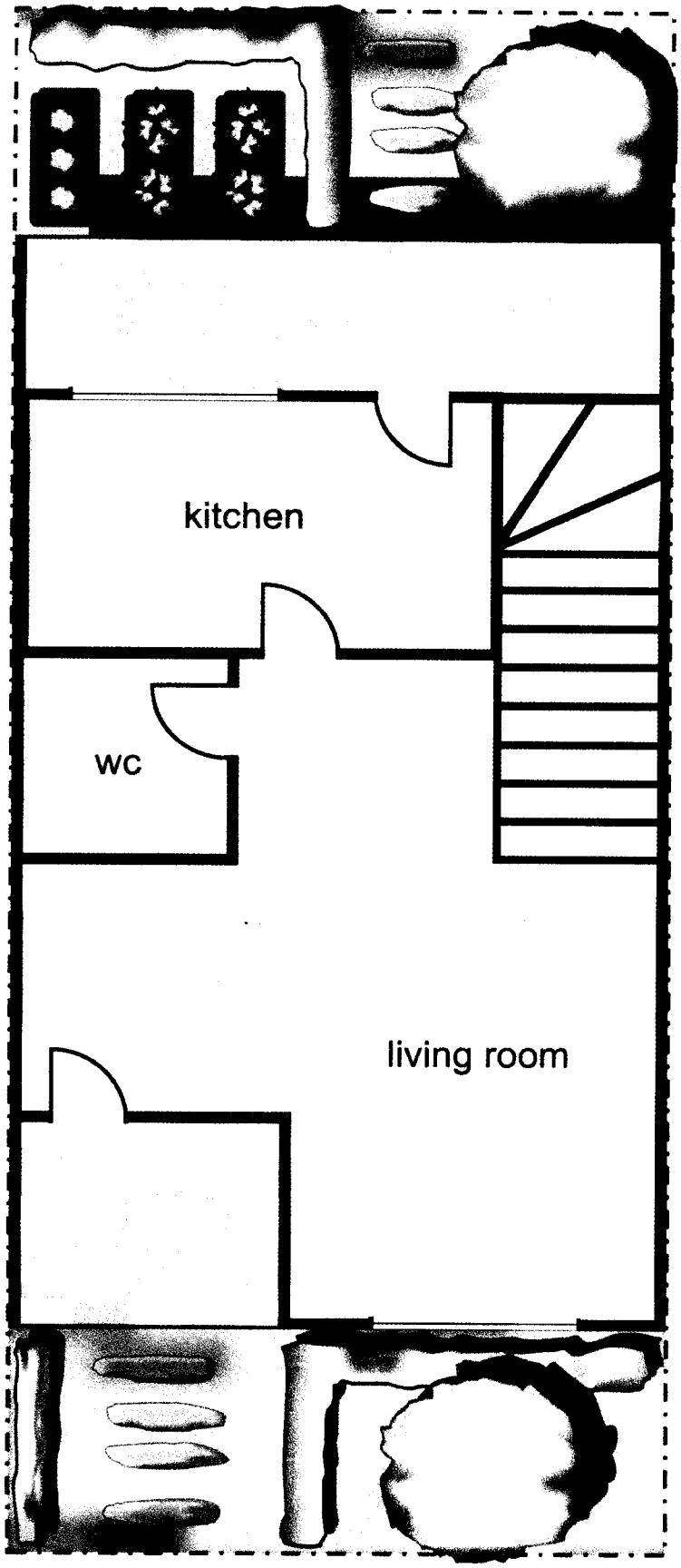


Figure 37 - Example of medium density lot.

- The yard should provide recreational, contemplative and planting opportunities.
- The minimum lot area recommended is around 100m².

☐ Medium Density (fig. 37)

- **Townhouses are one example of medium density. They allow individual front doors for each unit and also a private backyard. Providing individual accesses helps improving safety and also increasing acceptability;**
- Rear lane access for parking is generally required.

☐ High Density (fig. 38)

- **Buildings should take advantage of natural insulation and ventilation. Stepping floors and creating balconies are ways to maximize the benefits from the climate;**
- **Windows should also be used to maximize the availability of natural light into the units. Overhangs, light shelves and awnings can help protect from undesired insulation; balconies for each unit also helps control interior temperature and also provide plating opportunity and contact to the nature and the community;**
- Facades should be designed to frame views and contribute to the overall aesthetical quality of the community. Open courtyards and airy entries provide light and natural ventilation for larger buildings;[22]
- Higher densities don't have to sacrifice natural features. By articulating and placing carefully the building, it is

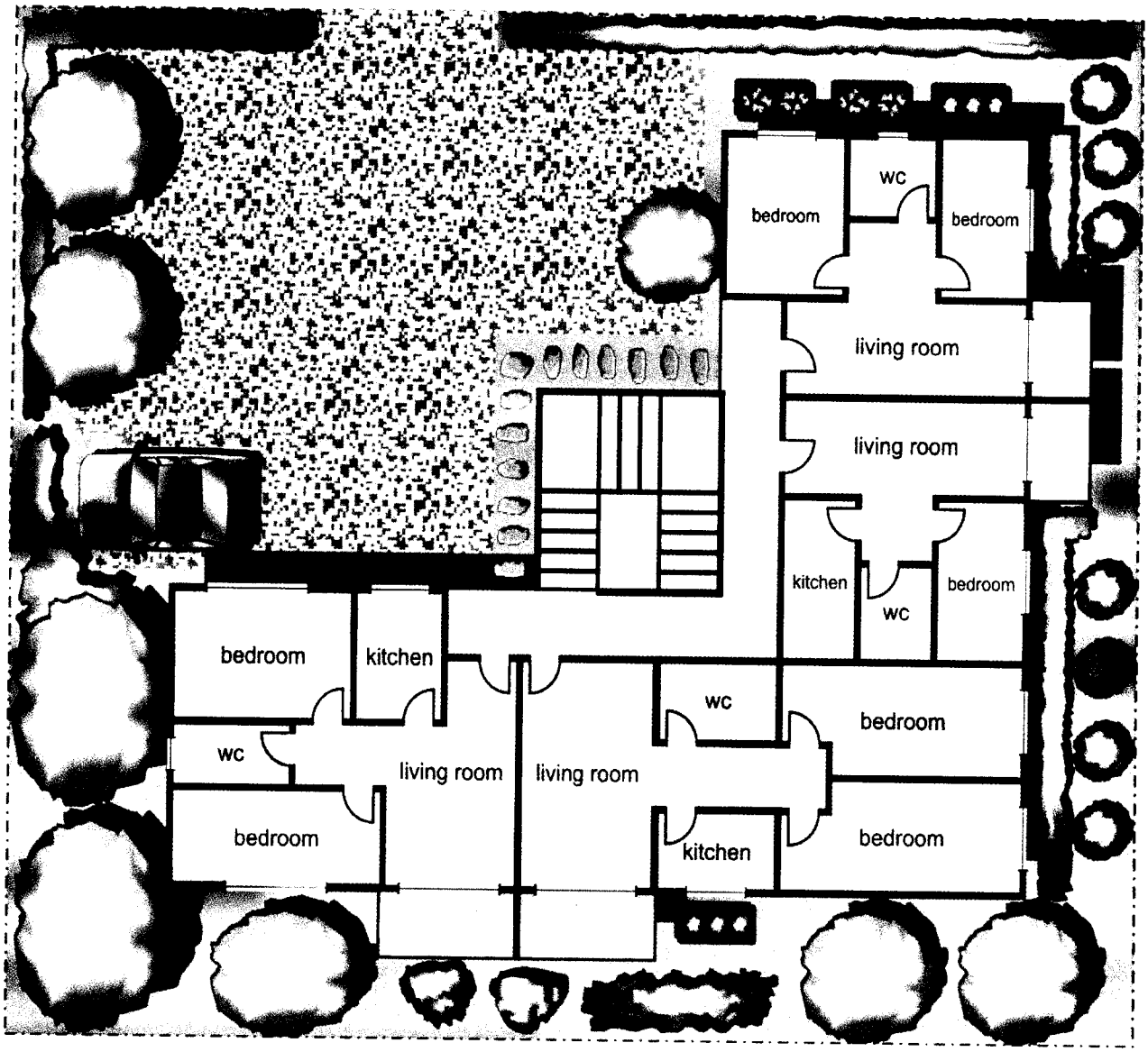


Figure 38 - Example of building typology for higher density lot.

possible to achieve good aesthetical appearance and also respect environmentally sensitive areas;

- Maximum height: for residential buildings should be around 4 storeys. The final decision however should also take into consideration specifics about the site and overall community context. Natural aspects such as soil characteristics, environmental impacts and others should be evaluated, as well as the impact of the building on the community, not blocking views or sunlight. It is also important for the community to have a harmonious skyline, without discrepancies like high rise buildings beside lower units;
- **An outside staircase provides independent access to all units, improving safety and acceptability of this type of occupation;**
- Higher-density units should be located at the heart of the community, providing residents affordable housing close to their daily needs. These units should be less expensive than the others. A balcony for each unit offers an essential connection to the nature and outside community.[23]

5.2.6. Energy

- ☐ Promote integrated and planned system in order to help ensure a mix of energy supply, as well as a more effective matching of energy quality to end-use;
- ☐ Cascade provision of

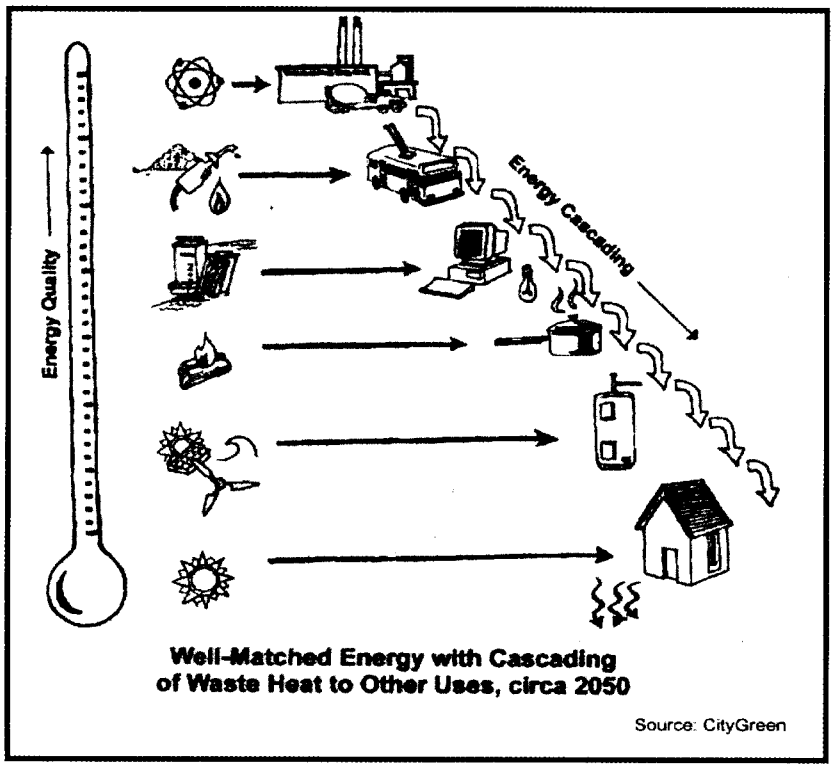


Figure 39 - Cascading energy system, matching final use. Source: CityGreen: A Guide to Green Infrastructure for Canadian Municipalities.

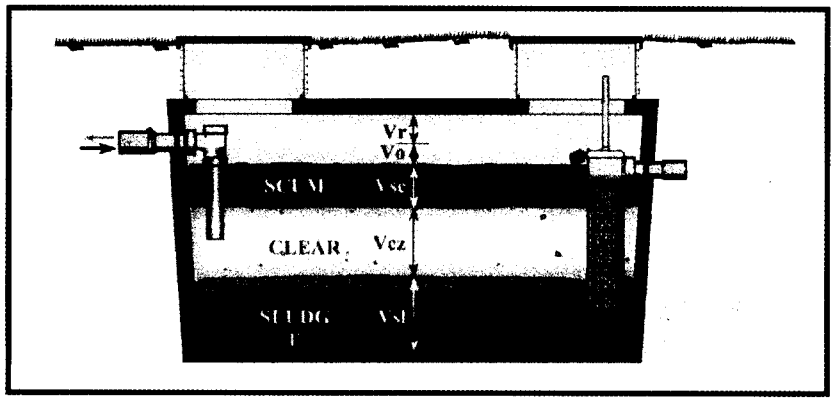


Figure 40 - Example of septic tank. Source: Bounds, P.E., 1994

quality energy according to demand (i.e. high quality energy for lighting, computers, motors and transportation; waste heat used for water heating)(fig. 39)

☐ Extract energy preferably from wastewater, solid waste, and all other resource flows within the city;

☐ Minimize need for consumption. Shading of parking areas and building surfaces reduces the amount of solar radiation reaching them, reducing the demand of energy consumption in cooling devices;

☐ Use energy-efficient devices and technologies in the buildings;

☐ Analyze site for possibilities of alternative energy resources;

☐ Rely primarily on low-impact renewable sources. The resources vary depending on the location, and can include wind, sunshine, geothermal, run-of-river hydro, tidal and wave power, wood waste, landfill gas and biogas, agricultural, forestry and animal wastes, and lake and ocean cooling. Generally the use of those renewable resources can benefit from the existing energy grids. The grid absorbs peak demand, and acts as a storage system when renewable sources are surplus. [24]

5.2.7. Waste

☐ Reduce amount of waste (solid waste and wastewater) generated. Encourage reusing and recycling materials when possible.

☐ Incentive use of waste as a resource. "What is waste to one person can be a valuable resource to another"[25].

a) Greywater/Blackwater [26]

☐ Adopt integrated and ecological wastewater treatment. The system should be able to remove not only pathogens but also VOCs, hydrocarbons, nutrients, herbicides and pesticides;

☐ Provide separate systems for greywater and blackwater in order to allow reuse of treated greywater as reclaimed water. The use of greywater is recommended since it reduces waste generation, disposing unwanted wastewater over land rather than dumping into the reservoir;

☐ Incorporate natural systems at a local scale, reducing ecological impacts and minimizing distribution costs and land use;

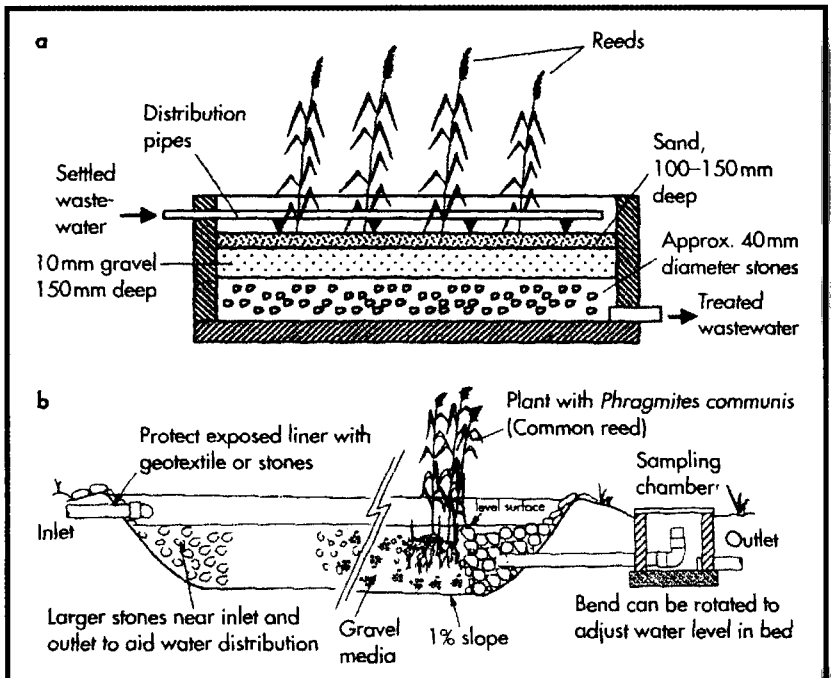
☐ Reduce flow of waste-

water leaving the building. Stormwater should be directed into open drainage systems. Water use should also be reduced by water-conserving fixtures;

☐ Primary sewage treatment installations should be considered at the building scale. Equipment like watertight, concrete septic tanks next to the foundation can be used. The advantage of locating the primary treatment system next to the building is that it allows reduction of cost and also a more flexible and advanced secondary treatment at the neighborhood scale. Submersible pumps should be used to decant the fluid in each septic tank, and then the fluid should be economically transported through small-diameter PVC pipes over short or long distances to a neighborhood scale digester; (fig. 40)

☐ Constructed wetlands can be used to treat runoff and wastewater. These structures temporarily impound runoff, and settle and retain suspended solids and other pollutants. Two approaches are possible: surface flow wetlands, suitable for buildings or large clusters, and subsurface flow wetlands, suitable for smaller volumes;

☐ Secondary treatment can be done by reed beds. These are self-contained wetland ecosystems in which complex soil-based microbiological processes promote degradation of both organic and chemical materials as well as low concentrations of dissolved metals. The reeds



Vertical (a) and horizontal (b) reed-bed waste -treatment systems.
Source: Thomas, R. (ed). Sustainable Urban Design: An Environmental Approach. Spon Press, 2003.

Figure 41 - Vertical and horizontal reed-bed waste treatment.

allow the introduction of air via their roots, promoting aerobic digestion. The waste water is delivered either over the surface of the reed bed, and then flow downward - vertical flow, or via a feeder trench at the front of the bed, and then flows horizontally - horizontal flow. Reed beds can be situated locally for a single dwelling or at a central facility for an area serving around 100 people. The application determines the scale and the appropriateness depends on the context of the site. This installation requires open land area, which could be parkland for example. Approximately 1-2m² of reed bed area per person should be allowed. Flow rate, topography of the site, organic loading and required quality of treated effluent should be considered when designing reed beds;(fig. 41)

☐ Another alternative method is the Biological sewage treatment. It is an alternative to conventional mechanical sewage treatment, and is cheaper than the conventional method, but requires a considerable amount of land. It consists of the replication of natural processes, by the use of plants and micro-organisms to break down the sewage and cleanse the water. This means separating the water from the solids beforehand and then letting the liquid waste material be consumed by the plants and micro-organisms. The

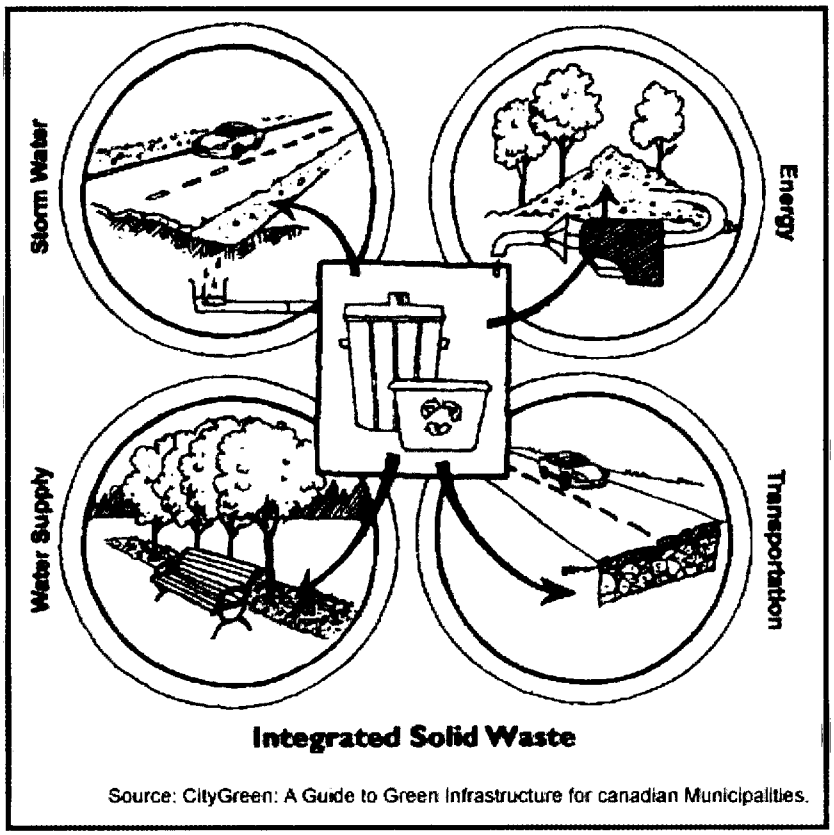


Figure 42 - Integrated solid waste management. Source: CityGreen: A Guide to Green Infrastructure for Canadian Municipalities.

process is repeated continuously as the water travels slowly through the ponds, wetlands or marshes, until the water is cleared and can be returned to the watershed system. [27]

☐ A third option could be the Solar Aquatics system, which is an ecologically-engineered sewage treatment method that replicates the natural purifying processes of fresh water streams, meadows and wetlands. In this system the wastewater flows through a series of clear-sided tanks located in greenhouses, and then through engineered streams and constructed marshes where contaminants are metabolized or bound up. Plants, aquatic animals, algae and bacteria are used in this system. This technology can be used to treat sewage flows from 75.7 to 189.3 cubic meters per day.

b) Solid waste[28]

☐ Promote compost production. Biosolids, biomass and offsite community based organic materials should be composted onsite with combinations of in-vessel composters - large containers that process organic wastes over a two-week period, the end product is humus that can be used in manufacturing soils, and restoring damaged landscapes and vermiculture composters - they use worms to rapidly digest and sanitize organic wastes, including kitchen waste and shredded cardboard. The end result is more worms and high quality organic fertilizer;

☐ Manage waste on-site as much as possible. Adequate space for separation and storage must be provided at convenient locations on-site;

☐ Depots should be managed within the community. They can also be used to reduce requirements for roads and to support lifestyles that include neighborhood shopping and walking;

☐ Promote integrated solid waste management. (fig. 42)

c) Recycling

☐ Promote recycling. Materials suitable for recycling include metals, plastics, glass and paper. Recycling can reduce the solid waste load and save energy - for example, it takes three times more energy to produce new aluminum than it does to recycle used aluminum;[29]

☐ Create a recycling program, and if there is demand, a recycling plant could also be installed in the community, creating job opportunities and creating a "culture of recycling" among the community. On a smaller scale, recycling bins should be provided for the community, making it easy to use. For example, one recycling bin for each building;

☐ **Incentive participation of schools and community center in promoting recycling and reusing materials.**

6. Case Study

6.1. Regional Context

6.1.1. Introduction

The study area is situated in Brazil's Southeast Region, in São Paulo State. This is an important economical and industrial centre of development, with a concentration of production and economical wealth.(fig. 43)

As a result of the concentration of industries and services, this area has faced a rapid population growth, with families searching for a better life. However non planned fast growth, added to other economical factors has driven the growth into a disorganized occupation of protected areas. This is a common situation in big cities of Brazil and other cities around the developing world, fast urban growth, social inequity and degradation of natural resources.

This study is going to focus on Santo André Municipality, part of São Paulo's Metropolitan Area and one of the cities of the Inter-municipal Consortium of ABC. (fig. 43)

6.1.2. Historical context[30]

The beginning of the occupation of ABC's region dates from the year 1553, when the first village was officially registered, called Vila de Santo André da Borda do Campo.

In 1867 after the implementation of São Paulo Railway -now Santos-Jundiai Railroad - a process of expansion of the area now known as ABC Region had began. The first settlement situated in the area where today is the Santo André Municipality started at that time, as a home for workers building the railroad, and later for the operators of the railroad system. In 1907 this village was elevated to a District status.

The occupation started to grow around São Bernardo Station in 1867, functioning today as the historic center. In 1910 the name of the city was officially changed to Santo André, remembering the first settlement formed in back 1553. The Santo André District was created, in the area where today the Center is located.

Because of the city's strategic location, close to the railroad, to the Santos harbor zone and to São Paulo - a big consumption center, Santo Andre attracted big industries and transformed into the biggest economic force of its region in 1938. Because of its economical importance, the city grew, incorporating more area and turning into the limits that now we see.

6.1.3. Socioeconomic and political context

The ABC Region is located southeast of São Paulo's Metropolitan Area and has a population of approximately 2.2 million inhabitants in 841 km^2. Of

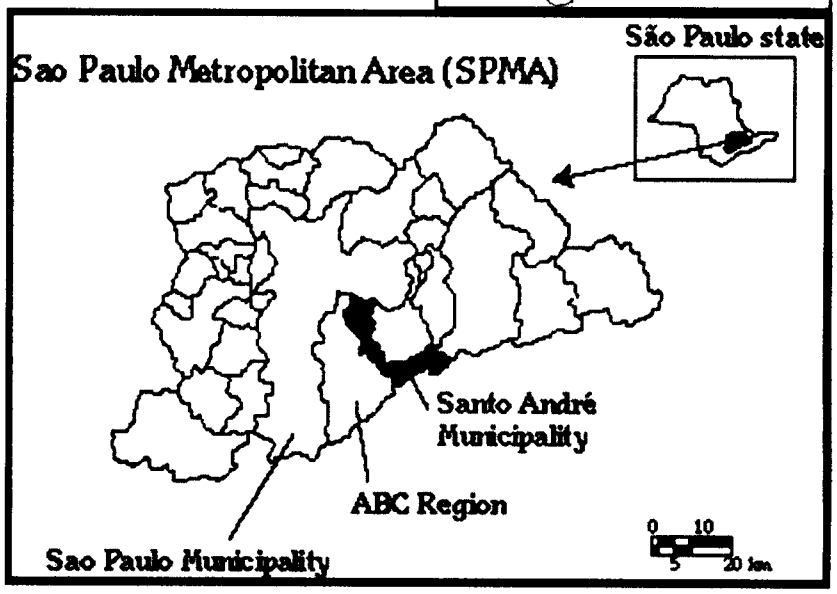


Figure 43 - São Paulo State on the national context (upper right), and ABC Region and Santo André Municipality (lower right). Source: GEPAM, 2002.

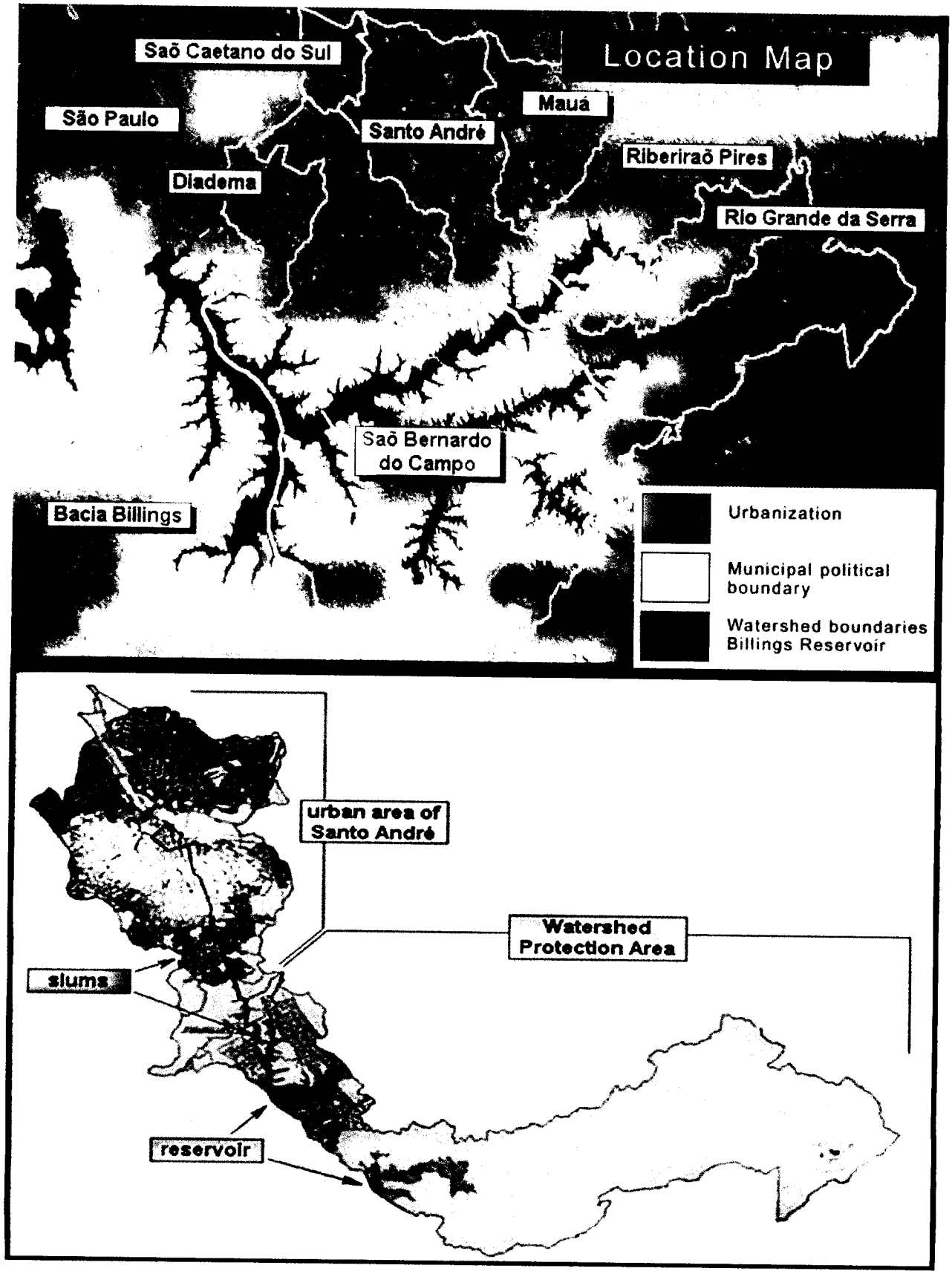


Figure 44 - The Billings watershed protection area and the adjacent urban area (top), and Santo André Municipality, 61.89% of its area located on zone of urban expansion area (bottom). Source: GEPAM, 2002.

that area, about 56% is situated within the watershed protected area of the Billings Reservoir.[31]

The city of Santo André has 648.443 habitants and an area of 25 km². Sixty percent of Santo Andre's area is devoted for watershed protection and its social function, as defined by the city's policy is to preserve water and the environment. The population is divided into 38 sections, 11% living in the urban zone and 61.89% living in the zone of urban expansion. (fig. 44)

According to Scarambone (2002), in Santo André Municipality around 120,500 habitants live in its 139 favelas within the municipality. Of that number, 5.11% live inside the watershed protection area. It is estimated that 6,160 habitants live in the 14 favela nucleuses.

Due to the focus of this research on environmentally sensitive areas, the socio economic context will focus mainly on the analysis of the population living inside the watershed protection area, more specifically on the Northwest area of the Watershed Protection Area, between the urban zone and the North part of the Billings Reservoir. (fig. 44)

According to IBGE (Brazilian Institute of Geography and Statistics) 1996 census, Santo André had 40% of population growth inside the Watershed Protection area from 1991 to 1996.

Within the study area, IBGE's 1991 census indicated that the density of occupation was between 1 and 10 inhabitants per hectare, a relatively low density of occupation. This study also indicated that between 50 and 60% of the head of the families made only minimum salaries or less, which would be less than US$ 60.00 a month in today values. At the same time, 26% of the people living in that area were illiterate.

In 1991, approximately 50% of the area had access to potable water by wells or springs, 25% by public water system and the other 25% by other means. For the sewage system only 30% were linked to the public sewage system and 15% had septic ditches, while the other 50% had a rudimental ditch, or other. As for the destination of solid waste, according to IBGE's 1991 census, the majority was collected while a small part was burned or buried.

6.1.4. Legislation

In the beginning of the 70s the Government started worrying about the necessity of planning at a more local level and in 1973 the Metropolitan Regions were created, giving to local agents the task to create basic guidelines managing the growth and promoting the preservation of the hydro resources. The worries about the preservation of hydro resources and the present environmental degradation of the watershed areas led to the creation of the following laws:

- **State Law number 898/75**: this law establishes the perimeter of the areas declared of public interest for hydro resources protection;
- **State Law number 1.172/76**: classifies the areas in 1st (more restrictive) and 2nd (less restrictive) categories within the hydro resources protection area, creating areas for different forms of occupation, with a preventive character;
- **Decreet number 9.714/77:** discriminate state organs responsible for the analysis and approval of enterprises within this area and establishes punishment for infractions;
- **State Law number 9.866/97:** establishes Protection Areas and Watershed Restoration Areas for the State, using the watershed contributors as delimitation factor and implement partnership with municipal governments in the management and elaboration of policies of use and occupation of the area and fiscalization.
- **Decreet number 43.022/98**: regulates the instruments related to the Watershed Urgent Recuperation Plan, referred to by the Article 47 of the Law number 9.899/97, contemplating actions and urgent projects when situations of risk of death or situation that puts in risk the utilization of the watershed as a supply of water.
- **Specific Law:** the State Law number 9.866/97, foresee the elaboration of a Specific Legislation for each Watershed within the State of Sao Paulo. The Inter-municipal Consortium of ABC and the Municipality of Sao Paulo have elaborated the first draft of the Specific Law for the Billings Watershed Area. It was delivered in August 2001 to the Sub-committee Billings-Tamanduatei for the beginning

of the discussions. The Specific Law has the following objectives:

I Promote actions of preservation, enhancement and conservation of the Billings Watershed Protection and Recuperation Area (APRM-B), guaranteeing the quality and quantity of water for public supply;

II Implement public participation and decentralized management of the APRM-B integration governmental sectors and the civil society;

III Manage socio economic development with the protection and enhancement of the watershed;

IV Encourage activities compatible to the protection and enhancement of the watershed;

V Guarantee instruments that promotes integration of regional and local policies, specially referring to habitation, transport, sewage treatment, infrastructure and management of natural resources and protection of the environment;

VI Establish guidelines and parameters of regional interest for the elaboration of municipal laws of use, occupation and division of land, with the purpose of guaranteeing the feasibility of the Development and Protection Plan.

- **Law number 7.333/95**: known as the "Director Plan" divides the municipal territory into two different zones:
  - Urban Zone: area densely occupied, with all urban infrastructure; and,
  - Zone of Urban Expansion: low density area, with little infrastructure offered. This is due to legal restrictions and its social function, which is preservation of water resources and the environment.

Figure 45 - Aerial view of the Billings reservoir. Pintassilgo community on the left. Source: GEPAM 2002.

It is important to consider that although all those regulations are important; they should take into consideration the existing problems and allow opportunities for solving them. Low income communities in illegal situations exist in every city of Brazil and political actions, including those related to environmental protection, should promote solutions to reduce the damage and help the residents of those communities. The Specific Law is going in that direction, allowing adaptations and recommendations based on existing situations and necessities.

6.1.5. Environmental context

a) The Billings Watershed

The study area is located in the Billings Watershed Area, one of the biggest Reservoirs in Brazil, with importance on both water supply and energy generation for the Region. (fig. 45)

The construction of the Billings Reservoir happened in the beginning of the 20's when the Canadian company Light and Power had to increase the energy production and choose this area for building a new reservoir. The construction lasted from 1925 to 1937 and the name Billings is in honor of the engineer Asa White Kenny Billings, idealizer of the project. [32]

The Billings Watershed takes part of the Municipalities of São Paulo, Santo André, São Bernardo do Campo, Diadema and Ribeirão Pires and involves completely the Municipality of Rio Grande da Serra.

The inundated area of the Billings Watershed is 127 km^2 and the volume of water is about 1,200,000m^3. This Reservoir provides to the Metropolitan Area of Sao Paulo nowadays 7m^3/s of water, corresponding to 9.4% of its consumption. [33]

According to Capobianco and Whately[34], Sao Paulo is a State naturally well served by water, with the Tietê and Pinheiros Rivers as well as some smaller rivers, reservoirs and vast watershed areas that involves practically all the metropolitan area. However this resource is being managed in a wrong way and they are suffering from rapid and non-planned urban growth. They continue, saying that the lack of planning and responsibility has led to contamination of rivers, waterways and reservoirs and the disorganized occupation of the watershed protection area. The contamination includes contamination by gray and black water, solid waste and chemical products.

Considering the fact that the main use of this Reservoir is public supply of water, it is urgent that action is taken to reverse the present situation, reducing the high levels of pollution and contamination. The environmental degradation is also associated with illegal urban growth and the degradation of native vegetation.

b) Soil

Observations of the site indicate that the main component of the topsoil is clay. The overall characteristics are fine grains, difficult absorption, and low permeability. This soil type requires special attention for urbanization, especially considering other aspects of the region are high intensity of rain and steep slopes.

c) Vegetation

According to the Brazilian Forest Code (Federal Law 4.771/1965) vegetation surrounding any water course is considered an area of permanent protection and therefore should not be occupied. The size of the permanent protection zone buffer should be established according to the length of the water course and it is usually between 50 and 200 meters, starting from the margin of the water course.

Figure 46 - Lianas. Photo Stefan Schnitzer site http://www.csam.montclair.edu/ceterms/rainforest/RFC2001/gallery_of_lianas.htm

As said before, the Billings Watershed is suffering from illegal occupation and degradation of its natural resources.

The Billings Watershed is situated within the domain of the Atlantic Forest. Originally this area was fully covered by the "Ombrófila" Dense Forest. According to research done by the "Socioambiental" Institute, in 1999, approximately 53% of the Billings Watershed Area was covered by natural vegetation, especially by Secondary Atlantic Forest in Medium or Advanced Regeneration Stage[35]. Urbanization and other atrophic activities are leading the deforestation of the area.

It is important to note that the vegetation plays a key role in the preservation of the watershed, since it regulates the water flow, controlling from both surface and underground. Roots work as a sponge, absorbing rain water and preventing sediment deposition on water bodies.

Vegetation also promotes better ecological conditions for fauna establishment, which also helps build soil structure, improving its capacity to retain water.[36]

Among the reminiscent species of the Secondary Atlantic Forest is: Lianas (fig.46); Epiphytes; Buttress roots; e Palmaceae. At the field vegetation, an ecosystem rich but restricted to some areas, is possible to find: Gramineae; Cyperaceae; Orchids; Bromeliads; Eriocaulaceae; Iridaceae; Droseraceae; Myrtaceae; Melastomataceae; Composts; Pteridophytes and Lichen.

d) Fauna

The fauna present in the region is decreasing as urban occupation increases and vegetative cover decreases, leading to a serious threat to their existence in this area. Originally this area was both huge in population and diversity of species and data from Hidroplan and Gepave[37] shows that there is an intense decrease in both population and diversity when com-

paring data from before 1965 and today. It is understandable that some species are not compatible with urbanization, but an effort should be made to protect them, develop ways to allow coexistence and, if not possible to coexist, relocation.

Among the species that are still in the area are: Agouti paca - mammal (fig.47); Triclaria malachitacea and Pyroderus scutatus -birds.

The marine population also suffered from pollution and urbanization. Analysis made by GEPAM (2002) relate the loss of species, diversity, trophic structure and possible biomass to impacts on the fishery community by alterations on the Reservoir water level; algae growth; introduction of exotic species; and others. The incidence of pollution tolerant species is also an indicator of the level of pollution.

Some of the species that can be found within the reservoir are: Among the species found on the reservoir are: Cará, Tilápia do Nilo, Lambari, Tilápia Comum, Canivete, Saguiru, Caborja, Peixe cachorro, Piau, Traira, Carpa Comum, Cascudo, Bagre e Mussum.[38]

e) Climate[39]

Tropical and subtropical climate characteristics are predominant in this region, where medium temperature is 19°C. Intensity and frequency of rain are high. Data of 1995 from HIDROPLAN indicates a medium rainfall of 1.500 mm/year.

The rain incidence is higher in the summer - December to March, although it occurs commonly throughout the year.

The relative air humidity is considered high all year round.

Predominant wind direction is northeast.

f) Land Use

Since the construction of the Billings Reservoir this area has attracted people for its beauty and recreational possibilities.

However, by the 60s and 70s the Sao Paulo Metropolitan area experienced a significant growth. The lower land value made peripheral areas grow and later it was extended to watershed protection zones as well.

Figure 47 - Agouti Paca. Source: www.chez.com/oncfs-guyane/ images/agouti.jpg

Today the Watershed accommodates different types of occupation. There is the middle-high class - low density residential neighborhoods considered not too impacting on the environment; occupations designated to tourism and recreation such as clubs, marinas, and others, also considered not too impacting to the environment; and higher density lower-income neighborhoods, usually with little or no infrastructure, and highly damaging to the environment.

The majority of the urban occupation along the Billings Reservoir does not have sewage and stormwater infrastructure. Some buildings use septic system, but most of the informal occupation use just pipes to direct black and greywater directly towards the reservoir without any treatment.

g) Parque do Pedroso (Pedroso Park)

This Park is approximately 8 millions square meters in area. Created by the Municipal Law 5.142/70, its limits coincide with the beginning of the Billings Watershed Protection Zone. According to the Director Plan, this is a Protection Zone, allowing only uses compatible to its preservation. (fig. 48)

Since 1943 Santo Andre Municipality captures potable water for the city supply from the Pedroso Creek, within the park boundaries. At that time this Creek was responsible for 30% of the Santo André and São Bernardo do Campo supply. Today, this creek is responsible for only 3.43% of only Santo André supply.[40]

h) Population

Data from IBGE (Brazilian Institute for Geography and Statistics) shows that Santo Andre had a 40% increase in population from 1991 to 1996. The population estimated population of Santo Andre is 665,000 inhabitants. Among them, 60% live inside Watershed Protection Area, Natural Parks or other areas protected by law.

6.2. Local Context

6.2.1. Pintassilgo

Pintassilgo is one of the informal communities situated within the Billings Watershed Protection Zone. This community is also located in part inside the limits of the Parque do Pedroso (Pedroso's Park). The legislation applicable to this area specifies areas of First and Second Categories of Preservation (see legislation section).

The occupation of this area started in late 70's, as an illegal expansion of the legal subdivision of Parque Miami. Topography and other environmental conditions lead to a linear occupation, separated by a hydroelectric transmission corridor, creating two somewhat distinct northern and southern communities.[41]

The southern neighborhood is contiguous to Parque Miami, densely built along a south-facing hillside that slopes steeply down to one arm of the Billings Watershed. The occupation goes from the edge of the reservoir up to the power line, with just one access street[42]. The steepness of the slope and the soil conditions, combined with lack of planning of the occupation has lead to several land slides taking some of the residences as well in this area. (fig.49)

The northern part is connected to the southern part by one gravel street. Here, the predominant force is linear and sinuous, following the one street that snakes through the valley between steep and heavily wooded hills. The only existent community facilities within the community are one soccer field, along the power line, several small churches and some small locally owned retail/bars. Services such as medical offices, shops and schools are not available in Pintassilgo, but they are accessible in the surrounding areas. The northwest part of the community is linked to an arterial road which takes you to downtown Santo André. At this intersection there is a bus stop providing access to public transportation. To the southwest of the community there are local shops and services, located in Parque Miami. Although the community is situated in part within the limits of Parque do Pedroso, there are some undeveloped private owned land close to the community that could be considered for

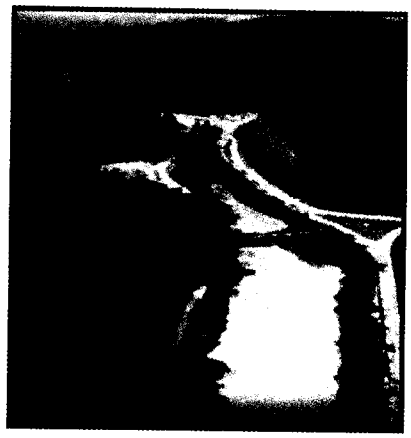


Figure 48 - Parque do Pedroso. Source: GEPAM 2002.

Figure 49 - Aerial photo showing Pintassilgo configuration and its relation with adjacent communities and natural environment. Source: GEPAM 2002.

development and relocation of the Pintassilgo neighborhood.

Pintassilgo is approximately 500 hectares. Today it is estimated to be home for 1,200 families, around 5,000 people.[43]

Data from IBGE's 1991 census indicates that 50-60% of the head of the families in that area made up to 3 minimum salaries - around U$190. The density of occupation was between 1 and 10 person/hectare. Around 26% of the population was illiterate (the average in Brazil is 20.1%). Regarding water supply, this area used approximately 50% of water from the reservoir or springs, 25% from water trucks and 25% from some other source.

According to GEPAM[44], data from two important streets within the community, the Pintassilva Street and Cacioporé Street shows that the average of residents per unit is 4,5; sewage collection is 100% nonexistent, energy supply is around 60% formal and 40% informal; and around 90% of solid waste is collected.

Figure 50 - A typically recent occupation, the house is made from wood aggregate.

Figure 51 - Evidence of the addition of floors some years after the construction of the first floor of the residence. Source: GEPAM, 2002.

6.2.2. Site Analysis

a) Building Typologies

There are some aspects of informal settlements that can be found virtually in every Brazilian favela. One of them is the differentiation between the occurrence of the occupation and the building material. More recent occupations are usually improvised, made with aggregate wood. (fig. 50)

Another stage is marked by the changing in materials; the wood aggregate is substituted by bricks.

The last stage is the enhanced version of the second one, the construction is the same but there is a finish made of cement and painting.

Another important characteristic is the growth of the units. As the family grows, it is common to see additions to the original construction. Those additions can be

Figure 52 - Example of flat roof, allowing for further growth if needed.

Figure 53 - Addition of floors and area prepared for further growth.

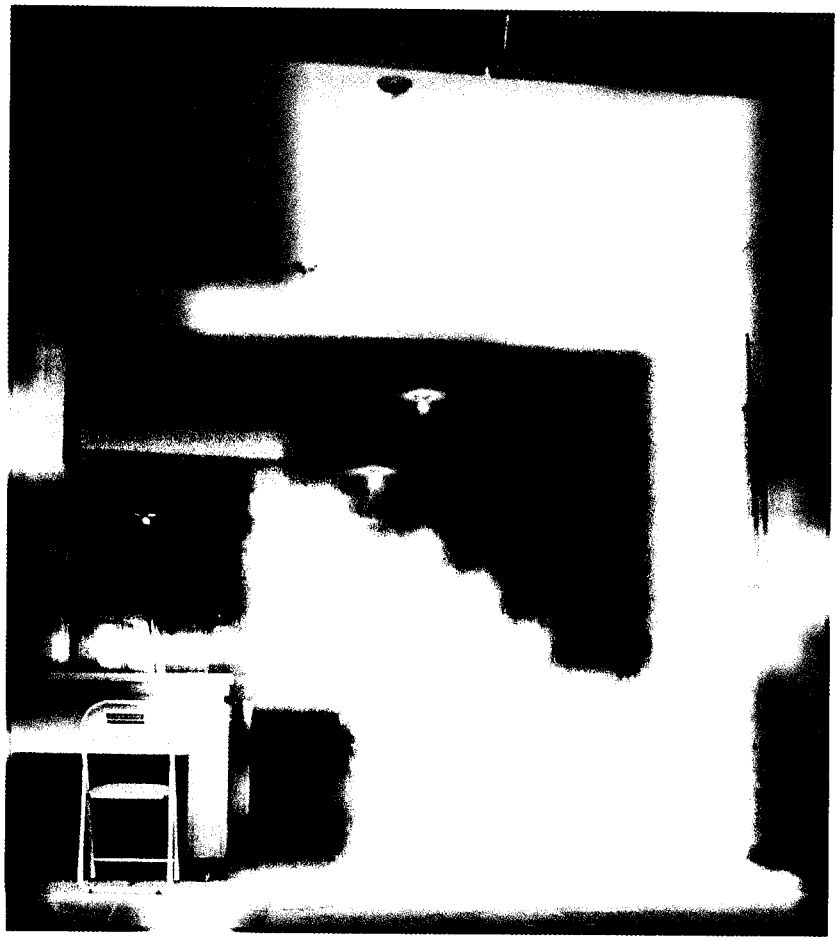


Figure 54 - Example of improvised parking, in that case, the first floor of the residence is also a bar.

either horizontal(occupying more area within the "lot") or vertical(with the addition of floors). It is also possible to identify houses that haven't been attached with a second floor yet, but they indicate the intention by leaving the top of the house flat. (fig. 51, 52)

In some cases the first floor can be used as a parking area for the family car, which is also due to safety concerns. The parking area is usually protected. (fig. 53, 54)

Due to the lack of potable water distribution system most of the houses have to have their own water tank, for water storage. The water is provided by a water tank truck that comes frequently to the community, or collected at the Reservoir. (fig. 55)

There is no official lot division, the occupation grows following the existing street accesses and the further growth happens by the densification of this line, the shape is usually linear and later spreading from the line. The access for this expansion happens with small corridors between the houses. (fig. 56)

The houses usually face the street, with no front yard and commonly no distance between the houses. If there is to be an open space, it usually happens on the back of the house and is usually a service area as well.

According to GEPAM[45], analysis of Pintassilva and Cacioporé streets show that around 65% of the residences are made of a type of brick -in Portuguese called alvenaria; 32.5% are made of wood and 2.5% of other materials.

Unplanned growth in environmentally sensitive areas usually lead not only to environmental

Figure 55 - Use of water tank, top left of the image.

Figure 56 - Access corridors leading to some residences.

Figure 57 - House built over unstable terrain.

problems, but also to danger for the residents. Landslides are frequent in this area. (fig. 57)

b) Accessibility

The connection to the region is poor. The community is similar to Parque Miami on the south and an arterial road provides linkage to downtown Santo André. The accessibility within the community is also weak. Gravel streets provide essential connection, but some residences are not served by them. In those cases the access is done by small improvised alleys. (fig. 58)

c) Community Facilities

Pintassilgo community has within its area no school, day care or health center, but adjacent communities such as Parque Miami can provide some of those facilities to the community. Today there are two Health centers, two schools and one day care in Parque Miami. There is also a school at another community, northwest from the Pintassilgo community, but the access is precarious. (fig. 59)

d) Vegetation

This area is in part within the boundaries of the Parque do Pedroso and also within the Watershed Protection Zone. The reminiscent forest is Atlantic Forest on Secondary or Advanced Evolutionary Stage. (fig. 60)

e) Topography

This area is characterized by steep slopes sitting on clay soil; therefore some restrictions in occupation should be applied. The analysis of topography took into consideration the demand for regulation of non-built areas. Four categories were estab-

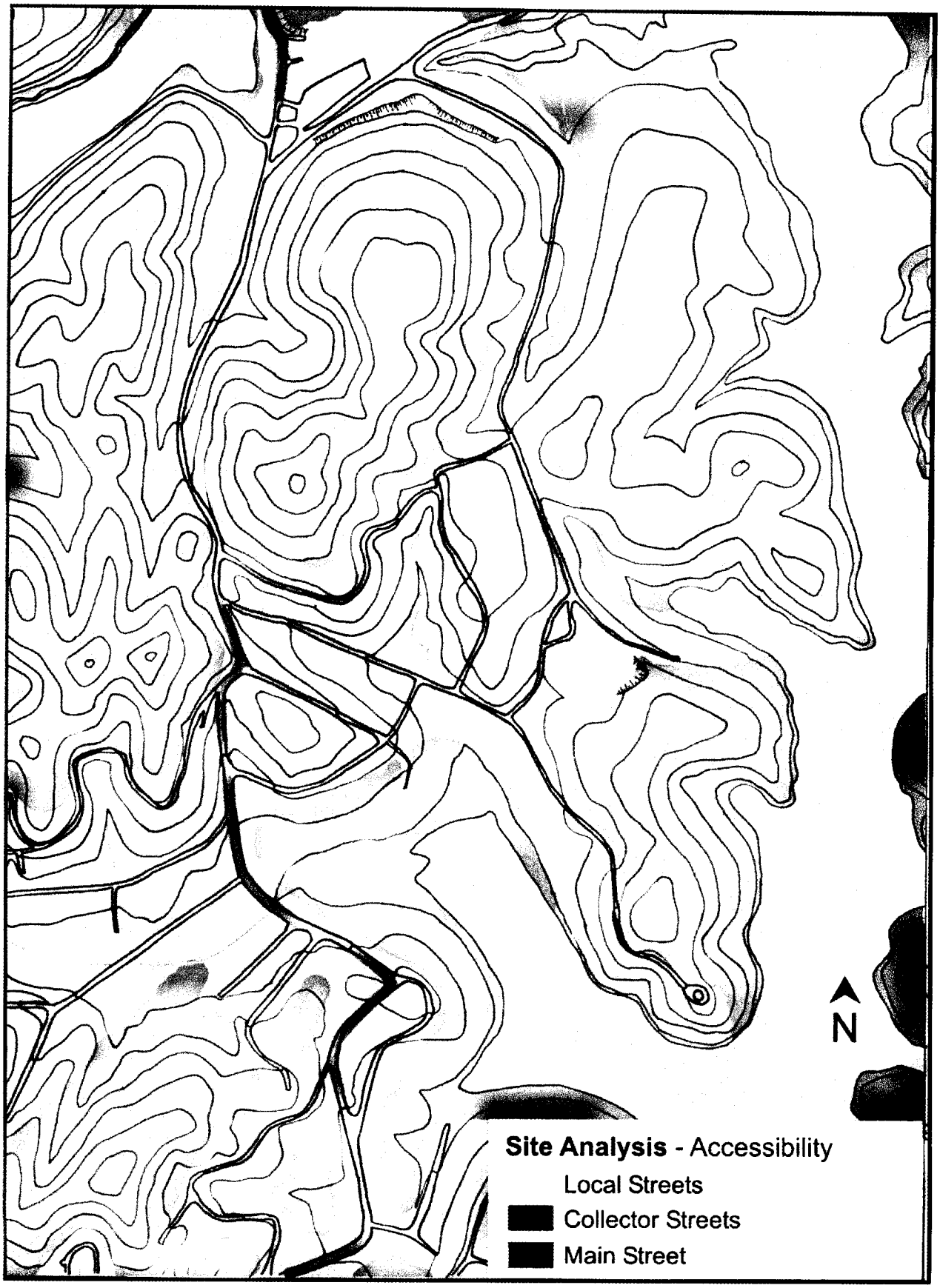


Figure 58 - Accessibility map.

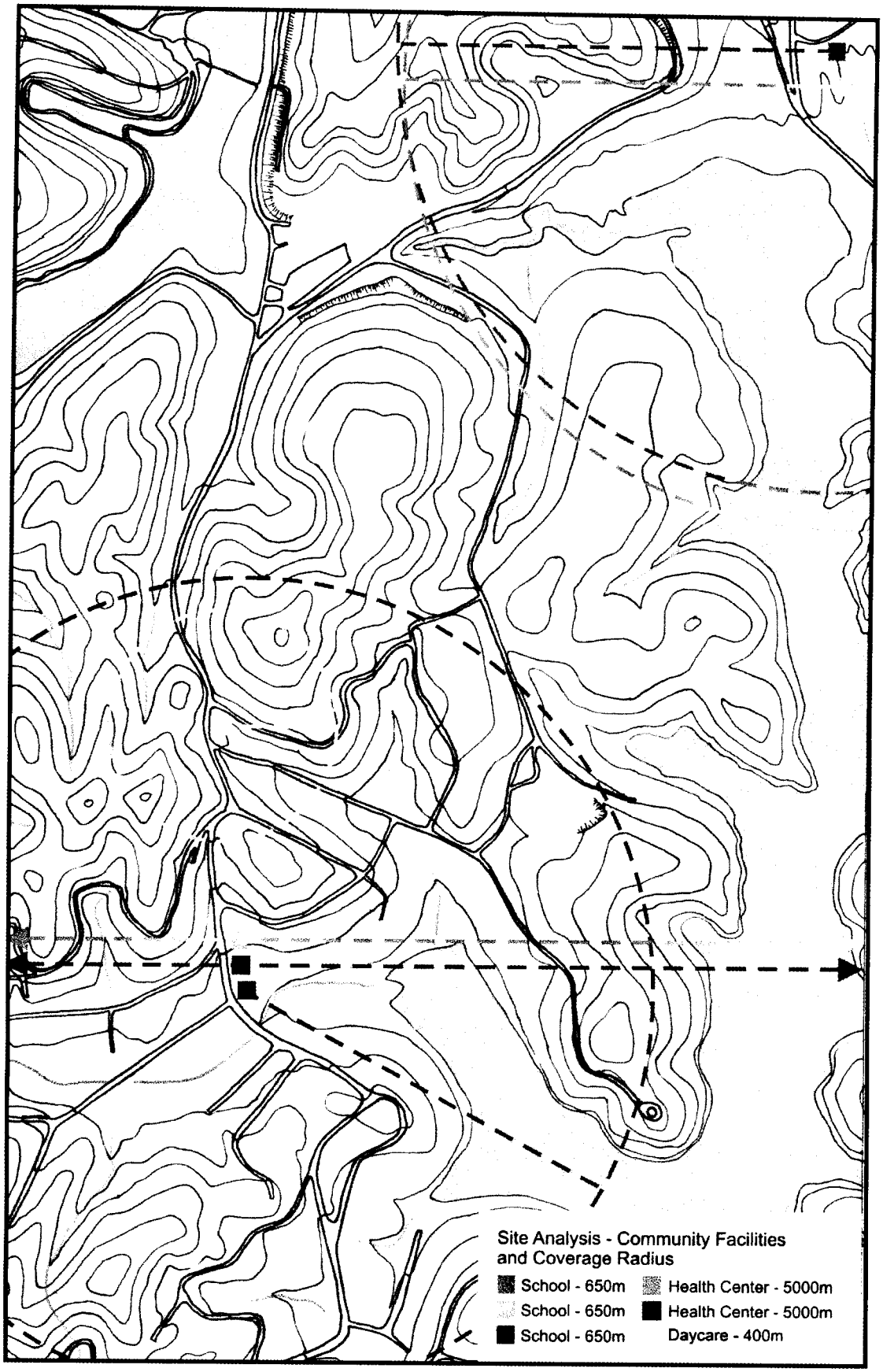


Figure 59 - Existing community facilities and their radius of community coverage.

lished, slopes of 45% inclination or more, where no occupation is recommended; slopes from 30% to 45%, were some special occupation could be allowed; 20-30% slopes, allowing residential occupation with some recommendations; and, 20% or less, where occupation is allowed, concerning topography issues. (fig. 61)

f) Water flow

This map serves the purpose of defining areas that collect water flow and establishing the demand and location of infiltration ponds within the community. (fig. 62)

g) Protection zone for springs, water courses and reservoir

For the purpose of this study, a buffer of 75 meters was defined as a protection buffer from springs, streams and the reservoir. Idealistically this number would be defined considering environmental sensibility, slope conditions, and soils, among other factors. It could result in a buffer varying in dimension, responding to site specific demands. (fig. 63)

The demarcation of the buffer in this study took the center of the water body and extended 75 meters in both directions.

h) Non-built zone (topography and buffer)

This map was defined combining topography and watershed protection restrictive zones, in order to orient design decisions and assure the preservation of those areas as protection zones in the final design. (fig. 64)

6.3 Proposal

6.3.1. Community design

This section has the intent to illustrate one example of application of the recommendations of the guidelines section in the Pintassilgo Community. The proposal did not consider existing structures due to the City of Santo Andre's decision to totally relocate the existing community, therefore this study takes into consideration the natural environment, existing major structures, such as the power line and major roads and connections. The existing population is also taken into consideration, as this proposed plan provides residences for 1100 families, but also allows

Figure 60 - Reminiscent forest cover.

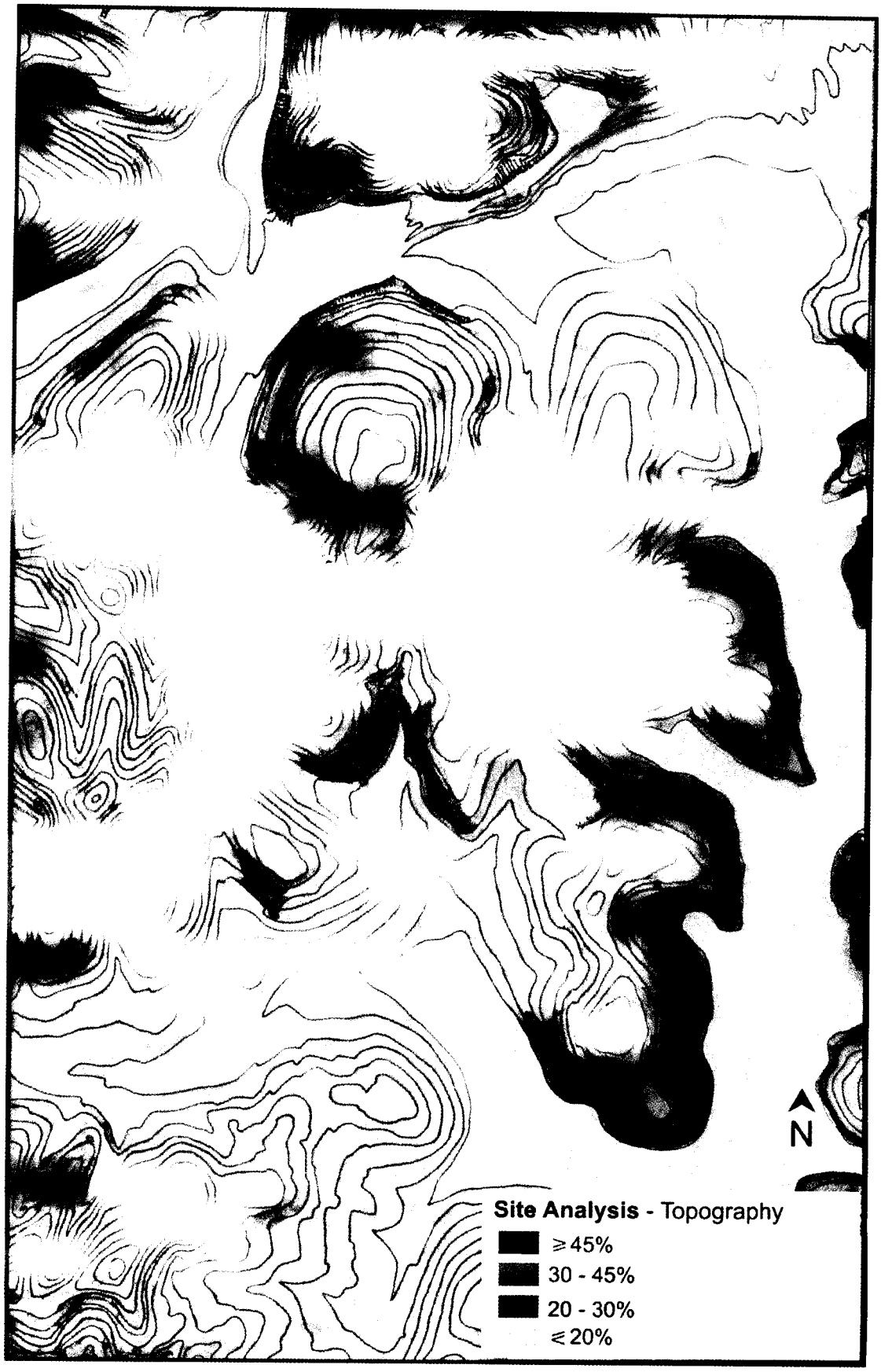


Figure 61 - Topography map.

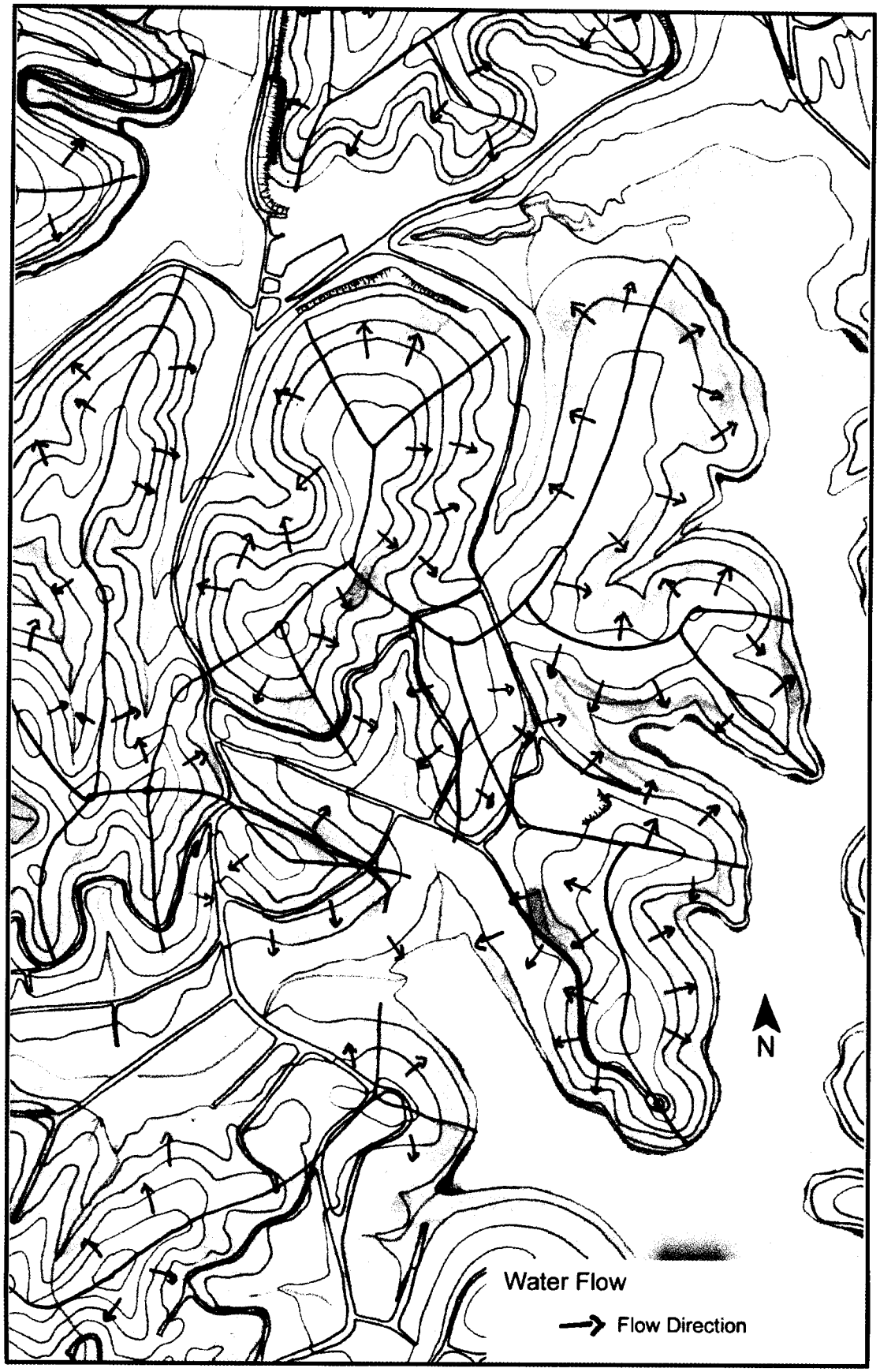


Figure 62 - Water flow.

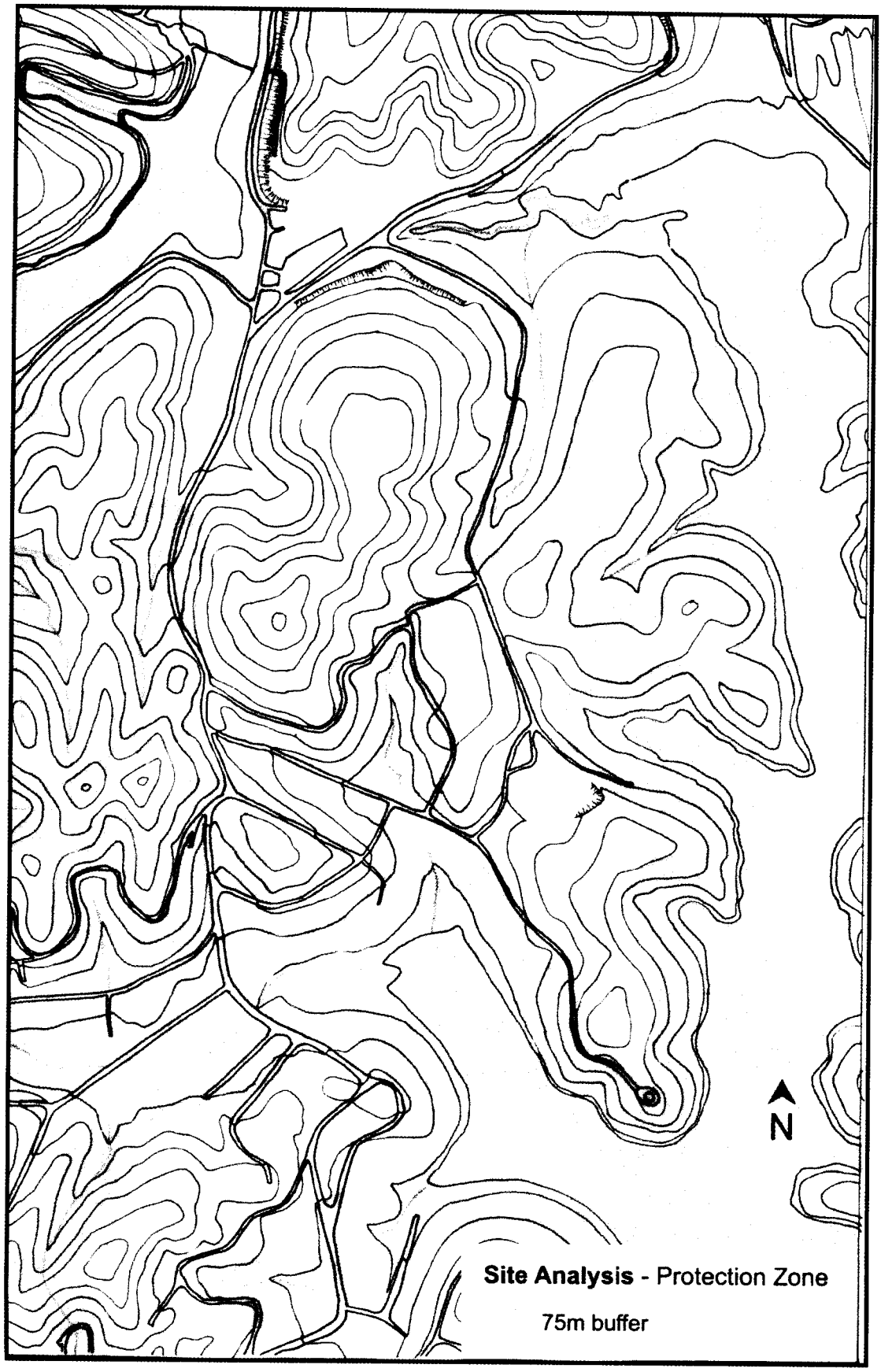


Figure 63 - Protection buffer.

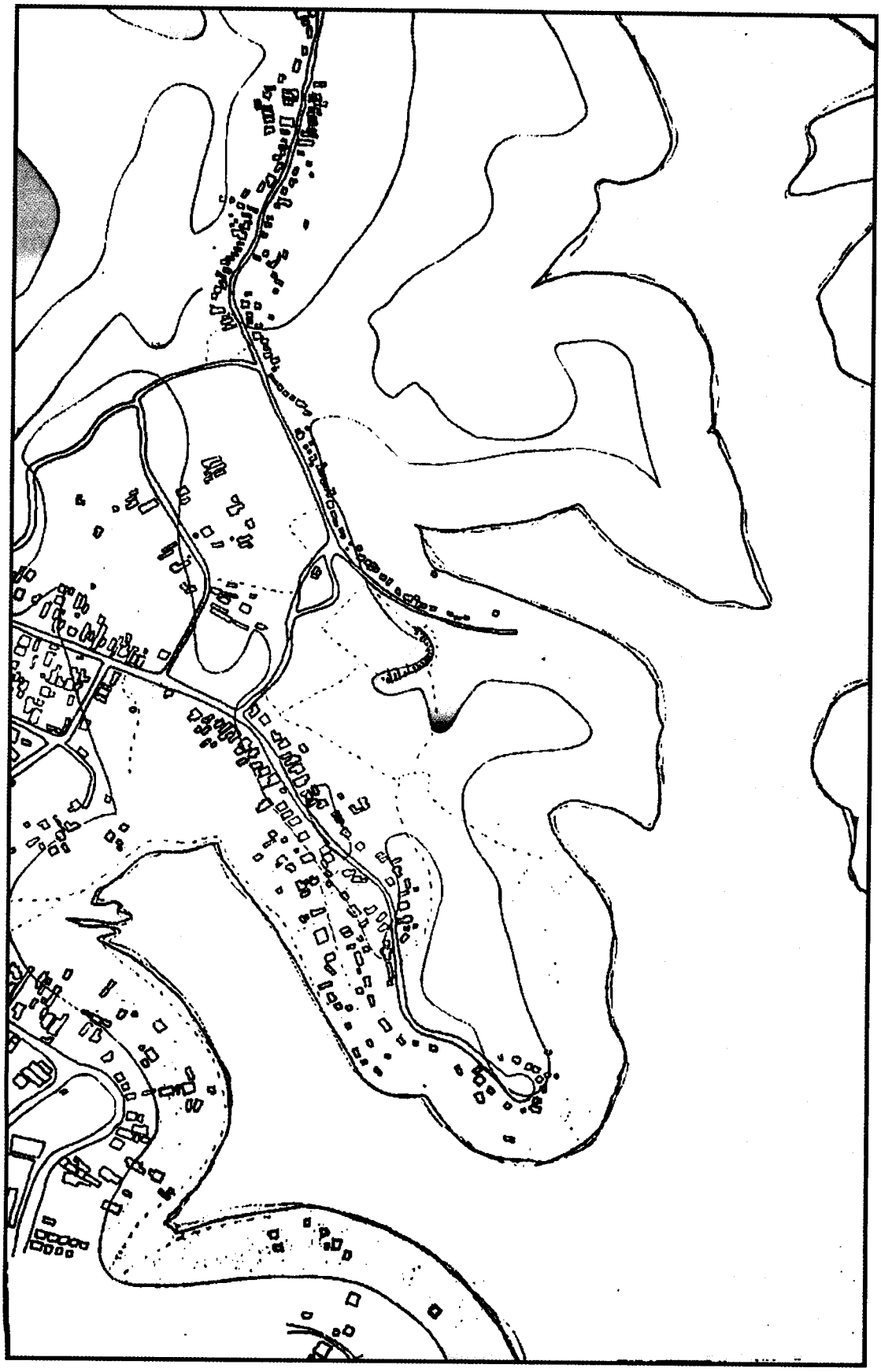


Figure 64 - Non-built zone.

some expansion.

The design is concentrated on the southern part of the site, considering higher environmental restriction on the northern part and also easier access to services and infrastructure on the edge with Parque Miami community.

Three major housing typologies were used (single houses, townhouses and apartment buildings), distinguishing higher, medium and lower density occupations. Higher densities are concentrated on the major circulation routes and also more distant from more sensitive areas.

The grid principle was adopted, respecting natural features of the land. Water bodies and protection zones should work also as green open spaces for Pintassilgo and adjacent communities as well. (fig. 65)

A hierarchy of streets was established to improve circulation and reduce the width of local and access streets. The structure works collecting and directing the flow. (fig. 66)

Parks were designed in different shapes and type of uses along the community, directing and orienting the use of parks and preservation zones. Contemplation decks were designed in strategic points as well as lookout points.

Community facilities and Institutional facilities were located through the community in order to guarantee efficient services and also to provide work opportunities within the neighborhood. The community is served with School, Day Care Center, Health Center, Police Station, Community Center, Community Gardens, Open Spaces, Playground, Sport Center and Commercial Areas, all less than 360 meters distance. (fig. 67)

Stormwater management is proposed in different scales: at the lot scale, with minimum of 50% of permeable surfaces, planting and rain water collection devices; at the street scale, with swales, planting and permeable paving for parking lanes; at the block scale with infiltration devices and at the community scale, were seven infiltration ponds were located to collect, infiltrate and return stormwater to the hydrologic system.

Safety and security issues were addressed by a strong distinction between public and private spaces, facilitating control and therefore improving safety. Individual accesses were designed for every unit and the visibility was also improved by the use of outside staircases and devices such as balconies and front porches, promoting "Eyes on the Street".

Every park edge is served with a public access, in order to encourage use and facilitate the control of new occupations, avoiding sprawl. The edge with protection zones were also the main location for public facilities. Promoting the adequate use of those areas is also a form of promoting preservation and control. (fig.68)

6.3.2. Detailed design

The detailed plan focused on a higher density part of the community, including the School site, a Community Garden, apartment buildings, infiltration pond, a spring and stream protection zone and the edge with Parque do Pedroso. (fig. 70-75)

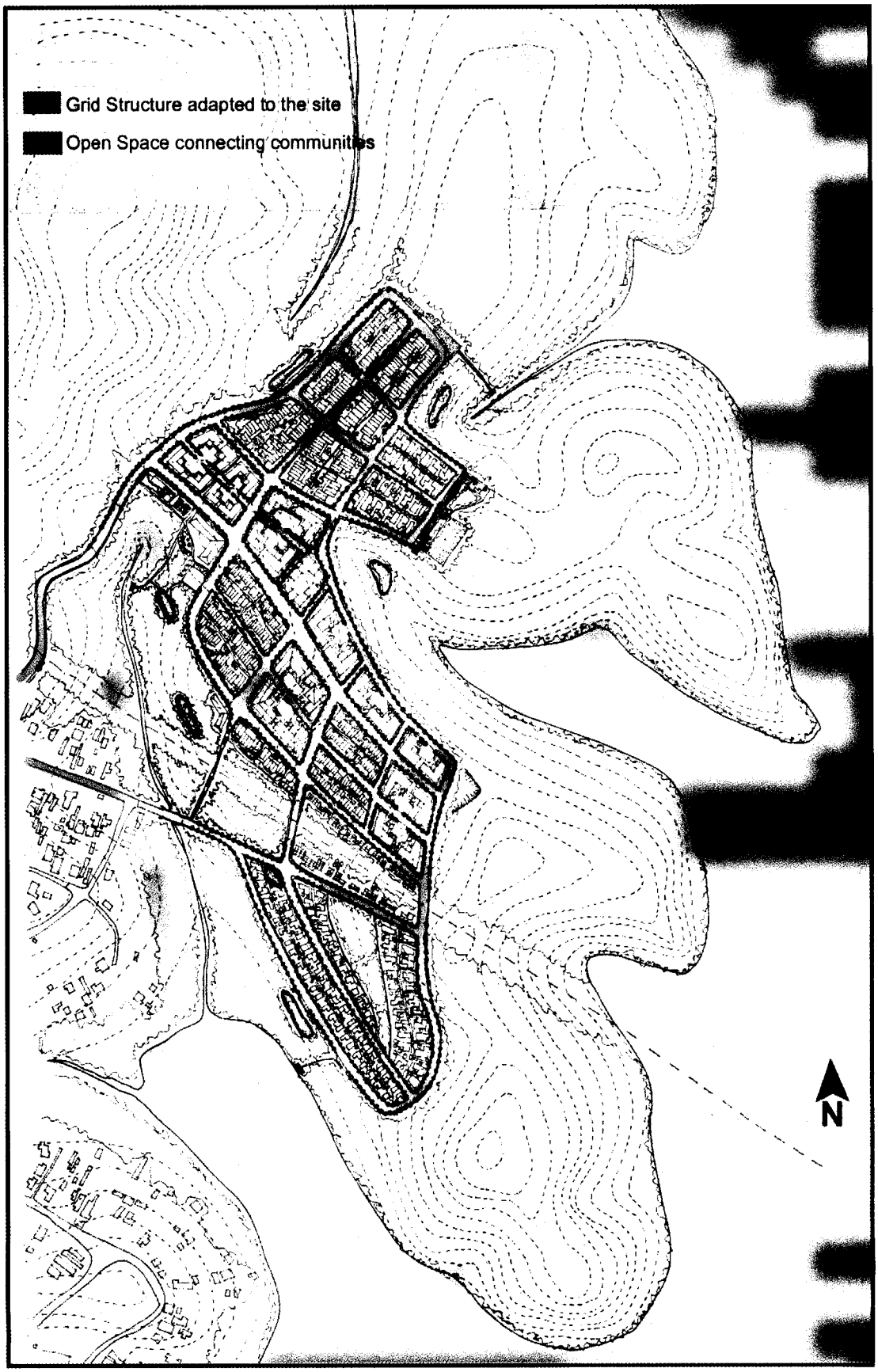


Figure 65 - Grid structure and link to adjacent communities.

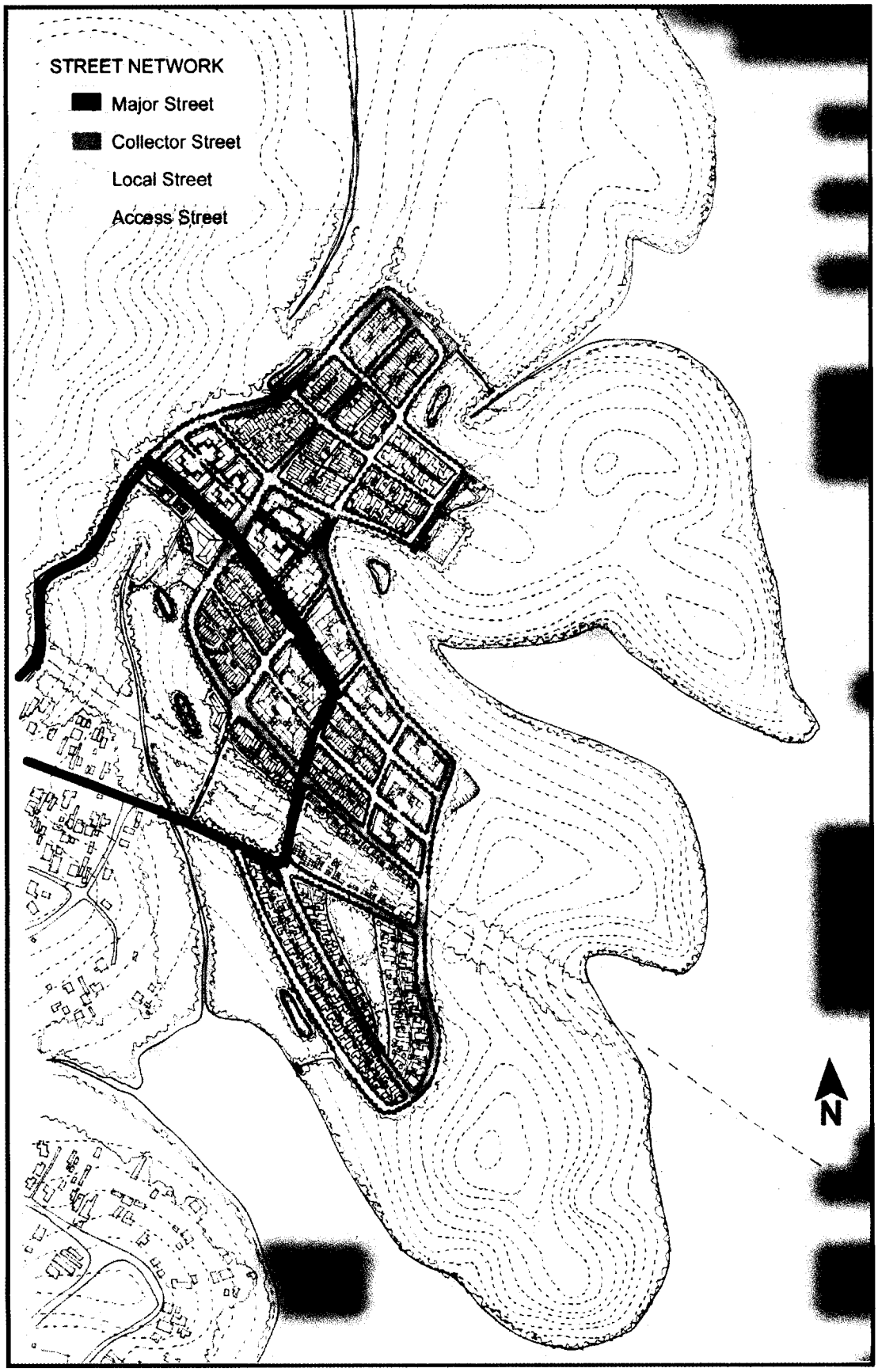


Figure 66 - Street network.

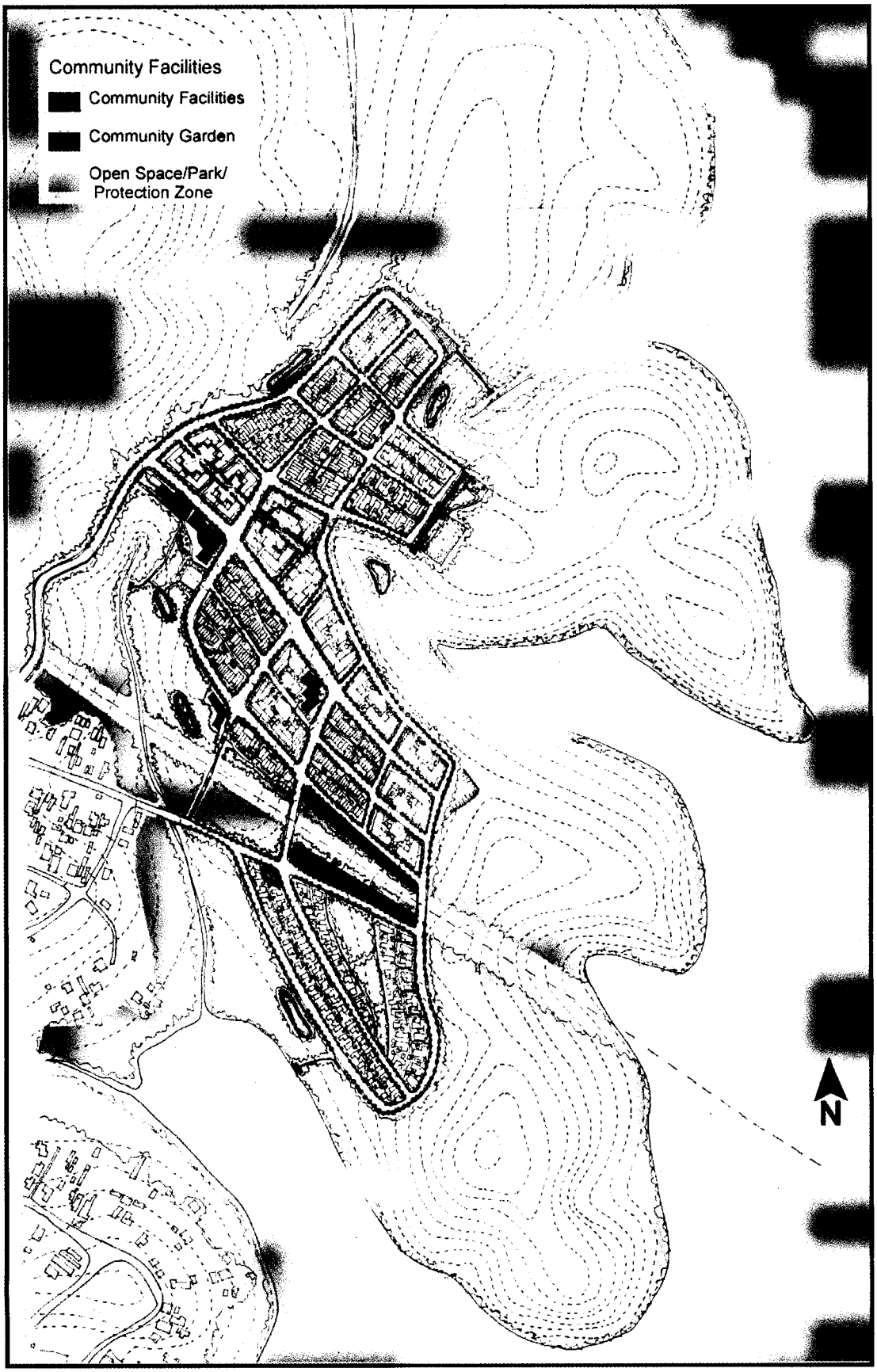


Figure 67 - Community and Institutional facilities, open spaces and access to protection zones

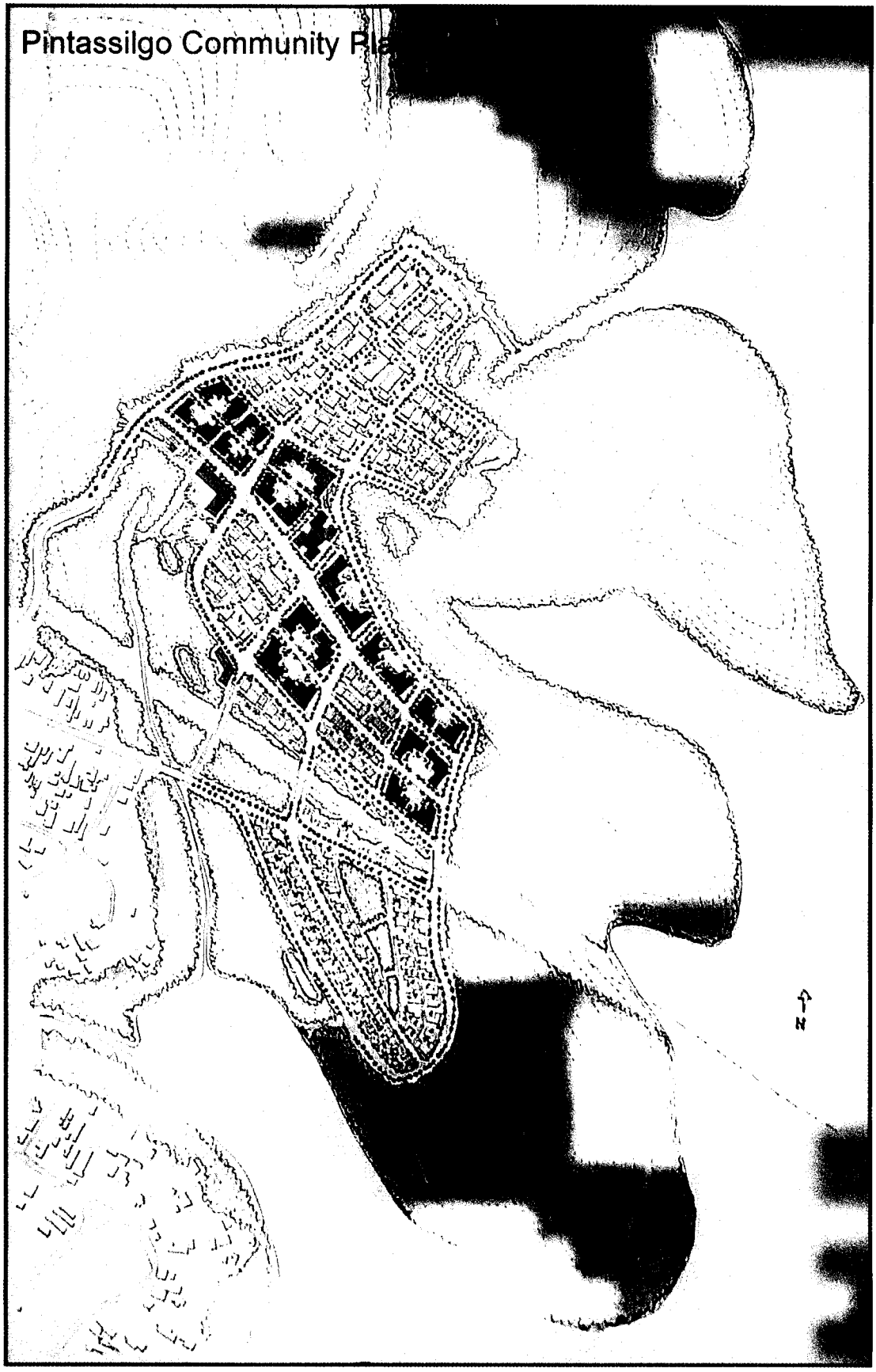


Figure 68 - Master Plan.

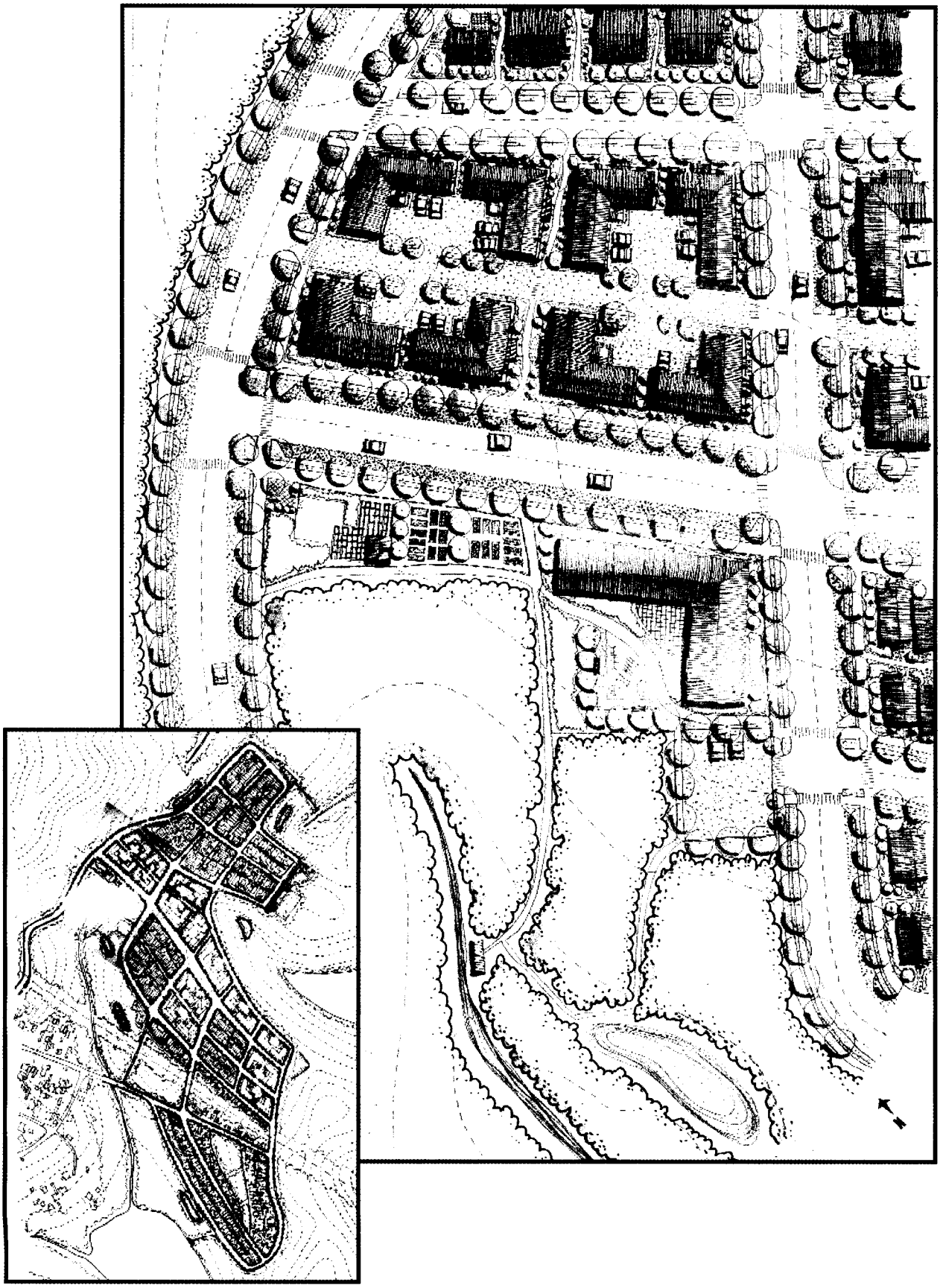


Figure 69 - Detailed plan

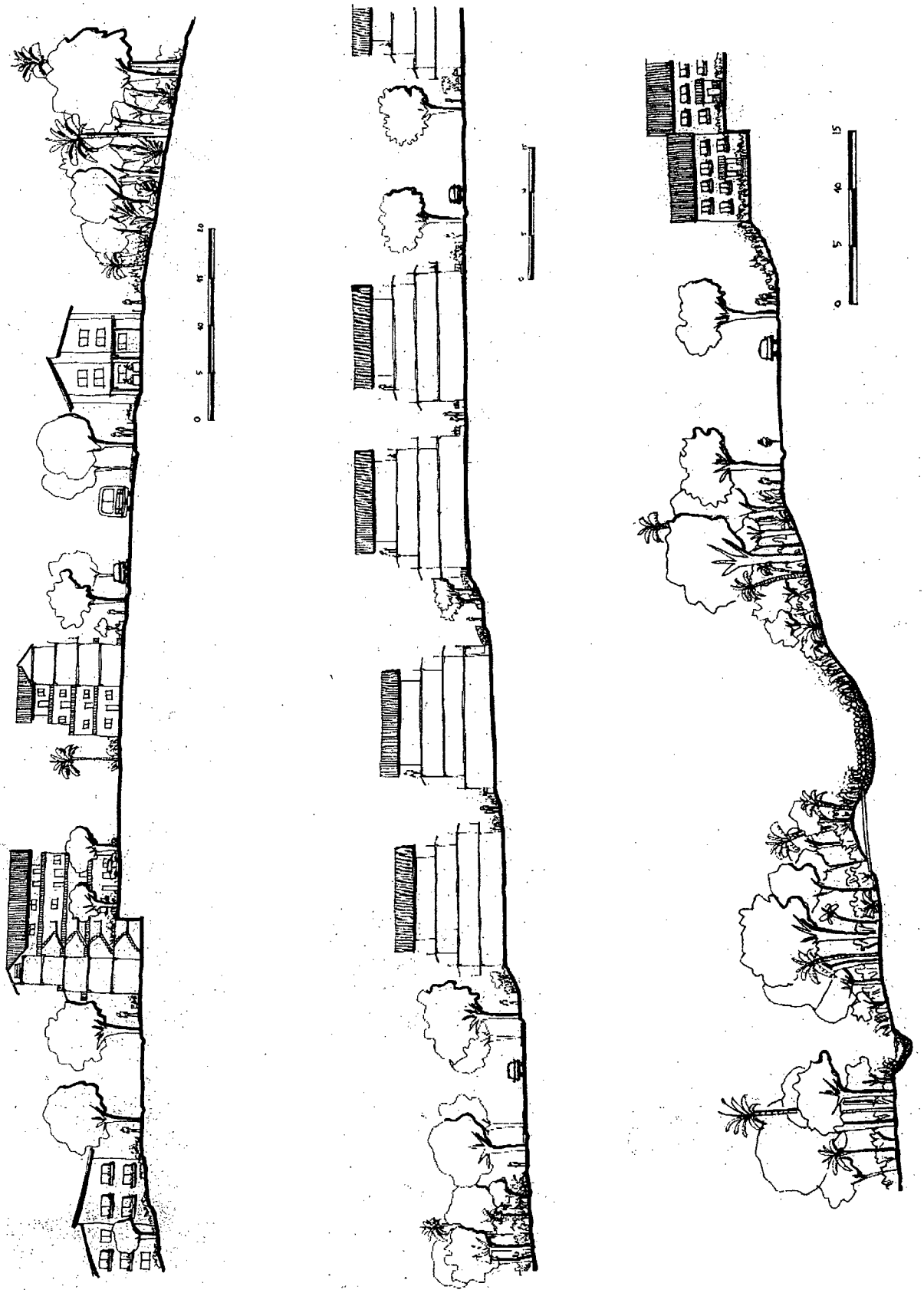


Figure 70 - Detailed design - sections.

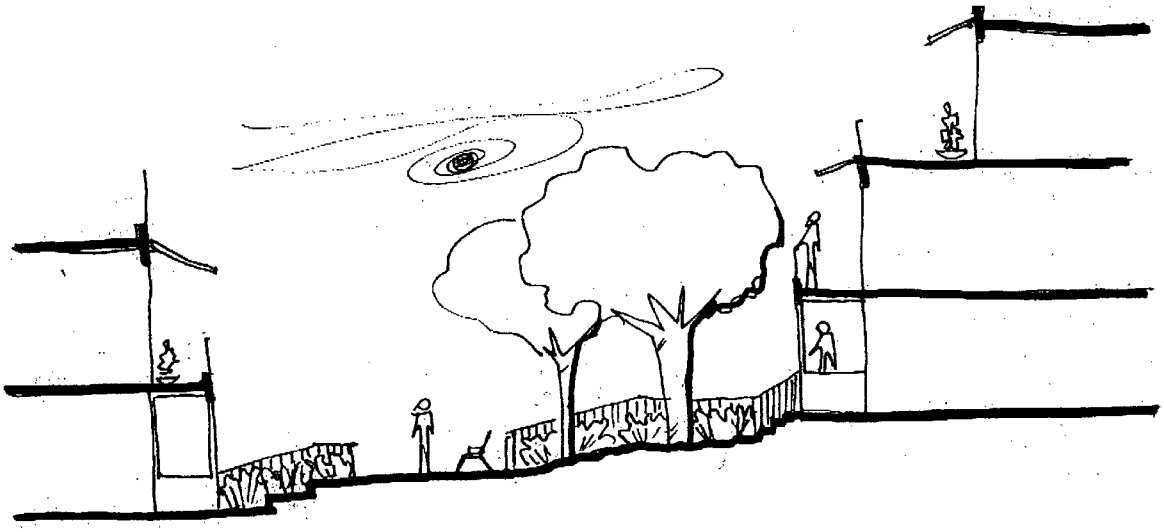


Figure 71 - Mid-block connections.

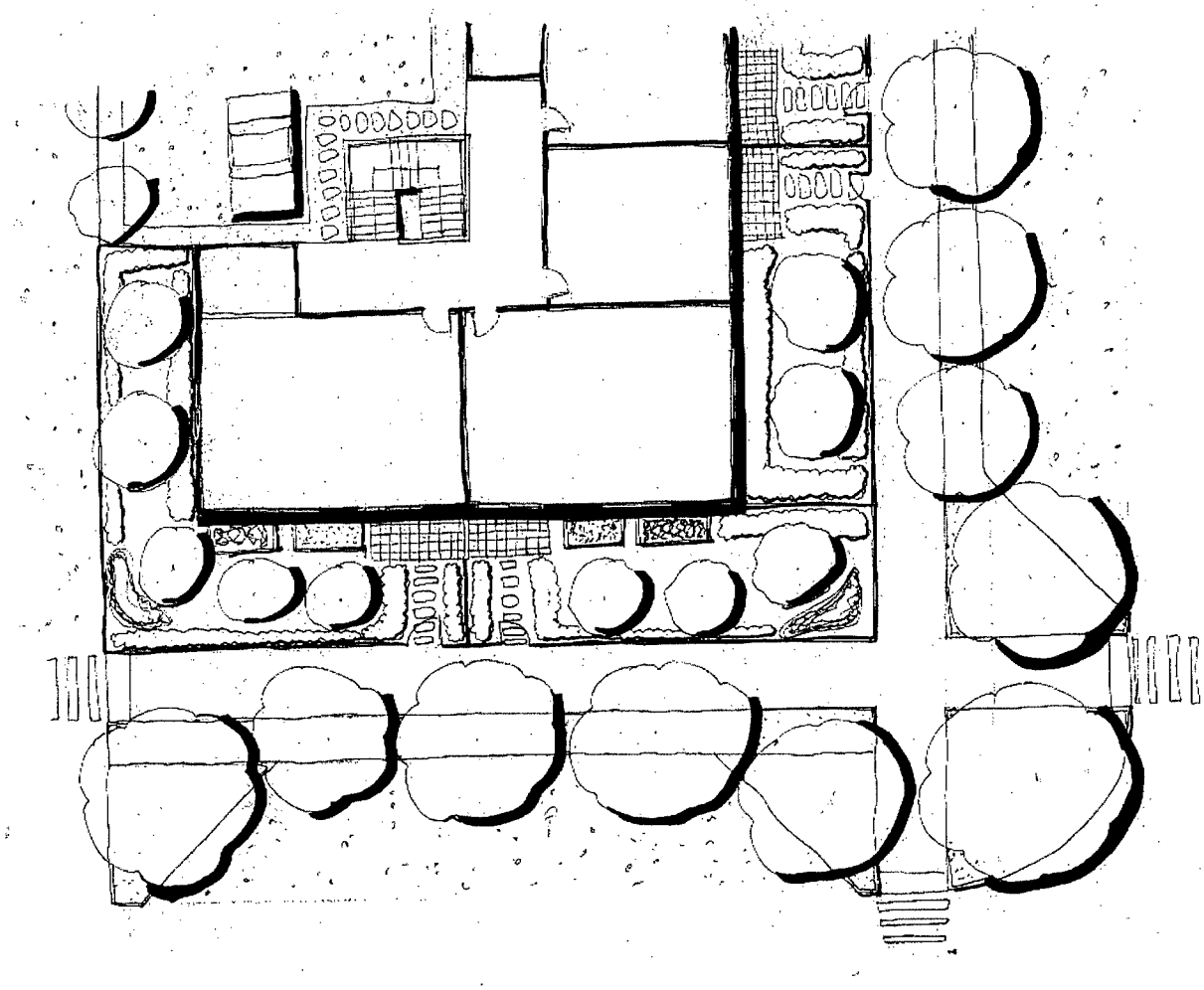


Figure 72 - Apartment building and its relationship with the street.

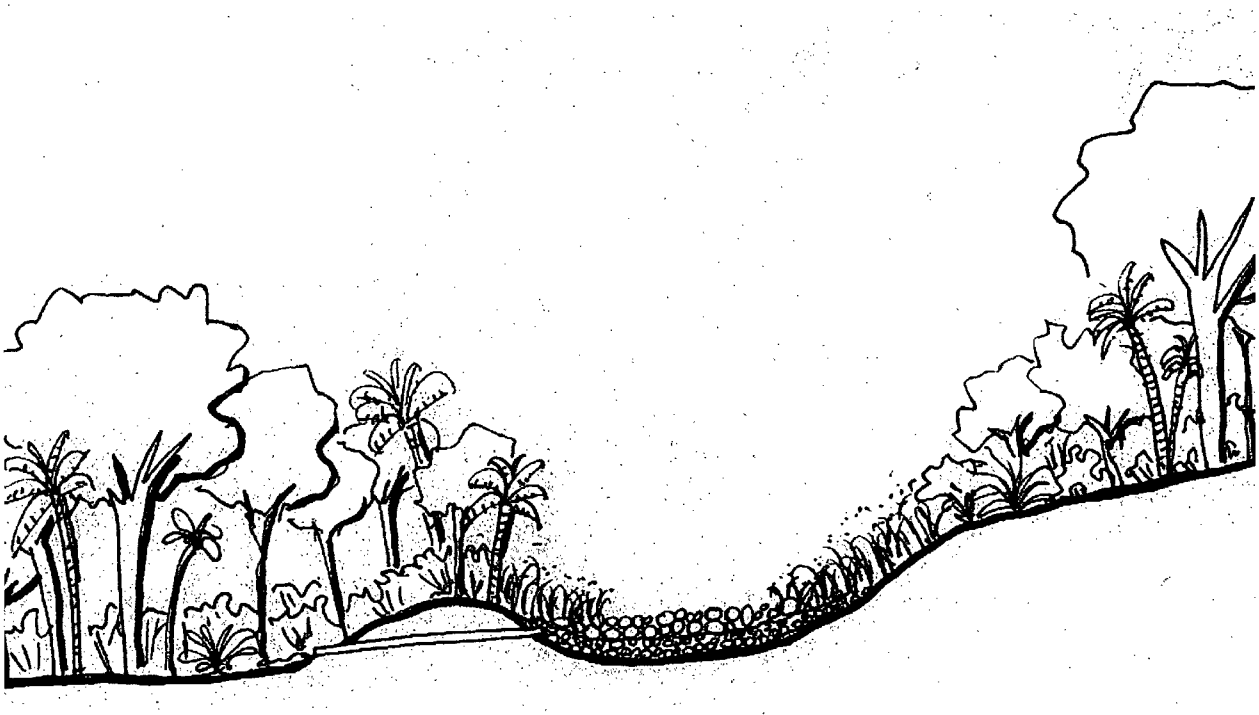


Figure 73 - Infiltration pond.

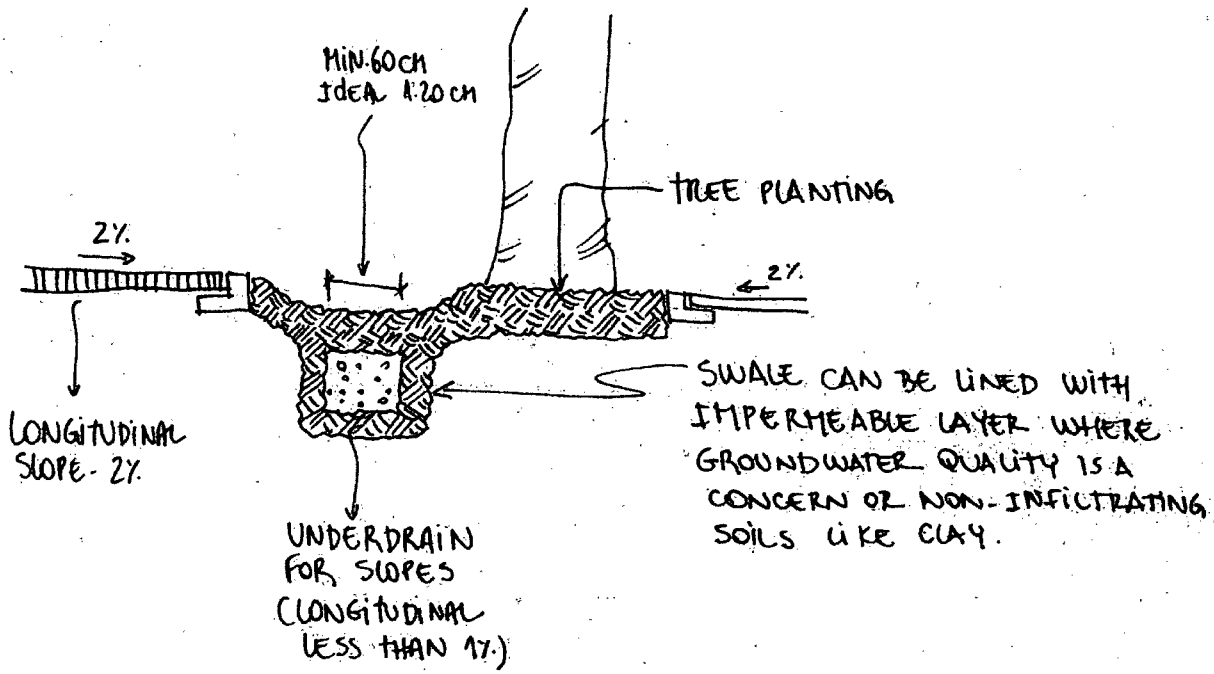


Figure 74 - Swale detail.

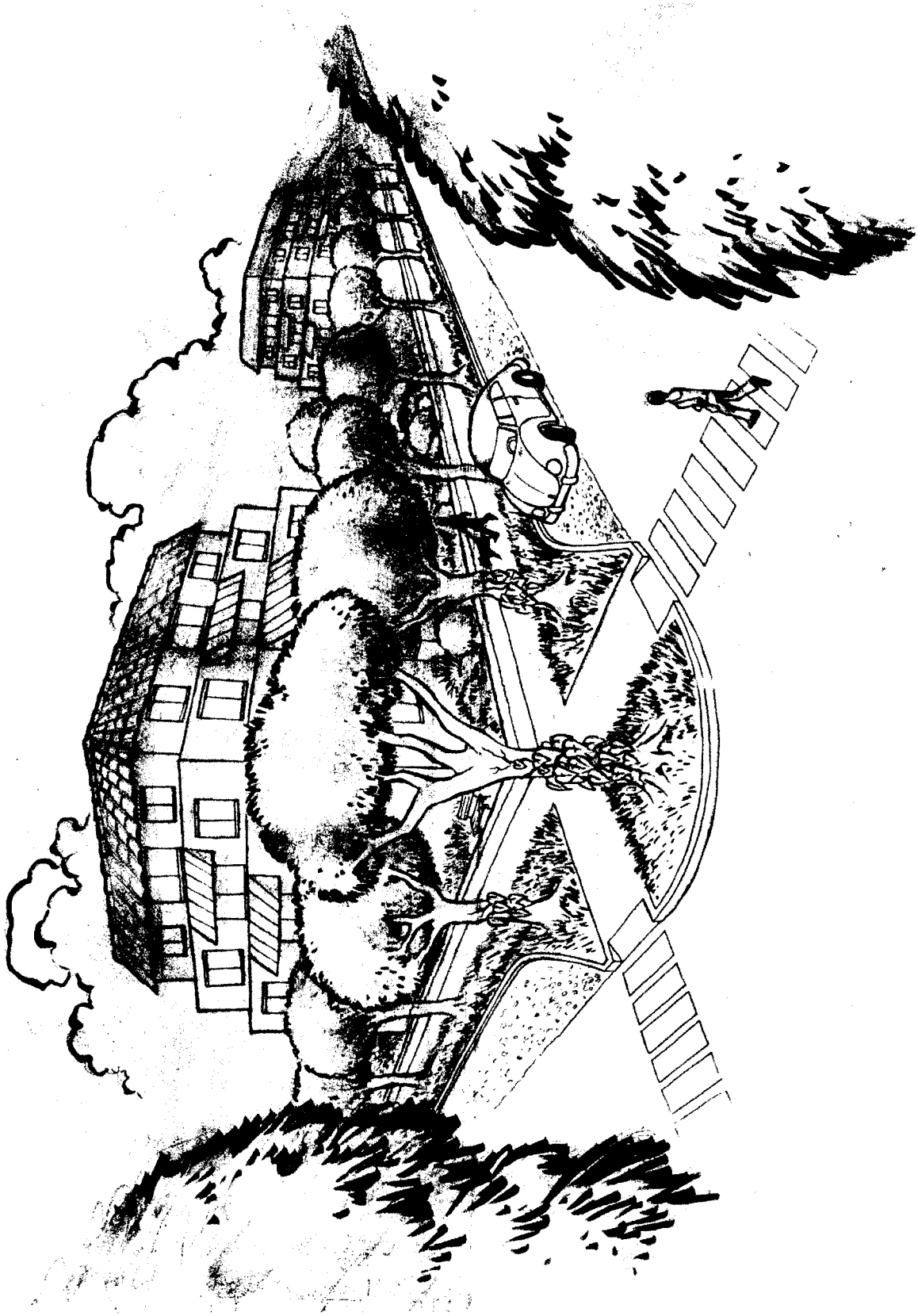


Figure 75 - The neighborhood environment.

7. Conclusion

The problem of social exclusion is chronic in the developing world. Many families never have a chance to get the minimum of what should be their right to have in the first place. School for the kids, health care, a roof to raise the family, safety, job opportunities, and so on. It is a sad reality that requires a group effort to change it, including every member of the society.

Sustainable design can be one of the elements in helping construct a better reality for those citizens. It has to come together with social and political actions, of empowerment, inclusion and opportunities.

Steps towards a more sustainable community are simple and applicable to our reality. The guidelines and its application on the proposal indicates that it doesn't take a lot of money to change this situation, but it does take compromise; education; exchanging of experiences and ideas; and finally, an active participation of the neglected population of those areas.

Developing countries have a unique opportunity to learn from other countries experiences, successes and also mistakes, allowing us to try a "short-cut" into development and more sustainable solutions for design.

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