A FEASIBILITY STUDY FOR THE ENVIRONMENTAL IMPACT ASSESSMENT OF THE ESTABLISHMENT OF THE TRANSFER- AND RECYCLING STATION IN GABORONE, BOTSWANA

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THERESE NYBERG
ABSTRACT

Waste management is a growing problem in Botswana’s capital Gaborone. One proposed solution is to establish a transfer- and recycling station there which could serve as an important part in the aim to create a well-organised waste management system. A transfer station could make the waste management more efficient meanwhile; a recycling station could provide the society with a possibility to reduce materials being disposed on a landfill. The purpose of the bachelor thesis is to conduct a feasibility study to support the Environmental Impact Assessment (EIA) that would have to be done before such a station can be constructed. The feasibility study presented here provides information about identified impacts and assessed consequences caused by the waste transfer- and recycling station. Methods used to present the study were mainly performed by field studies at the suggested alternative sites and by informal key informant interviews with experts from Gaborone City Council (GCC). The result of the thesis shows a summary of similar consequences at the suggested sites but the analysis, including additional aspects, concluded a differentiation between the sites that enabled a final recommended location, the Old abattoir.

Keywords: Environmental Impact Assessment, Waste management, Feasibility study, Impacts, Consequences, Mitigation Measures.
ACKNOWLEDGEMENT

This feasibility study has been conducted as a concluding thesis of our education in the Bachelor Program of Environmental Science at Mälardalen University. The bachelor thesis, of 15 ECTS, is a result of a study performed in Gaborone, Botswana, during 2 months of the spring semester of 2014.

The cooperation between GCC, Västerås City and Vafab Miljö AB has resulted in the Gaborone Transfer and Recycling Station project which provided us with the opportunity to use our acquired knowledge from our education to conduct our thesis.

First of all, we would like to thank the Swedish International Development Cooperation Agency that enabled our trip to Gaborone, Botswana through the Minor Field Study scholarship awarded to us.

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Mälardalen University, Gaborone, May 2014

Charlotte Jensen and Therese Nyberg
SUMMARY

As the urbanisation in developing countries increases so also does the demand for well-functioning waste management. In order to create sustainability in this matter would it be of importance to implement a waste management beneficial for the public health and for the environment. The establishment of a transfer- and recycling station could be a step towards a more sustainable society. A transfer station could provide a more efficient waste management system by decreasing the driving distances for waste collecting vehicles to the final disposing site. To engage citizens in the aim of a better waste system could a recycling station be an asset in the municipality since it could create awareness regarding the importance with recycling and reuse of materials.

Gaborone, the capital of Botswana, is a city that is striving to find a better solution regarding the waste management. Therefore, a cooperation between GCC, and the Swedish operators Västerås City and the company Vafab Miljö AB has been established. This cooperation has developed the Gaborone Transfer and Recycling Station project where Vafab Miljö AB will provide expertise to support GCC in the implementation of a waste transfer- and recycling station. To be able to select the most suitable location for the activity an EIA will be conducted to determine where it would have the least impact on the environment.

The purpose of this bachelor thesis is to create a feasibility study to provide information about identified aspects that could be affected by a transfer- and recycling station that will form the basis of the EIA. Since the Gaborone Transfer and Recycling Station-project is based in Gaborone, Botswana, has the study been conducted on-location.

Method used to identify impacts and consequences were field studies at the suggested alternative sites and the thesis is based on the content of the EIA-model made by the Department of Environmental Affairs (DEA) in Botswana.

The literature study describes the purpose of an EIA and a transfer- and recycling station. The function of an EIA is to define the zero alternative, assess consequences due to the activity and to propose mitigation measures to address the negative consequences. This process should be conducted in the beginning of a project.

In the result of the thesis are aspects evaluated concerning: ground- and surface water, biodiversity, noise pollution, air quality, soil, society and economy. A diversity of impacts is identified but because of the phase of the project are certain impacts in the need of further investigations. The result from these investigations has to be included in the final EIA to be able to conduct a complete and final assessment.

The assessment of consequences shows no difference at the alternative sites but the analysis of the result made it possible to distinguish attributes in favour for the location Old abattoir that is the final recommendation. Reasons for this are for instance: the nearby infrastructure, a possibility to reuse existing buildings and that the site is located in an industrial area.
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### DEFINITIONS AND ABBREVIATIONS

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<th>Term</th>
<th>Description</th>
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<tr>
<td>Ambient Air Quality</td>
<td>The quality of outdoor air affecting the public. (The Provision of British Columbia)</td>
</tr>
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<td>Aspects</td>
<td>Elements affected by the activity of the transfer- and recycling station.</td>
</tr>
<tr>
<td>Assessment</td>
<td>Evaluation of possible consequence.</td>
</tr>
<tr>
<td>Baler</td>
<td>Compacting the waste into bales to reduce the volume. (Environmental Protection Agency, 2002)</td>
</tr>
<tr>
<td>Compactor</td>
<td>Compresses the waste to reduce the volume. (Environmental Protection Agency, 2002)</td>
</tr>
<tr>
<td>Consequence</td>
<td>The result of an activity. (Hedlund &amp; Kjellander, 2007)</td>
</tr>
<tr>
<td>DEA</td>
<td>Department of Environmental Affairs.</td>
</tr>
<tr>
<td>Description of Baseline Environment</td>
<td>Description of the current status at the alternative sites. (Hedlund &amp; Kjellander, 2007)</td>
</tr>
<tr>
<td>Effect</td>
<td>A qualitative or quantitative change in the society and/or in the environment. (Hedlund &amp; Kjellander, 2007)</td>
</tr>
<tr>
<td>EIA</td>
<td>Environmental Impact Assessment.</td>
</tr>
<tr>
<td>EIA-model</td>
<td>A model for the establishment of an Environmental Impact Assessment.</td>
</tr>
<tr>
<td>Feasibility Study</td>
<td>A pre-study to collect information.</td>
</tr>
<tr>
<td>Field Study</td>
<td>Investigations in the field.</td>
</tr>
<tr>
<td>Fractions</td>
<td>Division of the waste. (Avfall Sverige AB, 2013)</td>
</tr>
<tr>
<td>GCC</td>
<td>Gaborone City Council.</td>
</tr>
<tr>
<td>GTARS-project</td>
<td>Gaborone Transfer and Recycling Station project.</td>
</tr>
<tr>
<td>Hydrological Conditions</td>
<td>The presence of water in an area. (Nationalencyklopedin, 2014, a)</td>
</tr>
<tr>
<td><strong>ICLD</strong></td>
<td>Swedish International Centre for Local Democracy.</td>
</tr>
<tr>
<td><strong>Impact</strong></td>
<td>A change in the environment and/or in the society. (Hedlund &amp; Kjellander, 2007)</td>
</tr>
<tr>
<td><strong>Key Informant Interviews</strong></td>
<td>Qualitative in-depth interviews to collect information.</td>
</tr>
<tr>
<td><strong>Landfill</strong></td>
<td>An area of land selected for disposal of waste.</td>
</tr>
<tr>
<td><strong>Mitigation Measures</strong></td>
<td>Actions recommended to limit negative consequences.</td>
</tr>
<tr>
<td><strong>Municipal Partnership Program</strong></td>
<td>A cooperation between municipalities in Sweden and developing countries financed by SIDA. (Swedish International Centre for Local Democracy, 2011)</td>
</tr>
<tr>
<td><strong>N/A</strong></td>
<td>Information not available.</td>
</tr>
<tr>
<td><strong>Pathogenic</strong></td>
<td>The ability to generate diseases. (Global Food Safety Resource, 2014)</td>
</tr>
<tr>
<td><strong>Permeability</strong></td>
<td>The ability of the soil to infiltrate liquid or gas. (Nationalencyklopedin, 2014, b)</td>
</tr>
<tr>
<td><strong>Recovery Company</strong></td>
<td>Companies in the business of recycling.</td>
</tr>
<tr>
<td><strong>Recyclable Material</strong></td>
<td>Materials possible to recover and reuse.</td>
</tr>
<tr>
<td><strong>Recycling station</strong></td>
<td>A facility where to separate clean material.</td>
</tr>
<tr>
<td><strong>Screening</strong></td>
<td>Inspection of the waste. (Environmental Protection Agency, 2002)</td>
</tr>
<tr>
<td><strong>SIDA</strong></td>
<td>Swedish International Development Cooperation Agency.</td>
</tr>
<tr>
<td><strong>Topography</strong></td>
<td>Description of the surrounding in details in text, pictures or maps. (Nationalencyklopedin, 2014, c)</td>
</tr>
<tr>
<td><strong>Transfer station</strong></td>
<td>A facility for intermediate storage of waste.</td>
</tr>
<tr>
<td><strong>Zero alternative</strong></td>
<td>A description of the development of the environment at the site if the activity is not implemented. (Hedlund &amp; Kjellander, 2007)</td>
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1 INTRODUCTION

1.1 Background

As the countries around the world develop, it is of highest priority that the development occurs in a sustainable way. Every society regardless of level of development creates waste and to make sure that the societies stay safe and healthy it is important to strive towards a well-functioning waste management. As populations grow and the rate of urbanisation is increasing, the demand for waste collection is increasing, requiring functioning waste management to sustain existing and create new sustainable societies. (Avfall Sverige, 2013)

According to Dong, Rotich and Zhao (2005), municipal solid waste management consists of five different phases: collection, transfer, resource recovery, recycling and treatment. In order to make municipal waste management efficient it is important to involve both private and public sectors so that the interest for municipal waste management is maintained. When there is a good cooperation between the stakeholders it will result in a sustainable environment, a healthy population and provide for a thriving economy.

Suneetha and Jain (2009) claims that there are environmental, economic and public health reasons for developing and implementing sustainable waste management. For example it has been stated that recycling and reusing of waste could create job opportunities and could have positive impacts on the environment. The economic benefits could also be generated from recovering and reusing of the waste since it is more beneficial and efficient than disposing of valuable goods at landfills. Furthermore, Goldman and Ogishi (2001) states that recycling and reusing would decrease the use of natural resources and a proper waste treatment and management would also result in health profits since it would reduce the spread of diseases, pests and rodents.

The end station for waste is in many cases a landfill which in some circumstances is located far from the cities where the waste collection takes place. The reason is to avoid a location that might disturb households with odour, birds and pests. When the landfill is situated far from the location of waste collection it can be a good alternative to establish a transfer station. The purpose of a transfer station is to simplify the waste management and to reduce the driving distance for waste collecting vehicles. Vehicles that can store bigger quantities of waste would instead handle the transport to the landfill, hence; make the waste management more efficient. (Environmental Protection Agency, 2002)

In order to encourage citizens to separate waste and enable recycling and reuse, it could be a good investment to establish a recycling station. A recycling stations purpose is to assist the municipality in their responsibility to collect domestic waste in a more sustainable way by
serving as a central part of the municipal waste handling system where citizens can leave separated, bulky and hazardous waste. The creation of a recycling station could strengthen the relations between the municipality and the citizens because it becomes possible to visualise the values of recycling, which could encourage a more sustainable behaviour. It is also important to consider the location to reach a big catchment area and to ease the access to the recycling station for the customers and citizens. (Avfall Sverige AB, 2013)

1.1.1 Botswana and Gaborone

This thesis has been conducted in the city of Gaborone, the capital of Botswana. Botswana has a land area of 566 730 square kilometres (km²) and is located in the southern part of Africa (The World Bank, 2014). The country borders to South Africa in the south, Namibia in the west, Zimbabwe in the east and Zambia in the north (figure 1). The population in Botswana is about 2 000 000 and the major ethnic group is Tswana. The official language is English, which has its history from when the country was a protectorate by the United Kingdom, but the national language is Setswana. (Landguiden, 2013) Botswana got its independency in 1966 and has since developed from one of the poorest country in the world to one of the most well-developed countries in Africa. This change was mainly made possible due to a stable political climate and the diamond industry. (Landguiden, 2012)

Figure 1: The arrow shows the location of Botswana on the map of Africa. (The University of Texas at Austin, 2014)
Gaborone is the capital of Botswana and the city has an area of 238.05 km². The city is located in the south-east part of the country, right next to the border to South Africa (figure 2). The capital has a population of 231,592 which generates a great need of a functional waste management. Currently municipal waste handling system involves collecting of the waste from the households around the city and to transport it to a landfill that is located about 35 kilometres (km) from the centre of the city. Not only the distance to the landfill makes it a time consuming task, but also the occasionally heavy traffic on the route slows down the transport of waste from the city to the landfill. (Mataela, 2014)

![Figure 2: Map of Botswana to show the location of the capital Gaborone. (Worldtravels.com, 2014)](image)

### 1.1.2 Gaborone Transfer and Recycling Station Project

The population in Gaborone creates a large amount of waste, approximately 60,000 tons per year. The waste collection is divided over 107 areas in the city and the activity is based on collection seven days per week. The routine is to collect waste until the waste vehicle has been filled and it is necessary to transport it to the landfill. Because of this time consuming task is the procedure only possible once a day, even though it is required more frequently. This results in a high burden for the personnel, the environment, the vehicles and also a high economic burden for the municipality. Therefore, to improve the situation and make it easier to manage the waste, GCC has the goal to establish a waste transfer- and recycle station. This facility would be located closer to the city centre, which would improve the situation, both from an economic and an environmental point of view. (Mataela, 2014)

To implement the idea of a transfer- and recycling station, have contacts been established between GCC and Västerås City in Sweden since the field of waste management is an area where Västerås City is prominent and possesses a lot of knowledge. Västerås City’s aim is to develop an international exchange of knowledge and the municipal partnership with GCC is
one important step towards long term cooperation between the two municipalities. This municipal partnership is extended over a three years period. (Swedish International Centre for Local Democracy, 2011)

The cooperation between Västerås City and GCC is financed by the Swedish International Development Cooperation Agency (SIDA) and was enabled due to an application to the Swedish International Centre for Local Democracy (ICLD) who supports Municipal Partnership Programs. This application resulted in the project Gaborone Transfer and Recycling Station (GTARS-project) and the company in Sweden that provides the project with expertise and knowledge is Vafab Miljö AB. (Swedish International Centre for Local Democracy, 2011) Vafab Miljö AB is a branch of the municipality in Västerås that is managing the waste management throughout the county of Västmanland and the municipalities of Heby and Enköping (Vafab Miljö AB, 2014).

One part of the GTARS-project is to create an EIA to evaluate the positive and negative impacts on the environment and also to decide the most appropriate location where to establish the transfer- and recycling station. The feasibility study presented here is made to provide the final EIA with information and to determine necessary investigations. (Lindblom & Tshotelo, 2013)

1.2 Purpose and Aim

The purpose of this bachelor thesis is to conduct a feasibility study to provide information for an EIA that will be conducted before the establishment of the transfer- and recycling station in Gaborone, Botswana. The purpose is also to identify impacts and consequences on the environment of the proposed transfer- and recycling station at three suggested sites and to investigate how the negative consequences can be prevented or mitigated.

The aim of the bachelor thesis is to collect and analyse data for a feasibility study that forms the basis for the final EIA of the transfer- and recycling station. The aim is also to identify the issues that have to be further investigated before the EIA can be completed. The feasibility study presented here will be a central contribution to the assessment of the viability of a waste transfer- and recycling station in Gaborone.

1.3 Problem Statement

A transfer station is being used to make the waste collecting system more efficient by temporarily storing and compressing the collected waste. The current waste management system in Gaborone has problems due to the fact that collecting vehicles have to drive a distance of approximately 70 km to the landfill. The collecting vehicles are not adapted to drive longer distances and cannot transport sufficient large quantities of waste, which results in long driving distances for the vehicles and a time consuming task for the personnel. This
system is very costly to the municipality, GCC, who has to make investments in new vehicles and spend money on repairs. Other challenges in the current waste management system are emissions from the collecting vehicles and the amount of waste disposed on the landfill that could instead be recycled. Therefore, GCC has established the cooperation with Västerås City in Sweden, to find a suitable solution. To solve the problem it is suggested to establish a transfer- and recycling station that would improve the efficiency of the waste collection by reducing the number of trips from Gaborone to the landfill as well as decrease the volume of waste transported to the landfill. This would decrease the negative consequences of the waste handling on the environment. The establishment of a waste transfer- and recycling station could therefore be a viable solution. To be able to establish the facility an EIA must be conducted to determine impacts, effects and consequences on the environment caused by the activity. It also important to propose mitigation measures to address the negative consequences. Therefore, the focus of this thesis is to create a feasibility study to answer the specific research questions presented below. Through these research questions the authors will determine which alternative site that would have the lowest negative impact on humans and on the environment.

1.4 Specific Research Questions

The thesis will answer the following research questions based on the purpose, aim and the problem statement:

- What environmental impacts could the transfer- and recycling station cause at the suggested alternative sites in Gaborone?

- What environmental consequences can be identified from the establishment of the transfer- and recycling station at the suggested alternative sites in Gaborone?

- How can the identified negative consequences be addressed?

- Which alternative site would be the most suitable location based on the result from the feasibility study?

1.5 Delimitation

This bachelor thesis is restricted to the GTARS-project in Gaborone, Botswana. The results presented in this thesis only deal with the feasibility study and the result will be used for the final EIA, which is not part of this study. The feasibility study is in line with the requirements for the creation of an EIA from the Environmental Assessment Act (2011) that is provided by the DEA in Botswana, appendix 1.
The literature study is delimited to a description of the purpose and the function of an EIA and a transfer- and recycling station. The result of the feasibility study is restricted to the main content of an EIA, which includes: description of baseline environment, zero alternative, assessment of identified consequences, analysis of the suggested sites, mitigation measures and recommendations.

1.6 Limitations

Comparisons of projects like the GTARS-project have been difficult to find even though projects comparable to the situation in Botswana have been completed in countries with similar circumstances, but few reports about the construction have been published.

Time and phase in the GTARS-project were two reasons why this bachelor thesis was focused to a feasibility study instead of a complete EIA. Due to the phase of the project, the authors did not have access to all necessary information. The time limit was dependent on the number of weeks that was provided for the thesis and therefore it was not possible to proceed and perform a complete EIA according to the model provided by the DEA.

1.7 Method

This bachelor thesis is a feasibility study based on the EIA-model formed by the DEA, in Gaborone, combined with guidelines from the Swedish EIA-model. A feasibility study is not a complete EIA but the content is based on a full scale EIA and is a necessary document before it is possibly to complete the EIA. The result of this study will provide the EIA with important information regarding, for instance, assessment of consequences at the alternative sites and furthermore to identify in which aspects further investigations have to be performed.

Field studies were performed at the alternative sites to give the authors a perception about the current status of the locations and this information was compiled in the result. The visits were photo documented to be able to visualise the environment described in the thesis. Information about site conditions has also been provided from Vafab Miljö AB.

To be able to access detailed information about the sites informal interviews with open- and guiding questions have been performed with key informants, e.g. experts in physical planning, environmental health and archeology from GCC and the Department of National Museum and Monuments.

A literature study was conducted to describe the purpose and use of an EIA and a transfer- and a recycling station. Scientific articles have also been included which were found through Web of Science and Google Scholar provided by Mälardalen University, Sweden.
1.8 **Disposition**

The structure of this bachelor thesis is:

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 2</td>
<td>Literature Study</td>
<td>The purpose and function of an EIA, a transfer station and a recycling station.</td>
</tr>
<tr>
<td>Chapter 3</td>
<td>The Current Study</td>
<td>A description of the methods used in this thesis.</td>
</tr>
<tr>
<td>Chapter 4</td>
<td>Result and Discussion</td>
<td>A presentation of the result of performed field studies and analysis.</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>Conclusion</td>
<td>Summary of the final result and recommendations for further studies.</td>
</tr>
</tbody>
</table>
2 LITERATURE STUDY

This literature study is divided in three parts. Subchapter 2.1 describes the procedure of an EIA and its purpose. The creating of an EIA varies depending on the EIA-regulations in a specific country. This chapter took a general perspective with the main focus on literature from Swedish guidelines since the authors have an educational background within the Swedish EIA-system. Moreover, the literature study also defines the purpose and the function of a transfer- and recycling station in subchapter 2.2 and 2.3. The aim is to provide an understanding of the implementation of a transfer- and recycling station in a municipality.

2.1 Environmental Impact Assessment

An EIA is according to Caldwell (2004), a document compiled to evaluate the consequences caused by a certain project regarding environmental, economic and social aspects. Since the implementation of the EIA in the 1970s it has grown to be a document that is used all over the world to support decision-makers in questions regarding environmental management. Hedlund and Kjellander (2007) claims that even though it is a concept spread all over the world, the variety of rules and content differs extensively which has to be considered by the executor. The authors are also stating that the purpose of an EIA is to make sure that the project is environmentally adapted, give involved stakeholders an opportunity to influence the project and to serve as a document to support decision-making. According to the Swedish model, an EIA allows stakeholders and authorities to get insights and an opportunity to influence the project before the construction.

Furthermore, Hedlund and Kjellander (2007) assert that the core of the EIA is to predict and characterise the positive and negative consequences of a certain activity. The document should include a comparison of different alternative locations where it could be possible to locate the planned activity. The assessment should also contain a zero alternative that would describe the development of the sites and the impacts on the society if the activity would not take place. Based on the EIA it should then be possible to choose the best suggested alternative site that would have the most beneficial consequences on the environment and on human’s well-being.

Caldwell (2004) states that an EIA could be conducted from for instance, a local or state, national or international level, it depends of the extent of the activity. The author continues one flaw with an EIA is that every estimated negative impact that might lead to a consequence, are not being carefully examined and followed-up. If there are no investigations that can prove that the identified negative consequences have been taken out of harm, the purpose of the EIA would be lost.
Before a final EIA, a feasibility study could be created and the World Bank (2014) describes what a feasibility study could include:

- a site analysis, which should describe the hydrological condition and soil qualities
- an evaluation of the most appropriate design for the activity
- an evaluation of the most appropriate techniques and constructions
- a selection of transportation methods

2.2 Transfer Station

According to the Environmental Protecting Agency (2002) is the definition of a transfer station an intermediate waste handling facility were the waste is delivered to by collecting vehicles and transshiped into outgoing transports with a larger loading space. The main purpose is to make the waste management more efficient and cost effective by collecting waste from various units in order to compact and reload it to larger vehicles adapted for longer driving distances. The station has a significant part in the municipal solid waste management and is a step between the waste collection and final disposal.

Municipal solid waste usually consists of waste from: companies, industries, households and institutions. Examples of what it may contain are: recyclables, garden waste, hazardous waste and constructions waste. These fractions are usually handled at a transfer station but there are also types of waste not received for example: explosives, radioactive waste, infectious medical waste, asbestos, fuel tanks and large bulky waste. (Environmental Protection Agency, 2002)

Depending on the ownership, the location and the operator; the use of a transfer station could vary. It could either be used by both commercial and public customers or focused on only one group. When a station is open for the public it is possible that the facility serves as a centre were citizens could dispose their own waste. This approach may also accomplish a greater public awareness about a well-functioning waste management and help the municipality to achieve recycling goals. (Environmental Protection Agency, 2002)

When making decisions regarding the location of the transfer station it should include criteria concerning: agricultural areas, wetlands, nature reserves, floodplains and protected habitats of flora and fauna. It is also important to involve the public in this procedure to offer a possibility to influence the project. This is significant in cases where the establishment might have an effect on the neighbourhood. (Environmental Protection Agency, 2002)

Decisions should also be made regarding the number of facilities that the municipality might be planning for. The result of planning for one station could be that the waste transfer management becomes centralised and a single station must encounter all demands from the society that otherwise could be divided in to several stations. A single station might be connected to a harbour and railway and thus reduce the impacts caused by the traffic.
However, the main disadvantages are that the impacts from the activity becomes concentrated into one area, traveling time for the collecting vehicles could be longer, it may lead to abrasion to the vehicles and wasted time for the personnel. Instead, an alternative might be to construct multiple facilities. By doing so, the transfer management would be decentralised and impacts from the activity would be spread out. Nevertheless, the disadvantages are higher investment- and operation costs. (Environmental Protection Agency, 2002)

According to the EPA (2002) does the transfer station include activities with incoming and outgoing transports of waste and the station must be adjusted after what type of vehicles that could operate at the facility. Furthermore, the determination of the capacity and size depends on:

- the type of collecting vehicles
- delivering patterns during operating hours
- the time needed to reload and transfer the waste
- accessibility of infrastructure that assist the transfer
- the time needed to reload containers and trailers
- the estimated future in waste quantities
- the amount and type of produced waste in the municipality
- the cooperation between facilities handling waste

When size and capacity are determined, next step is to design the facility and different aspects should be considered. Examples of this could be: the design of the waste transfer unit, the need for future expansion, the need of a weigh bridge, the function of drain wells, buildings and fence. (Environmental Protection Agency, 2002) Linder (2011) describes that incoming collecting vehicles usually passes a weigh bridge to be able to measure and document the amount of waste per vehicle. In connection to the weigh bridge could a waste transfer unit be located and this unit can be designed after different technologies depending on the circumstances, one design is shown in figure 3.

![Figure 3: One example of a design for a transfer station. (Linder, 2011)](image-url)
an outgoing transport and to reduce the volume a compacter can be used. Depending on how the waste is transferred it allows a possibility to screen for hazardous waste or recyclable material before final disposal. This could also reduce the waste volume and it is more resourceful to screen at the station then at, for instance, the landfill. Furthermore, same technology could also be applied in a different alternative. Instead of a ramp, can waste be disposed on a tipping floor which provides a possibility of screening and then push the waste into a trailer or an outgoing transport. (Environmental Protection Agency, 2002)

![Figure 4: The technology with a stationary compactor. (Environmental Protection Agency, 2002)](image1)

Another technique is a stationary compactor, which uses a hydraulic piston (figure 4). This involves that disposed waste is reloaded to a compacter that presses it into a transport or a trailer. A pre-compactor is also a system that uses a hydraulic piston but in this case is the hydraulic piston integrated in a cylinder. Blocks of solid waste are generated and then pressed into a cell for further transportation (figure 5). (Environmental Protection Agency, 2002)

![Figure 5: The technology with a pre-compactor system. (Environmental Protection Agency, 2002)](image2)

Likewise, are balers a technique that compacts waste into solid blocks that are placed in a flatbed trailer by a forklift (figure 6). (Environmental Protection Agency, 2002)
Figure 6: The technology with a baler system. (Environmental Protection Agency, 2002)

The station will be operated by heavy traffic and because of that it is important to have a logistic solution that allows the traffic to flow and avoid queuing, see figure 7. It is also necessary to have access to the city road net for a proper transportation possibility. (Environmental Protection Agency, 2002)

Figure 7: Photo over the logistic solution. (Weiring, 2012)

2.3 Recycling Station

Recycling of waste is becoming more common among communities as a strategy to reduce the amount of waste that is disposed at a landfill. Recycling includes the process of waste collected for the purpose of reuse and reconstructing to save materials and lower the cost of waste management by the possibility to sell the recyclables. (Environmental Protection Agency, 1995)

It is important to consider that this change in the waste management needs both political engagement and a well thought-out administrative plan to be able to implement the change in the municipality that a recycling station would imply. To succeed it would be important to investigate the amount and the availability of waste that could be handled at the facility.
Furthermore, the main recycling goals has to be considered, the decision-making has to be politically supported, the possible market for recyclables should be investigated and programs for educational purposes should be considered. Since the recycling highly depends on the engagement of the citizens, it is important to involve them in an early stage of the planning of a recycling station. (Environmental Protection Agency, 1995)

The purpose of a recycling station is to support the municipality in their responsibility to collect domestic waste. When planning for the construction of a recycling station it is important to consider both the location and the accessibility since it would determine the usability. If the distance to the station is too far from residential areas it might minimise the use. Regarding the accessibility, it is central to consider who the costumers will be and how they might arrive. If it is considered possible arrival by foot the facility should be adjusted accordingly to ensure the safety of these costumers since they will share the facility with a mixed type of traffic. Therefore, it is necessary to have a well-functioning logistic solution at the recycling station which could ease the accessibility for every customer no matter arrival manner. Furthermore, the planning has to include enough space: to allow trucks to operate, for temporarily storing of containers and separate lanes to avoid traffic congestions. An example of a possible solution is shown in figure 7. (Avfall Sverige AB, 2013)

In the planning phase of the station it is also of importance to consider expanding possibilities at the location if the activity might grow due to the development of the municipality and the waste management. Furthermore, it is important to consider what type of material that would be handled at the station. The material is to be divided into different fractions and the design should be planned with the possibility that there can be a need for adjustments for more fractions. Examples of often used fractions is cardboard, combustibles, plastics, metal, garden waste, wood waste, electricity, drywall and insulation material. (Avfall Sverige AB, 2013)

Figure 8: Example over storage of hazardous waste from the recycling station in Köping, Sweden. (Weiring, 2012)
The treatment for hazardous waste should be separated from the bulky waste because it demands a secure storing, see figure 8. There can also be a certain fraction for reusable items such as old furniture and clothes. (Avfall Sverige AB, 2013)

There are different alternatives how to design a recycling station, which depends on the accessible area. For instance, one alternative could be to construct a driving ramp for incoming vehicles and along the ramp would containers with different fractions be placed. The fractions could be positioned in a shape of a stream line or a horse shoe (figure 9 and 10). A third example of a design is to arrange the station in the form of a square and the containers are placed around it (figure 11). (Avfall Sverige AB, 2013)

Figure 9: Example of a recycling station with a stream lined shape. (Avfall Sverige AB, 2013)

Figure 10: Example of a recycling station shaped as a horse shoe. (Avfall Sverige AB, 2013)
Another design could be to build a recycling station without a ramp and position the containers to enable the customers to empty their waste from ground level. This design can also be altered with a ramp only made for walking which would allow the customers to empty the waste from above and therefore make better use of the container. Figure 12 is illustrating one example of this solution. As weather protection it can be possible to build a roof and walls on the facility. Walls and roof could also minimise the risk of waste being spread to the surrounding areas. (Avfall Sverige AB, 2013)
3 THE CURRENT STUDY

Field investigations were a central method used to gather the information which forms the basis of the analysis presented in the results of this thesis. Investigations were made by observations performed by the authors at each site to provide an overview of the environment and its surroundings. The field studies were also photo documented to enable a visualisation of the current environmental status. The collected information forms the basis for the estimated environmental impacts, effects and consequences caused by the transfer- and recycling station. This information regards: vegetation, distance to surrounding activities, industries, settlements and infrastructure.

Interviews were held during three different occasions with key informants through informal meetings with open- and guiding questions. No formal interviews were performed and the meetings were arranged as the work progressed and questions came up. The main purpose of key informant interviews was to provide the authors with information regarding the suggested sites for the transfer- and recycling station. The three interviewees were experts in their field of environmental health, physical planning and archeology from GCC and the Department of National Museum and Monuments. During the interview with the expert in physical planning were the open- and guiding questions made to answer issues regarding:
• Activities surrounding the sites the Old landfill, the Old abattoir and Kgale view?
• Distances to settlements, school, hospitals and churches from each site?
• Distances from each site to the landfill at Gamodubu?
• The localisation of the railway in relation to the Old abattoir?
• The water reservoir located nearby the Old landfill and what the distance is between the site and the reservoir?
• What type of surface water is located nearby the Old landfill?

The second interviewee, the expert in environmental health, was asked questions regarding:

• What is the annual amount of waste in Gaborone?
• Is there an alternative plan for the waste management in Gaborone if the transfer- and recycling station would not be built?
• Will the transfer- and recycling station receive hazardous waste?

The purpose with the third interview, with the archeologist, was to answer questions regarding if any archeological findings have been discovered and to determine the soil at the three alternative sites. The result has been documented by notes during the meetings with the key informants; there have not been outright interviews.

Vafab Miljö AB and GCC have provided the authors with extensive information about the GTARS-project. Likewise, scientific articles have been used to collect information and to support the authors in their arguments and statements regarding the analysis of the potential impacts, effects and consequences caused by the transfer- and recycling station. The scientific articles were furthermore used to learn about similar projects. The scientific articles were searched and found with Google Scholar and Web of Science, provided by Mälardalen University. Keywords used to find scientific articles were “EIA”, “Environmental Impact Assessment”, “waste transfer station”, “recycling station”, “municipal solid waste management”, “waste”, “environmental impacts waste management”, “waste management developing countries”, “waste disposal”, “feasibility study EIA” and “handbook of EIA”. To further identify relevant scientific articles were information from the found articles references used.

Due to the fact that the thesis is a feasibility study for the establishment of the transfer- and recycling station in Gaborone, Botswana, was the thesis based on guidelines for the creation of the EIA regulated by the DEA in Gaborone. This feasibility study follows the outline of an EIA concerning the chapters: description of baseline environment, zero alternative, assessment of consequences, archeological impact assessment, mitigations measures and recommendations. However, is a feasibility study not equal to a final EIA; it is rather a document that provides the EIA with necessary information about possible environmental consequences and determines which aspects requires further investigations. The authors based the result on the assessment of potential environmental consequences caused by the transfer- and recycling station, which is the foundation of an EIA.
The chapter “Result and Discussion” has been combined due to the fact that the assessment of potential consequences requires certain assumptions to be made by the authors regarding the outcome of the aspects caused by the activity. The authors have also made recommendations for further investigations concerning the lack of information about the assessed aspects.

In subchapter 4.3 was the focus to identify the environmental impacts at the suggested alternative sites and subsequently describe the effects and assess the consequences. According to Hedlund and Kjellander (2007) is an impact defined as a change in the environment and in the society. This change can lead to an effect that is a qualitative or a quantitative alteration that can be measured or described. Meanwhile, a consequence is the result of the effect and the significance of the consequence depends on the interested party and their interests. Following example could describe the linking between impact, effect and consequence; an impact is changing the environment because of air pollutants from vehicles with the effect of a qualitative change in surface water due to acidification and the resulting consequence would be that aquatic organisms dies.

The assessment of the environmental consequences is classified according to three different categories:

- Insignificant consequence
- Moderate consequence
- Significant consequence

The insignificant consequence equals no negative or positive impact neither on the environment nor on human’s well-being. The classification moderate consequence describes negative or positive effects on either the environment or on human’s well-being. The significant consequence represents negative or positive effects on both the environment and on the well-being of human’s. The consequences are also classified as direct or indirect, reversible or irreversible, short or long term, recurring or non-recurring and local or regional.

A positive or a negative direct consequence is a primary result of the project meanwhile a positive or a negative indirect consequence is a secondary result of the project. A reversible consequence explains a scenario that could be restored, whereas an irreversible consequence is a permanent change. The classification short term could be described as a positive or negative consequence that occurs during the project time-line meanwhile a positive or negative long term consequence could appear after the project closure. The meaning of recurring is a consequence that takes place repeatedly while a non-recurring is an incident that occurs at one occasion, both scenarios can be positive or negative. The classification local is the description of consequences narrowed within the project, whilst regional could be described as a consequence that could affect the entire city of Gaborone. (Republic of Botswana, 2012)
The Botswana Bureau of Standards provided limits for ambient air quality (BOS 498:2012) and the Environment Protection (Noise) Policy 2007 from South Australia provided limits for
noise pollution that is used in the assessment of consequences. The limits for air quality were acquired after a visit to the Botswana Bureau of Standards in Gaborone and limits for noise pollution was found through research for noise pollution limits on the Internet. Information about the current situation at each alternative site was provided by Vafab Miljö AB and is implemented in the assessment and in the description of baseline environment. Through identification of the consequences have the authors proposed mitigation measures to prevent negative consequences.

4 RESULT AND DISCUSSION

This chapter presents the result of the authors investigations combined with an analysis of the result. Investigations were made regarding the description of the current environmental status of the suggested alternative sites. The chapter also contains an analysis of potential impacts, effects and consequences caused by the transfer- and recycling station. Key findings from the analysis are presented in a summary at the end of this chapter.

4.1 Description of Baseline Environment

This chapter describes the current environment at the three alternative locations for the establishment of the transfer- and recycling station.

Common for all three alternatives are the following conditions:

- the precipitation of about 200-380 millimetres (mm) per year that consist of heavy rain, November through March (figure 13)
- the lowest temperature is estimated to 5 degrees Celsius (figure 14)
- the highest temperature is estimated to 33 degrees Celsius (figure 14) (Mitt resväder, 2014)
Figure 13: Illustrate the precipitation in mm for Gaborone in a year. (Mitt resväder, 2014)

Figure 14: Illustrate the lowest (green) and highest (red) temperature for Gaborone in a year. (Mitt resväder, 2014)
4.1.1 **Old Abattoir**

The Old abattoir (figure 15 and 16) is one of three alternative locations and has an area that is approximately 1.9 hectare (ha). The location is situated 3 km from the city centre and the distance to the landfill at Gamodubu is 33 km. Adjacent to the site is the railway and it passes by on the western side of the location. The plot is owned by the municipality of Gaborone and is in the current situation not in use. There are existing buildings at the Old abattoir and the main building is about 600 square metres (m²) and there are several smaller buildings as well, which all have access to sewerage, power and water. (Lindblom & Westman, 2014)

*Figure 15: Photo of a remaining building at the Old abattoir. (Jensen & Nyberg, 2014, b)*

*Figure 16: Photo showing a part of the site at the Old abattoir. (Weiring, 2013)*
The Old abattoir is located in an industrial area where there are companies that operate in recovering materials. Just outside of the location is an existing road network and connection to the main road A10/Kudumatse. The nearest residential area is approximately 400 metres (m) from the site. It is separated from the site by the main road and commercial plots. The nearest school is located in a distance of about 200 m. Distances to hospitals and churches is more than 5 km. (Lesenyegile, 2014)

As the Old abattoir is located in an industrial area, there is a risk that the soil has suffered from contaminations. The character of the soil is not determined but is estimated to consist of sand (Moroka, 2014). The ground water at the location is situated 50 m below the ground level. The topography is flat and the vegetation consists of grass and bushes. There are also a few trees at the northern and the southern borders. (Lindblom & Westman, 2014)

4.1.2 **Old Landfill**

The Old landfill is another alternative that is considered for the establishment of the transfer- and recycling station and the municipality owns the land (figure 17). The area is covering 4 ha and the site is located 4 km from the city core, 37 km from the landfill at Gamodubu and the distance to the railway is 5 km. Approximately 1 km from the site is: light industrials, commercial centre and material recovery companies. There are no longer existing buildings on the site but it is possible to connect future buildings to water, power and sewer systems to meet the need for utilities. (Lindblom & Westman, 2014)

![Figure 17: Photo of the site the Old landfill. (Jensen & Nyberg, 2014, b)](image)

The incoming traffic is entering from the connecting main road, Tlokweng Road. A school is located 2 km from the Old landfill and in a distance of more than 2 km can a church and a hospital be found. The closest residential is approximately 500 m from the site. (Lesenyegile, 2014) There is a risk that the soil is contaminated due to the closed landfill. The topographical
surroundings are flat except for the landfill itself which was built as a hill. The vegetation is mainly grass with a few trees along the northern and southern borders. Because of the closed landfill is the soil estimated to be a mixture of sandy soil due to the final covering of the landfill (Moroka, 2014). Considering the hydrological conditions, the ground water table can be identified on a depth of 20 m below the surface. (Lindblom & Westman, 2014) In connection to the site runs a stream and in a distance of 2 km can the water reservoir Gaborone dam be found, which provides the city with fresh water. The stream flows in north-east direction, away from the dam. (Lesenyegile, 2014)

### 4.1.3 Kgale View

The Kgale view, also named as Extension 23, is the third alternative location which is owned by the government of Botswana and has an unexploited land of about 5 ha (figure 18). The distance to the centre of the city is 6 km, it is 31 km to the landfill in Gamodubu and the nearest access to the railway is located 5.5 km from the site. There is also a paper collecting company and a can and bottle collecting company within a distance of approximately 12 km. There is a distance of 3 km to the nearest church and 6 km to closest hospital. (Lindblom & Westman, 2014)

![Figure 18: Photo of the alternative site Kgale view. (Jensen & Nyberg, 2014, b)](image)

Power supply, water and sewer system can be accessed since there is residential adjacent to the site and on the opposite side is the Gaborone Technical College located. The site can be entered from the main road, A1, and can be connected to the existing road network. (Lindblom & Westman, 2014)

The topographical conditions are flat and the vegetation consists of a mix of bushes, grass and trees. The soil is estimated to consist of sandy soil (Moroka, 2014). Concerning the
hydrological conditions, the ground water can be found 50 m below the surface. (Lindblom & Westman, 2014)

### 4.2 Zero Alternative

A zero alternative describes the impacts on the surroundings if the proposed project would not be implemented (Hedlund & Kjellander, 2007). This is an important part of the EIA to be able to understand the differences of the consequences with or without the establishment of the transfer- and recycling station. The authors came to the conclusion that the conditions at the sites are alike and the following text is therefore valid for all three alternative locations. The zero alternative is based on the description of the baseline environment that is a part of this study, and assuming that the GTARS-project does not result in the establishment of a transfer- and a recycling station.

A zero alternative could mean that the municipal waste management would continue as today, meaning no changes. There is also no other existing alternative plan for the waste management (Mataela, 2014). The transports to the landfill would continue with vehicles not adapted for remote transportation, which could result in high emissions to the air. The municipality of Gaborone would have reparation costs since the waste collecting vehicles breaks down due to the long trips to the landfill. These damages could also result in investment costs in new collecting vehicles. These investments could require a demand for material use, which in turn may be a burden on natural resources. From another point of view, investments in new vehicles with newer technologies could lower the environmental impacts.

A zero alternative could mean lost opportunities of employment for the citizens that might be offered through the transfer- and recycling station. The material recovery companies could lose their opportunity to develop and grow since the amount of recycled material would not increase. The municipality would not encourage the citizens to change their habits regarding waste handling and recycling, hence, a lack of improvement towards a more sustainable living. It might also reduce the trustworthiness and legitimacy towards the municipality that claims they want to improve the waste management.

The residential in the areas would not risk being affected by diminished air quality, noise and odors from the facilities and an increased traffic density. The traffic situation would be unaltered if the project does not get approved and noise and emissions to the air from the traffic would be at the same level as today. Impacts of air emissions from the collecting vehicles would overall be high and result in a local effect.

The zero alternative would not decrease the use of natural resources since it would not promote the recycling possibilities and the extraction of new resources would continue instead of reuse of materials. The lack of a recycling station would not reduce the amount of waste and the covering of the intended area for the landfill would be faster. Concerning the
environment and the biodiversity would a zero alternative result in an unchanged condition at the alternative sites, therefore, no impacts.

If the transfer- and recycling station would not be established at any of the three alternative locations, the alternate use of the sites would differ. For the Old abattoir would other tender and project ideas be taken into account e.g. commercial use. The Old landfill has no specific future use due to the fact that the closed landfill could be leaking methane gas that can be a risk for any kind of establishments. Kgale would be maintained as a recreational area, no other plan exists. (Lesenyegile, 2014)

4.3 Identification of Impacts and Effects and Assessment of Environmental Consequences at the Alternative Sites

The following assessment regarding the identified aspects first describes the common consequences for all three alternative sites. In case the assessment differed between the sites, are the differences described in subchapters related to the aspects.

The assessed aspects are:

- ground- and surface water
- biodiversity
- noise pollution
- air quality
- soil
- society
- economy

4.3.1 Ground- and Surface Water

An impact from damaged sewer pipes connected to sanitary waste water system could lead to leakage to the ground water. This could result in the effect of dissemination of bacteria and virus throughout the water system and the consequence could be that people catch diseases. This is classified as a moderate, a reversible, a direct, a short term, a non-recurring and a regional consequence. (Förbundet för vattenskyddsföreningarna i Finland rf, 2014)

Received hazardous waste could have an impact on the ground water due to a spread caused by an accident e.g. an explosion or fire. The spread depends on, for instance, the soil condition, the characteristic of the substance and the hydrology. (Djokic´, 2013) Since the soil is estimated to be of sandy character this could result in a spread of hazardous waste due to the permeability. (Andersson-Sköld, Nilsson, Norrman, Rosqvist, & Starzec, 2005) This could result in the effect of ground water pollution and a serious consequence could be that the ground water becomes polluted which would make it unfit for human consumption. (Svanberg, 2007) If hazardous waste would be received at the recycling station it would only
be for intermediate storage before further transportation. The recycling station would only handle a smaller amount of hazardous waste from households, not from industries, and the transfer station would not accept hazardous waste at all. (Mataela, 2014) This is estimated to a moderate, a reversible, a direct, a long term, a non-recurring and a regional consequence.

The ground water table at the site Old abattoir can be found 50 m below the ground level. As there is existing water supply for utilities there is no need for new abstractions of the ground water and therefore, no impact and no consequence on the ground water level. No existing surface water at the site and therefore no risk of flooding. (Lindblom & Westman, 2014)

At the Old landfill the ground water can be found 20 m below the ground level. Utilities concerning water supply exist at the site, meaning no impacts or consequences on the ground water level due to new abstractions of ground water. (Lindblom & Westman, 2014) There has been an identification of surface water, a stream, in connection to the site. (Lesenyegile, 2014) Depending on location of the facility the risk for flooding could vary. If the transfer- and recycling station is to be located on top of the landfill the risk could be reduced. To assess the consequences of flooding it is necessary to determine the exact location of the facility.

The impact on the stream depends on where the transfer- and recycling station is being established. To assess if the stream could be exposed for consequences due to the project, further investigation has to be made when the exact location is determined.

The ground water at Kgale view can be located on a depth of 50 m below the surface. Kgale view has no risk for flooding because of the lack of surface water. (Lindblom & Westman, 2014)

No cumulative impacts are identified for this aspect, therefore no cumulative consequences.

4.3.2 Biodiversity

At all three sites have been visited and the biodiversity has been studied to get an initial overview of the flora and fauna and it mainly contains of: trees, grass and bushes. It is also a habitat for: birds, reptiles, insects and soil organisms. (Jensen & Nyberg, 2014, a) Further investigations should be performed at all three sites to determine whether or not the sites might represent a habitat for protected species. These investigations should also include a thorough identification of the biodiversity at the sites.

The impact can be a change in the environment at the location because of the establishment of the transfer- and recycling station. Furthermore, the effect would appear as an alteration in the habitat for the flora and fauna. The consequence of this effect could be that the flora and fauna vanishes from the site. The assessment of this consequence is moderate, reversible, direct, long term, non-recurring and local. The impacts, effects and consequences are
concentrated to the construction phase. (Naturskyddsföreningen Stockholms län, 2007) Figure 19, 20 and 21 illustrates the biodiversity at the three sites.

No differences have been identified between the location alternatives. No cumulative impacts are identified for this aspect, therefore no cumulative consequences.

Figure 19: The vegetation at the Old abattoir. (Jensen & Nyberg, 2014, a)

Figure 20: The biodiversity at the Old landfill. (Jensen & Nyberg, 2014, a)
4.3.3 Noise Pollution

The transfer- and recycling station can create impacts of noise pollution due to the activities such as: heavy traffic, private costumers, equipment from the facility and delivering and reloading of waste. (Environmental Protection Agency, 2002) The effects of these impacts are noise and the consequences are concentrated to the personnel on the facility and could result in loss of hearing, increased blood pressure and reduced performance ability. Increased blood pressure can lead to further consequences associated with cardiovascular diseases. (Karolinska Institutet, 2014)

Example of equipment that could cause a disturbing noise is when containers are handled at the facility or when the compactor is in use. Further investigation has to be done after deciding what kind of vehicles and machinery will be used at the facility to be able to assess the consequences of the noise pollution. Impacts from noise do also depend on the direction of the wind and this has to be considered when assessing the consequences.

When machinery and vehicles are decided it is important to investigate the level of noise from these sources in order to determine the noise dissemination area. When this is known, it is possible to estimate if the noise would exceed the determined limits.

It is estimated that approximate 60 000 tons of waste per year will be received at the transfer station. (Mataela, 2014) The volume of the loading capacity for outgoing transports from the transfer station is estimated to 28 tons per vehicle and the number of daily outgoing vehicles is approximately calculated as in table 1.
Table 1: A calculation of the estimated number of incoming- and outgoing vehicles.

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<table>
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<tbody>
<tr>
<td><strong>Amount of waste/year</strong></td>
<td>60 000 tons/year</td>
</tr>
<tr>
<td><strong>Loading capacity of collecting vehicles</strong></td>
<td>5 tons</td>
</tr>
<tr>
<td><strong>Loading capacity of remote vehicles</strong></td>
<td>28 tons¹</td>
</tr>
<tr>
<td><strong>Number of public holidays</strong></td>
<td>13 days²</td>
</tr>
<tr>
<td><strong>Number of working days</strong></td>
<td>352 days</td>
</tr>
<tr>
<td><strong>Number of incoming transports/year</strong></td>
<td>60 000/5= 12 000/year</td>
</tr>
<tr>
<td><strong>Number of incoming transports/day</strong></td>
<td>12 000/352= 34/day</td>
</tr>
<tr>
<td><strong>Number of outgoing transport/year</strong></td>
<td>60 000/28= 2 143/year</td>
</tr>
<tr>
<td><strong>Number of outgoing transport/day</strong></td>
<td>2 143/352= 6 transports/day</td>
</tr>
</tbody>
</table>

¹(Lindblom & Westman, 2014)²(Botswana Stock Exchange)

According to the result of the approximate calculation of a total of 40 incoming and outgoing transports related to the transfer station with the additional unknown number of traffic associated with the recycling station. Given this, the authors have determined an increase of the daily noise pollution. However, due to the unknown traffic situation and current noise pollution at all three sites it is problematic to estimate the impacts of the increased noise without further investigations.

Calculations with accurate figures should be done to estimate the loading capacity of the transportation vehicles to determine the exact daily number of traffic at the transfer station and estimate the daily number of customers to the recycling station. This is important to be able to assess the consequences of noise pollution. When this information is known, it is important to compare the result against the determined limits for noise pollutions that are presented in table 2 (appendix 2) (EPA South Australia). The comparison could determine if the limits would be exceeded or not.

Table 2: Limits for noise pollutions. (Government of South Australia, 2014)

<table>
<thead>
<tr>
<th>Land use category</th>
<th>Limit value, day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural living</td>
<td>47 dB(A)</td>
</tr>
<tr>
<td>Residential</td>
<td>52 dB(A)</td>
</tr>
<tr>
<td>Rural industry</td>
<td>57 dB(A)</td>
</tr>
<tr>
<td>Commercial</td>
<td>62 dB(A)</td>
</tr>
<tr>
<td>General industry</td>
<td>65 dB(A)</td>
</tr>
<tr>
<td>Special industry</td>
<td>70 dB(A)</td>
</tr>
</tbody>
</table>

No differences have been identified between the location alternatives. No cumulative impacts are identified for this aspect, therefore no cumulative consequences.
4.3.4 **Air Quality**

To assess the consequences caused by the air emissions from the machinery at the facility, the type of machinery must be known. Therefore, it is necessary to do further investigations in the final EIA. As described in subchapter 4.3.3, it is of importance to determine the loading capacity of the transportation vehicles to be able to estimate the number of daily transport combined with the traffic associated with the recycling station to evaluate the amount of air emissions. An approximate calculation of daily transport can be viewed in table 1, in subchapter 4.3.3. According to the reasoning in subchapter 4.3.3 regarding the total of 40 transports from the transfer station together with the number of traffic from the recycling station the daily air quality can be decreased. However, without further investigations about the current air quality and the traffic situation at all three sites it is not possible to estimate the impacts of the decreased air quality.

Table 3 describes the accepted limits for the most common air pollutants and these has to be considered in the further investigations and not be exceeded neither during the establishment of the station nor the activity.

Traffic queuing at the facility could be a local impact on the air quality and the effect could be diminished air quality due to emissions from vehicles. Consequences might result in health concerns for sensitive individuals. (HRM - Helsingforsregionens miljötjänster) The limits presented in table 3 must not be exceeded. To be able to assess the consequences would further investigations about logistic solutions be required.
### Table 3: Limits for air pollutions determined by Botswana Bureau of Standards (appendix 3). (Botswana Bureau of Standards, 2012)

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Limit value</th>
<th>Averaging period</th>
<th>Permitted exceedences each year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide (CO)</td>
<td>30 000 µg/m³</td>
<td>1 hour</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>10 000 µg/m³</td>
<td>8 hours</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Ozone (O₃)</td>
<td>120 µg/m³</td>
<td>8 hours</td>
<td>25 days averaged over 3 years</td>
</tr>
<tr>
<td>Sulphur dioxide (SO₂)</td>
<td>350 µg/m³</td>
<td>1 hour</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>125 µg/m³</td>
<td>24 hours</td>
<td>3</td>
</tr>
<tr>
<td>Benzene (C₆H₆)</td>
<td>5 µg/m³</td>
<td>1 year</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO₂)</td>
<td>200 µg/m³</td>
<td>1 hour</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>40 µg/m³</td>
<td>1 year</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Particulate matter (PM₁₀)</td>
<td>200 µg/m³</td>
<td>monthly</td>
<td>Not applicable</td>
</tr>
<tr>
<td></td>
<td>100 µg/m³</td>
<td>1 year</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>0.5 µg/m³</td>
<td>1 year</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Impacts from dust due to the activity could occur when waste is delivered and unloaded at the transfer- and recycling station and also from cleaning activities such as sweeping. The effect would be that the employee’s inhales the dust and depending on how often could the consequences varies. Acute consequence from occasionally exposure can be irritated mucous and upper respiratory tract (Dagens arbete). This consequence is classified as moderate, reversible, direct, short term, recurring and on a local level.

No differences have been identified between the location alternatives. No cumulative impacts are identified for this aspect, therefore no cumulative consequences.

#### 4.3.5 Soil

One of the first steps when establishing the transfer- and recycling station is to construct an impervious surface, depending of what kind of material being used, it has different consequences to the soil. In this assessment it is assumed that the facility would be built on an impervious surface made of asphalt which not contains coal tar. Referring to this assumption, the impact from the construction of the impervious surface with asphalt could lead to the effect that soil organisms are harmed because of the heat and the constituents of the asphalt. The consequence could be that these organisms vanish from the location. This is classified as a moderate, a reversible, a direct, a short term, a non-recurring and a local consequence.
An impact on the soil can be that storm water runoff could transfer dangerous compounds from the facility to the surrounding soil. The effect of this impact could be that it might harm sensitive organisms in the soil and the vegetation. (Miljöförvaltningen i Stockholm, 2003) To assess the consequence must the characterisation of the dangerous compound first be determined.

An impact from damaged sewer pipes can lead to leakage to the soil, the effect of the leakage could be that the soil gets contaminated from bacteria and virus in the sewage water and the spread of diseases since the virus and bacteria might be pathogenic. The consequences could be that people becomes ill. (Förbundet för vattenskyddsföreningarna i Finland rf, 2014) It is estimated to a moderate, a reversible, a direct, a short term, a non-recurring and a local consequence.

If dangerous compounds from hazardous waste run off with storm water and penetrates the soil in combination with damage on the sewer pipes the impact could result in a cocktail effect. According to the Förbundet för vattenskyddsföreningarna i Finland (2014) this effect could contaminate the soil with bacteria and virus from the sewer and dangerous compounds from hazardous waste and also cause a spread of diseases. The authors of the thesis described the cumulative consequences as a harm of the organisms in the soil. The cumulative consequence is assessed as moderate, reversible, direct, short term, non-recurring and on a local level.

There is a risk that the soil might be contaminated at the Old abattoir from previous industrial activities on the site. (Lindblom & Westman, 2014) The effect could be that existing contaminations are being spread during the construction phase (Värmö kommun). According to Naturvårdsverket and Boverket’s rapport (2006) this could cause negative health effects for the workers and a spread of the pollution to the surrounding soil and the air. Furthermore, this could also affect people’s health and well-being in the nearby surroundings. It is of highest importance that this feasibility study is being complemented with further investigations regarding the possible pollution in the ground to be able to assess the consequences. Thorough investigations should be performed to determine the type of the soil. The character of the soil must be known since different types of soil vary in permeability.

At the Old landfill there is a risk that the soil might be contaminated due to the closed landfill and there is a need for further investigations to determine the existing soil pollutions. (Lindblom & Westman, 2014) The risk of potential consequences due to possible contamination of the soil in subchapter 4.3.5.1 applies. Investigations that would enable a final result regarding the soil and its permeability should be performed, combined with the investigations to determine possible contaminations.

The difference with Kgale view compared to the Old abattoir and the Old landfill is that the site is located on unexploited land which could mean that there is no exciting contamination of the soil. Further investigations have to be performed to confirm this statement. It is necessary to further investigate the soil to determine the permeability and it could be
beneficial to arrange this at the same time as the investigations regarding the possible soil contaminated.

4.3.6 **Society**

One impact on the society during the construction phase of the transfer- and recycling station could be it creates possibilities of employment. Likewise, it would create employment possibilities when the facility is ready to take in use. The effect of these impacts could be that the citizens are being employed which result in improved standards of living for the employees as a consequence. (Suneetha & Jain, 2009) These impacts are classified as a moderate, a reversible, a direct, a short term, a recurring and a regional consequence.

A second effect from the impact of implementing a transfer- and recycling station could be that the municipality might strengthen their legitimacy towards the citizens because of a more efficient waste management. The consequence could create a higher credibility among the people. (Avfall Sverige AB, 2013) The classification of this consequence is estimated to a moderate, a reversible, a direct, a short term, a non-recurring and on a regional level.

A third impact through the recycling station could result in the possibility that the citizens become more involved in the waste management because of the own responsibility in separating their waste at the station. (Environmental Protection Agency, 2002) This could have the effect of an increased knowledge about the importance about a well-functioning waste treatment and therefore could the consequence result in citizens with a new feeling of responsibility for the environment. This is assessed as a moderate, a reversible, a direct, a long term, a non-recurring and a regional consequence.

A fourth impact could be a reformed treatment of hazardous waste because of the new facility and the effect of this could be that hazardous waste is being treated. Hence, the consequence could result in avoidance of improper dispose of hazardous waste and therefore protecting the environment and the society against contact with harmful compounds (Dong, Rotich, & Zhao, 2005) The consequence due to this impact is classified to be significant, reversible, direct, short term, recurring and on a local level.

A fifth impact could be to provide the society with an opportunity to educate the citizens regarding waste management and recycling. Youths can be offered an opportunity to learn about the environment in an early stage of life. The effect of this would be that citizens get educated in this field and the consequence would be a higher awareness of the benefits with recycling and reusing of materials. This consequence is estimated as moderate, reversible, direct, short term, recurring and on a regional level.
No differences have been identified between the location alternatives. No cumulative impacts are identified for this aspect, therefore no cumulative consequences.

### 4.3.7 Economy

The transfer- and recycling station could have an impact on the economy because of fewer mileages to drive for the collecting vehicles. The effect of this matter could be that the vehicles do not break down as often and could result in saved investments for the municipality as a consequence. (Environmental Protection Agency, 2002) The assessment of this consequence is moderate, reversible, direct, short term, recurring and on a regional level.

The project could have an impact on the economy through the job opportunities in the municipality since it is creating employments, both during the construction phase and whilst the transfer- and recycling station is in use. The effect of this impact is the chance for the field of waste management to develop and grow and it could lead to a thriving economy as a consequence. (Goldman & Ogishi, 2001) This consequence is classified to be moderate, reversible, direct, long term, recurring and on a regional level.

An impact from the transfer- and recycling station could be the contribution of disposing less waste at the landfill in Gamodubu due to the possibilities to recycle materials and understanding the value of recycling. The effect of this could be a reduced quantity of waste disposed on the landfill and the consequence could be economic benefits due to the recycled material and the available area at the landfill would not be depleted as rapidly. (Goldman & Ogishi, 2001) This consequences are estimated to be moderate, reversible, direct, short term, recurring and on a regional level.

The Old abattoir has remaining buildings from previous activity that could result in economic benefits since there is a possibility to reuse the buildings. The impact in this matter could be the reuse of facilities and the effect could be that no new material has to be used. Investments could be saved for the municipality as a consequence since the need to build new facilities declines. (Environmental Protection Agency, 2002) The assessment of this consequence is moderate, reversible, direct, short term, non-recurring and on a regional level.

Aside from this matter, has no other differences been identified between the site alternatives, see the description in subchapter 4.3.7. No cumulative impacts are identified for this aspect, therefore no cumulative consequences.

### 4.3.8 Uncertainties

Due to the absence of limits for noise pollution developed by Botswana Bureau of Standards, were the authors required to implement guidelines from a country with similar conditions to Botswana. Therefore, have limits from the Environment Protection Authority South Australia been used.
The authors made an assumption regarding the choice of impervious surface during the establishment of the facility although a final decision not yet has been made. Furthermore, did the authors also a hypothesis concerning that the asphalt would not contain coal tar, since the negative consequences on the environment is previously known.

Regarding the calculation in subchapter 4.3.3 have the authors implemented information that might contain error margins due to the fact that it is not determined what type of outgoing vehicles that will be used.

Since only estimations are made regarding the soil it would be necessary to perform thorough geological surveys to define the soil at all three alternative sites. Due to the lack of information regarding the biodiversity at the sites, the authors are not able to state neither an exact presentation of the species nor the possibility of existing protected species.

4.4 Archeological Impact Assessment

The three alternative sites have been evaluated by an archeologist from the Department of National Museum and Monuments in Gaborone and it has been constituted that no findings have been discovered on the sites. Former findings have been made at Gaborone dam, 2 km from the Old landfill. However, the archeologist made the conclusion that these findings should not affect future activities at the site due to the fact that it is a closed landfill. (Moroka, 2014)

4.5 Summary of Consequences

The identified consequences are summarised in table 4 to visualise the outcome of the assessments. The negative value represents the negative consequences, meanwhile the positive value represents the positive consequences caused by the transfer- and recycling station. Table 5 describes how the classifications are valued compared to the primary classifications insignificant-, moderate- and significant consequence. In the column “Common Conditions” are the summaries of the common conditions for each site represented and in those cases where the conditions differed are individual assessments performed. The designation not available (N/A) is used since assessment in these aspects could not be performed due to the need of additional information and further investigations. As shown in table 4 are there no differences among the estimated consequences at the sites.
Table 4: A chart of the identified positive- and negative consequences.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Old abattoir</th>
<th>Old landfill</th>
<th>Kgale view</th>
<th>Common conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground- and surface water</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
</tr>
<tr>
<td>Noise pollution</td>
<td>N/A*</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Air quality</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
<td>2 -</td>
</tr>
<tr>
<td>Soil</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>2 -</td>
</tr>
<tr>
<td>Society</td>
<td>2 +/3 +</td>
<td>2 +/3 +</td>
<td>2 +/3 +</td>
<td>2 +/3 +</td>
</tr>
<tr>
<td>Economy</td>
<td>2 +</td>
<td>2 +</td>
<td>2 +</td>
<td>2 +</td>
</tr>
<tr>
<td>Total negative</td>
<td>6 -</td>
<td>6 -</td>
<td>6 -</td>
<td></td>
</tr>
<tr>
<td>Total positive</td>
<td>7 +</td>
<td>7 +</td>
<td>7 +</td>
<td></td>
</tr>
</tbody>
</table>

* Not available

Table 5: Describes the primary classification of the consequences.

<table>
<thead>
<tr>
<th>Classification categories</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insignificant consequence</td>
<td>1</td>
</tr>
<tr>
<td>Moderate consequence</td>
<td>2</td>
</tr>
<tr>
<td>Significant consequence</td>
<td>3</td>
</tr>
</tbody>
</table>

4.6 Analysis of Alternatives

The location of the three alternative sites in the city differ and therefore also the distance to the landfill in Gamodubu. Closest to the landfill is Kgale view within a distance of 31 km, the Old abattoir is 33 km away and the Old landfill is located 37 km away. The most central alternative location is the Old abattoir with 3 km from the city core, meanwhile the Old landfill is 4 km away and Kgale view is located in a distance of 6 km. It could be beneficial to choose the most central location to reduce the mileages and the wear and tear for the waste collecting vehicles. It is also important to consider the location when it comes to the proximity to companies in the waste business. The Old abattoir and Old landfill is both located nearby recovery companies and these companies could benefit from having a recycling station close to their business.

In relation to transportation options is the Old abattoir adjacent to the railway which could be connected to the facility. Benefits of railway usage are a decreased impact on the environment and humans’ well-being because of a lowered pollution from vehicles operated on non-renewable fuels. The other two locations do not have the same opportunity since the distance to the railway is too far. All three locations have a good connection to the road network; however, the adjacent roads must be optimised and adapted for heavy traffic. The Old abattoir and Kgale view has a near connection to the main road A10/Kudumatse respective A1, compared to the Old landfill which does not have a direct connection to a main road.
As previously mentioned, there is a need for further investigations to determine the level of noise and the diminished air quality caused by the traffic. Nevertheless, the authors can conclude that the increase of traffic flow will locally increase the air pollutions and the level of noise. The adjacent college and the residential at Kgale view could be affected by the consequences of intensified noise. It is therefore important to consider this aspect when the location is chosen since the impacts would be greater in a residential area than in an industrial area that has noise-causing activities.

Air emissions from the traffic could affect the surroundings because of diminished air quality. The Old abattoir is in comparison to Kgale view located in an industrial area with longer distances to residential and school and therefore would the impacts be lower. The Old landfill is the most advantageous location in terms of impacts on nearby facilities and residential sensitive to disturbing activities, the nearest resident is located on a distance of 500 m. Due to the long distances from the three sites to the nearest hospital should the transfer- and recycling station not contribute with impacts on this kind of object of protection.

When decision is made regarding the establishment of the transfer- and recycling station, it is important to consider the possibilities for future expansion. The need for expansion concerns the traffic situation if the number of costumers increases and also the increasing amount of waste due to the growth of the city. If the amount of recycled waste increases it is beneficial to have the possibility to expand the activity with, for example an extended number of fractions to meet the need. In this matter would the most beneficial site be Kgale view with an area of 5 ha and the absence of other facilities that could impede future expansion. The Old landfill has an area of total 4 ha but the suitable area varies depending on where the transfer- and recycling station would be established. It could be beneficial if the decision-makers are planning for future expansions early in the process to be able to determine the total necessary size of the site. If the needed size is known this could mean that the 1.9 ha at the Old abattoir would be enough.

Regarding the ground water, one of the differences between the sites is the depth of the ground water and at the Old landfill it can be found 20 m below the surface. The other two alternatives have a depth of 50 m. From this the authors could make the conclusion of a lower risk for ground water contamination in case of an accident with, for instance, hazardous waste at the Old abattoir and Kgale view compared to the Old landfill.

Due to the fact that the Old landfill is a closed landfill, is there an existing risk that the water might be contaminated from previous disposed waste. Among the three sites surface water could only be found at the Old landfill with its connection to a stream, which similar to the ground water might suffer an existing risk of contamination. The authors have made the estimation that the transfer- and recycling station should not have a direct impact on the surface water because new contaminations should not emerge. The closed landfill could probably have a higher impact on the water than the transfer- and recycling station. The risk of impacts from the intended facility is rather during the construction phase because of the spread of potential existing soil contaminations. Furthermore, can the water reservoir
Gaborone dam be found 2 km from the Old landfill and due to the distance have the authors estimated no direct impact on the dam.

The plot at the Old abattoir has remaining buildings from previous activity and this could be both positive and negative. It is positive from an economic point of view since no new investments are necessary if it is possible to reuse the remaining buildings, which also provide an opportunity to save construction materials. On the other hand, it could be negative because it could be difficult to adjust the facilities according to the needs. Due to the fact that there is no other identified difference in impacts on the economy has it not been possible to conduct further analysis between the sites.

The identified consequences regarding the soil could occur on all three alternative sites and the only difference between the locations is the unexploited land at Kgale view. Decisions must be made if it is better to use, and sanitise, already used land or if it considered more beneficial to use unexploited land. If decided to make the establishment on used land the Old abattoir could be a better option than the Old landfill since it most likely is easier to sanitise the soil at the Old abattoir than on a closed landfill.

Impacts on the biodiversity are similar on all sites since the authors, after investigations, have determined that there is no significant difference in the flora and fauna between.

Regardless the choice of location the impacts from the transfer- and recycling station on the society should remains indifferent. Education opportunities concerning recycling and reusing are equal for the three alternatives, but as the Old abattoir and Kgale view is located nearby a school and a college these sites could be more suitable from an educational point of view.

4.7 **Recommended Location**

To determine the most suitable location for the transfer- and recycling station the result from the analysis has been summarised in table 6. The classifications 1-3 show how the authors have valued the different aspects at the three locations according to the analysis. The lowest number is the highest rated location.
Table 6: Final recommendation of alternative sites for the transfer- and recycling station.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Old abattoir (OA)</th>
<th>Old landfill (OL)</th>
<th>Kgale view (KV)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to landfill</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>Difference of 2 km between KV and OA</td>
</tr>
<tr>
<td>Transport</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>OA: Access to both railway and main road</td>
</tr>
<tr>
<td>Ground water</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>No difference between the OA and KV</td>
</tr>
<tr>
<td>Surface water</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>No difference between the OA and KV</td>
</tr>
<tr>
<td>Expansion possibilities</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>The needed size would determine if the area of OA could be enough</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>No difference between the alternatives</td>
</tr>
<tr>
<td>Noise pollution</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Air quality</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Soil</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>Dependent on decisions about land use</td>
</tr>
<tr>
<td>Society (education)</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Economy</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>No existing buildings at OL and KV</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16</strong></td>
<td><strong>24</strong></td>
<td><strong>19</strong></td>
<td></td>
</tr>
</tbody>
</table>

Based on the result presented here the authors concluded that the Old abattoir is the location that is most suitable for the construction of the transfer- and recycling station because of the more beneficial features compared to the other alternatives. However, the size of the area might not be the most suitable to meet the need for future expansion. On the other hand, this circumstance does not have to be a limitation since it can result in an establishment of a second transfer- and recycling station. That could result in positive outcomes for the citizens providing a higher availability and a decentralise waste management. If the transfer- and recycling station would be established at the Old abattoir it would not further degrade the landscape since it is located in an industrial area.

### 4.8 Mitigation Measures

This chapter focused on suggested mitigation measures for the predicted negative consequences that are described in subchapter 4.3. With the restriction that this is a feasibility study is the recommended location only a suggestion based on the available information at this phase of the GTARS-project, moreover, not a final decision. Therefore, the authors decided to propose mitigation measures applicable on all three alternative sites.
To prevent damages on the sanitary waste water system due to poor conditions on the pipes, the authors are recommending that the sewer pipes should be inspected during the construction phase and be replaced if necessary. This mitigation measure is to prevent the spread of bacteria and virus throughout the sewer system. After the inspection it would be beneficial to document the status of the sewer system for future reparation- and replacement plan. In the event that an accident should occur, it would be required to perform samplings on the drinking- and ground water. Additional, it is important to implement recurring routines for samplings of the drinking water.

Sewage- and storm water must not be contaminated from the dangerous compounds that might be handled at the facility. In case of accident equipment for sanitation could be used to avoid spread of dangerous compounds to human and to environment throughout the water system. To avoid impacts could drain wells be equipped with filter for absorption to be able to separate the compounds from the water. The impervious surface at the facility can be designed with a gradient towards the drain well where an oil separator can be installed, which will protect the environment from oil contamination. The oil separator demands maintenance and draining regularly which is important to consider if selecting this mitigation measure (Tekniska förvaltningen, 2006). The facility can also be equipped with removable covers for the wells that can be of use in case of accidents with hazardous waste. The cover will prevent the substance to reach the water in the drain wells and enable absorption of the leaking substances.

Mitigation measures to prevent noise pollution and odours from the transfer- and recycling station are important to consider. Regarding the design of the facility decisions must be made whether it should be enclosed or not. An enclosed facility can prevent noise pollution and odours to surrounding areas, and also prevent waste from being spread. If the facility are enclosed it could be beneficial to provide walls and roof with materials that can absorb the sound and thereby protect both the personnel and customers. The buildings can also be positioned with the entrance turned away from the surroundings sensitive for noise (Environmental Protection Agency, 2002). On the other hand, it could increase the level of noise inside the facility which would demand additional mitigation measures to protect the staff. To prevent the impact of noise on the employees containers and compacters should be regularly lubricated and maintained (Avfall Sverige AB, 2013). Furthermore, the personnel could be protected from consequences caused by noise if it is possible to implement regulations to provide guidelines in the protection of the employees from harm. For instance hearing protection could be mandatory.

To be able to take mitigation measures against noise it would be of value to consider the machinery operating at the facility and how the waste will be handled at the station. Residential and other sensitive facilities adjacent to the transfer- and recycling station can be protected against the noise pollution by constructing noise barriers and also plant a vegetation that can absorb the noise. Regarding the containers at the recycling station could it be possible to put rubber mats that would lower the noise. (Avfall Sverige AB, 2013)
Noise limits must not be exceeded and to verify it is necessary to conduct noise measurements on a regularly basis. These measurements should be performed both indoors and outdoors.

Mitigation measures to prevent air pollution from the traffic are of highest importance to consider during the planning phase. Emissions to air from activities at the transfer- and recycling station can occur from dust, traffic and operations on unpaved surfaces. To avoid dust can cleaning activities be combined with watering of the surface. A well-planned logistic solution with designated traffic rules and pavement markings can prevent traffic-queuing and furthermore, prohibit idling at the facility can be proper solutions (Environmental Protection Agency, 2002). Transportations can be planned after the daily traffic situation which could avoid traffic congestions on the connecting road network and therefore lower the impacts from air pollution.

When decisions are being made regarding the machinery it is important to consider the limits for ambient air quality by selecting vehicles with newer technology to lower the consequences. To verify that the limits for air quality not exceeds, it is necessary to implement routines for air measurements. A proper system for ventilation could be installed to protect the personnel against air pollution and employees should also be instructed to use masks in dusty work environments.

Before the construction of the facility investigations should be performed to determine whether or not the soil has existing contaminations. Results from this investigation would define if the soil requires decontamination and appropriate methods could be applied. This measure could reduce the risk of contaminations being spread during the construction and furthermore reduce the impacts on the surroundings.

Preventions against impacts from hazardous waste should be considered when designing the transfer and recycling station. This regards the storage area which can be an enclosed and immersed space to, for instance, prevent leakage of dangerous compounds. It would also be important to implement routines and procedures for the handling of chemicals and to keep records over received chemicals.

For the safety at the transfer- and recycling station it is of high importance to create a plan for emergencies and to have the right equipment, likewise, should safety routines be implemented. The routines and the emergency plan should be practiced regularly by the employees. Emergencies and incidents should also be documented to prevent it from recurring and for the possibility to perform follow-ups.

Mitigation measures against burglary, theft and scavengers could be to hire security guards that operate the facility 24 hours a day.
4.9 Key Findings

This thesis is a feasibility study which has been conducted in an early phase in the GTARS-project and because of this have many important decisions yet not been made. The purpose for the feasibility study is to provide the final EIA with necessary information to identify where it would of importance to perform further investigations and to identify in which aspects decisions have to be made to proceed with the project.

4.9.1 Motivations for the recommended location

According to the result of the summary of consequences are there no differences between the alternative sites, yet did the analysis indicate that the location at the Old abattoir would be most suitable. Because of the comparison in the analysis between all three sites the authors have distinguished advantages and disadvantages in the identified aspects.

The Old abattoirs central location in the city, the nearby located recovery companies and the accessibility to the railway are the main reason for this recommendation. The location facilitates access to the transfer- and recycling station for waste collecting vehicles, customers and for people visiting the station for educational purposes. The recovering companies nearby the Old abattoir could benefit from having the transfer- and recycling station closely connected since it could create a growing market for recyclables. Dong et al. (2005) states that manufacturing companies would benefit from purchase recyclables instead of raw material since it would be more cost effective.

Common for all three sites are that the adjacent road network needs to be adapted to heavy traffic. What distinguishes the Old abattoir in this particular matter is the possibility to connect the site with the main road and the ability to choose way of transportation, either by road or rail. The main road also constitutes as a barrier between the residential area, the school and the intended activity that could minimise the spread of noise.

The Old abattoir is located in an industrial area and therefore have the authors assessed that the increased level of noise pollution would not disturb the surrounding as much as in an area without similar activities. The construction and the activity of the transfer- and recycling would be more noticeable in a residential area.

The risk of consequences on the ground water would be low at this site because of the depth to the ground water. Lack of surface water is also a positive aspect.

Due to the previous activity at the Old abattoir are there remaining buildings and these would be possible to reuse which could save investment costs. Furthermore, it would provide an opportunity to sanitise potential contaminated soil. That would be beneficial for the environment since the project would not exploit virgin land rather decontaminate used soil.

Even though the area needed for the transfer- and recycling station has not yet been determined, the authors have evaluated that the area at the Old abattoir would be sufficiently large for the activity, even regarding possibilities for future expansion. If it in the future
would be necessary to expand the activity more than sufficient for this location have the authors made the conclusion that it could be more beneficial to establish a second transfer- and recycling station to meet the need. A second establishment can result in an improved availability for the public because of the shorter distance, which could encourage the will to recycle. Moreover, would the consequences from the first facility not be concentrated to one site instead it would be divided into two areas.

4.9.2 Discussion concerning the research

The result of this thesis has identified the possible impacts caused by the transfer- and recycling station in Gaborone and also in what aspects these impacts could occur. The aspects are: ground- and surface water, biodiversity, noise pollution, air quality, soil, society and economy. Based on the detected impacts the authors have predicted and assessed consequences and through this assessment has mitigation measures been formed.

Noise pollution, air quality and soil are aspects not possible to completely assess since there are needs for further investigations before a correct assessment can be conducted. Nevertheless, the authors have made approximate calculations based on the existing information to identify possible impacts of noise and changes in air quality caused by the activity at the transfer- and recycling station. Since the numbers are estimations and because many decisions yet not have been made are the authors not able to determine the absolute consequences from these aspects.

Ground- and surface water could suffer from impacts of damaged sewer pipes and from the spread of hazardous waste at the transfer- and recycling station. The consequences of this are that people could become ill and the spread of hazardous waste could make the ground water unusable.

The station would be built on an impervious surface and claim a large area of land and this would lead to the local impact of a changed habitat for biodiversity and the assessed consequence could be the disappearance of the flora and fauna from the site.

Soil could be affected from impacts regarding damage on sewer pipes which could spread virus and bacteria throughout the soil with the consequence that people can caught diseases. This is the only aspect where the authors assessed a potential cumulative impact. This could be possible if damages on sewer pipes happen simultaneously as storm water brings hazardous waste into the soil. The assessed cumulative consequence is that soil organisms are harmed.

Identified impacts regarding the aspect society could be that the municipality establish the transfer- and recycling station and creates opportunities of employment for the citizens. The consequence of this could be enhanced credibility for the municipality because of the pursuit towards a more efficient waste management. Moreover, the job opportunities could enhance the standard of living for the employees. Another impact due to the establishment of the
activity could result in the consequence of higher awareness of the importance of recycling and also about the environmental benefits that follows.

The economy of the municipality could be affected by the establishment of the transfer- and recycling station because of the reduced mileages for waste collecting vehicles. This results in the consequence of saved investment costs because of a more efficient waste management. Moreover, the establishment and the creation of job opportunities could have an impact on the economy which as a consequence could make it possible for the market of recyclables to develop.

All negative consequences can according to the authors be prevented through the proposed mitigation measures. When the authors formed the measures was the focus to suggest measures suitable for all three alternative sites. The reason why general measures are recommended is to avoid limiting the decision regarding choice of location. The authors’ intention of the chapter representing the result is only to recommend the most suitable location and to provide the final EIA with information to enable a final decision. The authors considered the described measures to be realistic and could be applicable at all alternative sites. It would also be beneficial to include these in an early phase of the GTARS-project to avoid unnecessary impacts on humans’ well-being and on the environment.

4.9.3 Other studies

In the literature study have the authors investigated the purpose and the functionality of a transfer- and recycling station. The result from this study is consistent with the authors own presumption of how the transfer- and recycling station should be implemented. The authors consider that the description of the facility would be possible to establish based on the prevailing conditions in Gaborone, Botswana. The reason why GCC wants to establish a transfer station corresponds with the main purpose of the station described in the literature study which is to improve the efficiency of the waste management and to make it more cost effective. Moreover, would the description of the recycling station also be suitable according to the situation in Gaborone and for the purpose with the GTARS-project. As the literature study explains, the purpose of a recycling station is to facilitate the municipality’s obligation to collect waste in a sustainable way and the authors believe that this purpose could be fulfilled if the GCC would establish the recycling station. Furthermore, GCC has realised the value of recovering and reusing of waste and the possibility to create an income from the recyclable’s business. The ambition of GCC, which also agrees with the literature study, is to improve the recycling and reuse of waste to be able to reduce the amount that is being disposed at the landfill in Gamodubu. According to Christensen, Lu, Wang, Wu and Zhao (2010) it is important to identify alternative solutions instead of only disposing the waste at landfills since it could be difficult to find new disposing sites when the previous is closed.

According to the demands described in the literature study for a transfer- and recycling station the Old abattoir would fulfil these regarding e.g.: the localisation, the accessibility, the
design and the possibilities for future expansion. The authors have not been able to distinguish controversies that would contradict the result of the feasibility study.

Based on the literature study, the presented result and the mentioned above reasoning do the authors consider the location Old abattoir as a reasonable choice for Gaborone and GCC in the endeavour to move towards a sustainable society.

5 CONCLUSIONS

This bachelor thesis is based on the cooperation between Västerås City, Vafab Miljö AB in Sweden and GCC in Gaborone, Botswana. The thesis investigated the possibility to establish a waste transfer- and recycling station in Gaborone and aims to support the EIA that has to be conducted before the station can be constructed. The feasibility study provides the EIA with information about possible impacts, effects and consequences of the station at three suggested sites. It also identifies the aspects that would require further investigation before the construction.

The feasibility study also presents a literature study regarding the purpose and the functionality of an EIA, a transfer station and a recycling station. The main focus of the feasibility study has been to: perform field studies, identify impacts and effects, assess environmental consequences, analyse alternative locations, propose mitigation measures and recommend a location.

The identified aspects that are evaluated in the feasibility study were chosen based on environmental impacts that a transfer- and recycling station could cause. The detected aspects are:

- ground- and surface water
- biodiversity
- noise pollution
- air quality
- soil
- society
- economy

This thesis is based on specific research question regarding the potential environmental impacts and consequences caused by the transfer- and recycling station at the suggested alternative sites. Moreover, how the identified negative consequences could be prevented and also to recommend a suitable site.
The project has impacts in many aspects and therefore many consequences, not only negative but also positive for the environment, the society and the economy. Positive impacts of the establishment of the station could be it creates job opportunities and result in positive consequences such as an improved standard of living and awareness about recycling of materials. The economy could also be affected with positive consequences because the business of recycling could grow and the field of waste management can develop. Noise pollution and air quality are two aspects associated with negative consequences and these are assessed to have the biggest impacts on human’s well-being and on the environment due to the activity at the transfer- and recycling station. Mitigation measures proposed to prevent the consequences are to consider the design of the facility and to perform noise- and air measurement regularly to ensure that determined limits does not exceed.

Based on the result from the feasibility study have the authors made the conclusion that the most suitable location for the establishment of the transfer- and recycling station would be at the Old abattoir. The reason is because this site had the most beneficial qualities regarding the possibility to connect with infrastructure and the localisation. Furthermore, it would not affect the surrounding landscape negative since the Old abattoir is located in an industrial area.

6 RECOMMENDATIONS FOR FURTHER STUDIES

Due to the fact that the project is still in the developing phase, there are many decisions yet to be made. Decisions regarding the design of the facility and the operating machinery have to be known to assess the consequences. The following points are in the need for further investigations in the identified aspects regarding:

- the exact location of the stream connected to the Old landfill
- the assessment of consequences caused by noise pollutants from the operating machinery and the vehicles at the facility
- calculations concerning the loading capacity of the daily outgoing transports have to be made in order to determine the number of transports and therefore be able to assess the consequences of noise- and air pollutants
- vehicles and machinery operating at the facility have to be known to estimate the noise level, the air emissions and the dissemination area
- the identification of potential soil pollutants at the Old landfill and the Old abattoir
- whether or not the site at Kgale view has no existing contaminations
- the soil at all three alternative sites
- the presence of protected species and a detailed identification of the biodiversity at the sites
In further studies would this additional research be of interest in the final EIA to assess the impacts caused by the transfer- and recycling station and create a better understanding concerning the consequences on human's well-being and on the environment. The authors wish that the final EIA would support decisions beneficial for the environment. Moreover, the authors hope that the EIA will create an understanding of the importance of recycling and reuse of materials.
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