5

Development of Park City

Viktor Berglund, Amanda Hedenborg, Ariana Kubart, Magdalena Mähler, Karin Nilsson & Chanette Viklander
at the Department of Physical Geography, Stockholm University

Sammanfattning

Expansionen av Arlanda ger ett större behov av hotell, kontor, affärer och inte minst parkeringsmöjligheter. Tillgängligheten till Arlandas centrala delar så som terminaler och Sky City, från parkering i Benstocken-området gör den till en utmärkt plats för *Park City*. Swedavias vision för *Park City* är att den ska bli Arlandas entré. Förutom parkeringsmöjligheter ska här också finnas utrymme för handel och service inom ett grönskande parklandskap. Området ska innehålla både små och stora parker med sammanhängande parkstråk. Dem gröna områdena kommer att komplettera dem hårdgjorda ytor som anläggs och skapar ett ekologiskt hållbart landskap. Miljökonsekvensbeskrivningen kommer att beskriva två alternativ för den möjliga utvecklingen av *Park City*.

Alternativ 1 föreslår byggnader med kombinerade lokaler och tjänster med focus på hållbarhet. Närmare halva området kommer att vara dedikerat till gröna områden för att bl.a. attrahera besökare och anställda till att röra sig i området och öka rekreationen, öka den biologiska mångfalden samt minimera oönskade effekter såsom översvämning, buller och luftföroreningar. Samtidigt kommer det att finnas 38 000 parkeringsplatser för att tillgodo se de ökade behovet. Området kommer att innehålla flera implementeringar för att minska de negativa effekterna av utvecklingen och för att uppnå visionen om ett hållbart samhälle.

Alternativ 2 kommer att fokusera på att maximera och effektivisera parkeringsmöjligheterna i Benstockenområdet. Detta ska även kombineras med lokaler för kontor, butiker samt hotell och konferens. Andelen gröna ytor kommer vara hälften så stor som i alternativ 1. De mest signifikanta negativa effekterna av *Park City* kommer vara luftföroreningar, speciellt i Alternativ 2, pga. ökad trafik

Vi rekommenderar alternativ 1 som har flest positiva och minst negativa effekter på miljön samt är i linje med Swedavias vision för framtida *Park City*. Alternativ 1 kommer att tillhandahålla en större diversitet av tjänster, bättre möjligheter till rekreation och möjlighet till att öka biologisk mångfald.

Vid utvecklingen av *Park City* kommer alla berörda miljöaspekter att påverkas mer eller mindre negativt oberoende alternativ. Nyttjandet av *Park City* kommer att leda till flera positiva effekter bl.a. elproduktion ifrån solceller, tillgängligheten till grönytor för rekreation och fornminnen som finns i området.

För att minimera vissa oönskade effekter på människa och miljö kan flera åtgärder göras ex. rening av luft, vatten och mark, begränsning av människans nyttjande av gröna ytor, förändrat beteende och planerad placering av vegetation.

Vi hoppas att *Park City* kommer att vara en levande och social miljö som inspirerar till hållbart samhälle

Non-technical summary

As Arlanda growths, so increases the need of connected facilities, such as hotels, offices, shops and parking places. These should be easy to reach from the terminals and Sky City, airport's central part. The "Benstocken" area is ideally located for such development and Swedavia's vision is to construct *Park City* there. This new airport city district will combine diverse services with greenery, and is now in an early planning phase. This environmental impact assessment describes and compares two alternatives of possible development of the future *Park City.*

Alternative 1 suggests building combination of the facilities and services. Almost half of the area should remain green which would, together with innovative urban planning, attract visitors to longer stays. In contrast, Alternative 2 focuses to increase parking possibilities to maximum, completed by several hotels and business facilities. The amount of green would be reduced to one fifth of the area.

The construction of *Park City* will bring diverse negative consequences for all targeted environmental aspects. In contrast, several positive effects can be expected during the operation, such as better access to greenery and cultural sites or production of energy.

The most significant negative effects during operation would be caused by increased emissions by increased car traffic, especially in Alternative 2.

For that reason, we recommend the more environmentally friendly Alternative 1 that would provide higher diversity of services and better possibilities for recreation.

We suggest diverse mitigation measures to decrease the negative impacts to the large possible extent, as well as to enhance benefits of the positive ones. These are often connected to use of modern technologies in the constructions.

We hope that *Park City* can become a lively and enjoyable part of the airport and serve as positive example for sustainable urban development elsewhere.

Table of contents

5.1 Introduction

5.1.1 Background

Within 50 years the aim for Arlanda airport is to have the capacity of 70 million passengers. In the moment, 50 % of the visitors arrive to Arlanda airport by car. Such increase in airport's capacity affects then directly the capacity of parking availability. Therefore, car parks in the area need to increase in amount and efficiency. In the Arlanda airport area there is a section dedicated mostly for parking, Benstocken. Today Benstocken is a long-term parking and larger part is still unexplored. This is the area which Swedavia has a vision to transform into a more attractive place, *Park City;* a green and sustainable area with sufficient parking availability.

5.1.2 Aim for the study

The aim of this EIA is to describe significant environmental effects from the construction and operation of *Park City*. Purpose of this study is to achieve Swediavia's vision of *Park City* with different alternatives. The planning for the *Park City* is still in its early phase. For that reason, this assessment should be read as an early stage, strategic assessment, describing visions rather than an exact project. The focus of the study is to suggest well-functioning alternatives and mitigation measures for the significant negative impacts as well as enhancing benefits of the positive ones.

5.1.3 Present study area

The area is located in the south-west part of Arlanda, west of runway 3 (figure 5.1). Along the west border, parallel to Arlandaleden, is road 273 with junctions to the area and road 893 east and road 905 south of the project area. One of the nine parking areas in Arlanda is the BETA-parking (figure 5.2) and it is located in the northern part of the project area containing 4700 parking spaces, service facilities along with car rental firms. A small part of the parking area constitutes of asphalt but most is gravel. A power line runs through the area in a south-north direction and the majority of the study area makes up of green areas, mostly coniferous forest. Within this green area there is a small quarry operated by NCC as storage area. A small part of the southeast study area is located on the Stockholm esker. In the south of the project spatial boundaries the aviation authority has its facilities, and this area is not included in the Swedavia masterplan or vision and is therefore not included in this EIA. The area dimension is 110 ha but excluding the avian authority the project area is 76 ha. Existing parking area is 17 ha and of that about 3 ha is paved parking.

Figure 5.1. Future Park City area on an aerial photo in grey crosshatch and the present BETA parking in turquoise. Background map ©Lantmäteriet.

Figure 5.2. The Beta parking. Photo: Ariana Kubart.

5.1.4 The vision of Park City

The future *Park City* aims to become a welcoming entry part of Arlanda Airport (Airport City Stockholm, 2014), characterized by green areas and recreation. *Park City* has a great potential to be developed to an attractive and pulsing part of the airport, compared to its present status. The long-term parking and car-renting services could be accompanied by offices, retail services and hotels (Airport City Stockholm, 2014).

Many passengers pass by the future *Park City* area when arriving by the "Arlandaleden" highway from the E4 national highway. The chances that they might stop at the *Park City* and profit from the services are high.

Those needing to leave their cars at the airport could use parking services in the area and continue to the terminals by public transport, similarly to present.

In order to keep or even increase current parking capacity and exploit the area for other services, there is need to rethink the parking lots. Instead of parking horizontally on a large paved area as today, the cars could move to underground garages or multi-storey car parks (Airport City Stockholm, 2017), giving space for other buildings and for green areas.

To increase the connectivity with other part of the Airport City and to cover the increased number of passengers and employees, a network of streets will be planned within the area. Such streets will include pedestrian pavements, bike lanes and roadways. Simultaneously, all buildings will be within walking distance of a bus stop and both the buildings and bus stops will be equipped by bicycle parking facilities. As *Park City* lies within an area where the noise levels can exceed the limit of 60 dB, housing cannot be exploited (Airport City Stockholm, 2017).

5.2 Methods and boundaries

5.2.1 Interviews

Several interviews were made together with the other groups of the Arlanda project, with one person responsible for the external communication. Swedavia was contacted through email with a list of prepared questions from all project groups. The list of questions from the Park City project group can be found in appendix 1. Few questions were answered, therefore the specifics about *Park City* is sparse.

5.2.2 Field study

The group visited the area of *Park City* on the 30th of November with the goal to get an overview of the area, when available maps could be slightly outdated. One goal was also to get an idea of how the effects and impacts of the different alternatives will turn out.

5.2.3 Impact assessment matrix

A matrix was made together with the other project groups to measure the impacts of the Arlanda development. The matrix has 5 scales (table 5.1) and it extends from major positive impact to major negative impact. The matrix is used as a tool to evaluate the environmental impacts and to compare the alternatives.

Table 5.1. The five stages of the impact assessment matrix.

Major positive impact	Major positive impact on national, regional or municipal interests, or a large improvement of current quality standards
Minor positive impact	A positive impact that does not add up to a major positive impact
No impact	No notable impact
Minor negative impact	A negative impact that does not add up to a major negative impact
Major negative impact	A major negative impact that is irreversible

5.2.4. Causal loop diagram (CLD)

A causal loop diagrams was made to identify and visualize the variables, effects (impacts) and their relationship. The CLD will show what factors are within our project and needs to be considered, what the impacts are and how it all is connected.

5.2.5. Boundaries

5.2.5.1 Temporal

Time boundary is approximately 50 years ahead, according to the Master plan. The time frame is less important compared to passenger capacity, i.e. the 70 million passengers which the Master plan aims for.

As the planning of the *Park City* is in its early stage, the time scale is not delimited into construction and operation phases in an exact way. On the contrary, the impacts are predicted separately for the phases.

5.2.5.2 Spatial

The geographical boundaries for the proposed *Park City* project are shown in the maps below and correspond to the boundaries given in the Master plan. The area of 0.76 km^2 in total is delimited by road 273 from west, road 905 from south and by road 893 from east and north, with exception of the south-east part, extending from road 893 on both sides of Torvmossevägen. The property of the Aviation authority in the mid-east part of the area is not part of the *Park City* plan and will remain as it is.

5.2.5.3. Boundaries of significant impacts

As the planning of *Park City* is in early stages, it is not decided yet what will be constructed and where. Therefore, impact identifications and prediction are preliminary and precautionary, rather than specific and exact. For the same reason, high uncertainties remain in the prediction.

Significant impacts are expected for the following environmental aspects, as described in individual chapters below: Air quality and climate change, Cultural values, Energy, Natural values and recreation, Noise, vibrations and electromagnetic fields, Geology and soil, Waste disposal, Water.

5.3 Alternatives

5.3.1 Alternative 1 - Sustainable parking and recreation

The vision for *Park City* is to create one of the most sustainable and innovative facilities, combining accommodation, offices, attractions and parking, in the world. There are examples from all over the world of innovating projects combining parking with other social interest. Copenhagen, Denmark, combined parking with a playground on the roof with view over the harbour (ArcDaily, 2017). In Miami, USA, a parking building also included shops, restaurants and luxury residences (ArcDaily, 2010). Another example from USA in Santa Monica is a LEED certified parking building with conference space, café and civic center with a view of the Pacific Ocean and the city. Apart from the building being built with sustainable and recyclable materials, the east and west facade and roof have solar panels making the building self-sufficient of electricity. The solar panel on the roof also gives shade to the parked cars (ArchitypeReview, 2017).

The goal of *Park City* is to be Arlanda airport and Sweden's flagship for sustainability and turn Arlanda into a landmark. With *Park City*, Arlanda shall no longer just be an airport for travellers, where people arrive and depart, and instead become a part of the journey. *Park City* is a place for travellers, employees and others to relax and enjoy nature and green landscapes like they never have before. Therefore, *Park City* is not just part of an airport but also a destination on its own. *Park City* will be innovative and have high standards in sustainability. Swedavia's vision of zero CO_2-emission will be ensured. The goal is to have the first subsistent facility in Sweden, using the principles of zero-carbon and zero-waste.

Innovative and high standards in sustainability could be implemented by:

- Solar panels
- Green roofs
- Green walls
- Geothermal heating
- High-efficiency insulation
- Waste water recycling
- Efficient solid waste separating and recycling
- Energy efficient appliances in the building
- Air filtration towers
- Heat storage in the ground e.g. Aquifer
- Wood constructions to sequester carbon instead of releasing it when building with conventional substrates
- Smart windows that reduce noise pollution and with thin-film cover to decrease room overheating in summer as well as to decrease warm-energy losses during heating season
- Air-conditioning run on solar energy
- Biodiversity implementations

Park City aims to create a diverse area containing not only parking spaces but also other facilities with proximity to green areas with a network of small and large parks for recreation.
At the moment there are few recreational spaces for the employees and visitors at Arlanda airport. Alternative one will then also focus on

recreational spaces. This will enable people to not only travel through the area but possibly stay and interact in a social and living environment. It also enables the employees of Arlanda airport to recreate which decreases stress and other mental health illnesses.

The total area is 76 hectares and 40 % of this is planned to be greenery, which includes parks, green-passages, roofs and walls. These implementations can increase the infiltration capacity, groundwater recharge, reduce flooding, increase the air quality and reduce noise pollution. The *Park City* area was from the beginning a nature reserve which could then be the theme for the area, with large amounts of implementations for biodiversity.

Additionally from recreational values and opportunities there are also existing cultural values implemented in the park's scenery. Green exercise is physical activity which is performed outside to increase the wellbeing and will be included in *Park City* in the form of an activity center, running tracks on the roof and in the park.

Car parks and parking is estimated to occupy approximately 25 % of the area which is 19 ha, to meet the increased demand of parking facilities at Arlanda. Multi-storey car parks with five floors will generate a capacity of 38 000 parking spaces. By using automatic parking it will be possible to enhance the capacity even more. Another 25% of the area is reserved for other facilities e.g. hotels, conferences, shops etc. some of which are located adjacent to the parking buildings. The remaining 10 % of the area is estimated for surrounding infrastructure (roads, walkways etc.) to enable space and movement in the area.

Alternative 1 is visualized using the program Cities:Skylines (developed by Colossal Order, published by Paradox Interactive) in figures 5.3 and 5.4 below.

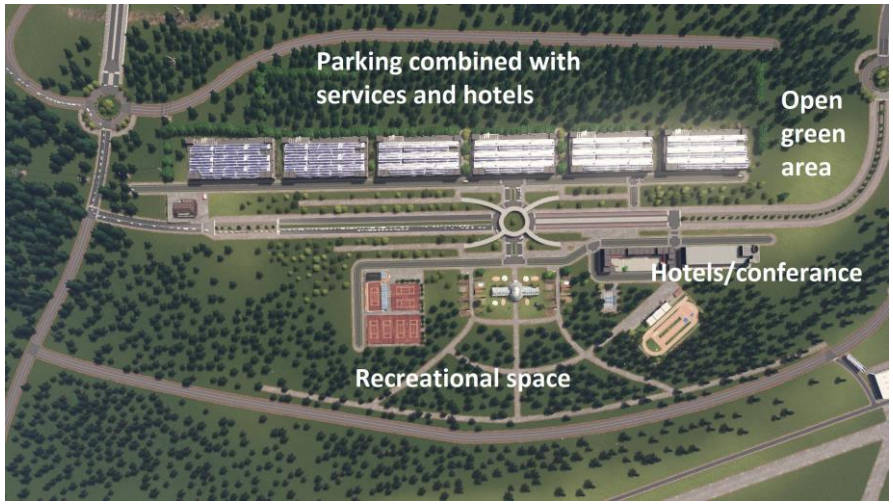

Figure 5.3. Alternative 1, view from above (Berglund, 2017)

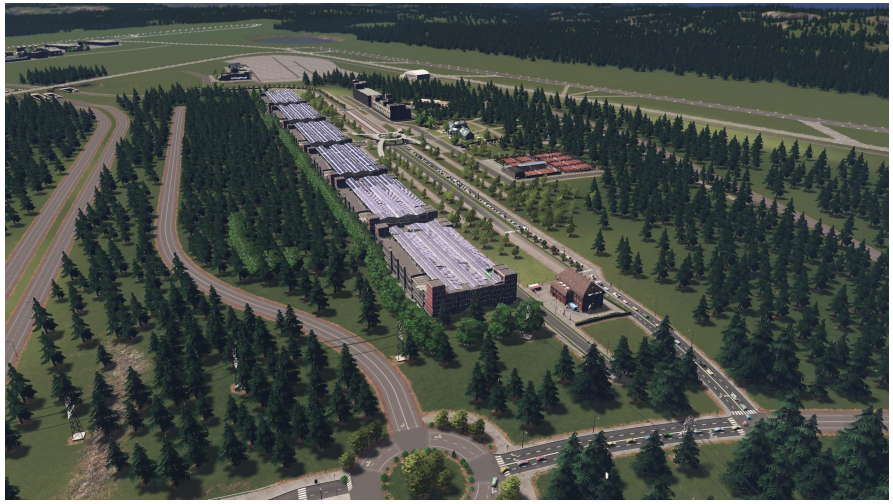

Figure 5.4. Alternative 1, view from south-west (Berglund, 2017)

5.3.2 Alternative 2 - Efficient parking

The main focus in this alternative is the number of parking spaces. By using almost 50 % of the area for parking the maximum capacity is estimated to be 76 000 parking spaces. To save space and time the multi-storey car parks could have an automatically system for parking, you never have to enter the car park and so does no one else, this save space and increase the security for you and your car.

Additionally, to the parking spaces there will be hotels and conference centres in the area, for those who prefer to stay over the day before an early flight or for those who just want to relax and have a good night sleep after a long flight in the evening. The roofs of the parking buildings will be equipped with solar panel to be more self–sufficient from electricity.

By effectively using the space to fit many parking spaces into a quite small area, there is also a possibility to have about 14 hectares of green area, where green passages will connect the car parks and to the hotels. These small green passages will benefit the infiltration capacity and the groundwater recharge in the area, reduce the risk of flooding, improve the air quality, reduce noise pollution as well as increasing the aesthetics. Near the hotels there will be a small park for exercise and recreational purposes. Alternative 2 is visualized using Cities:Skylines below (figures 5.5, 5.6 and 5.7).

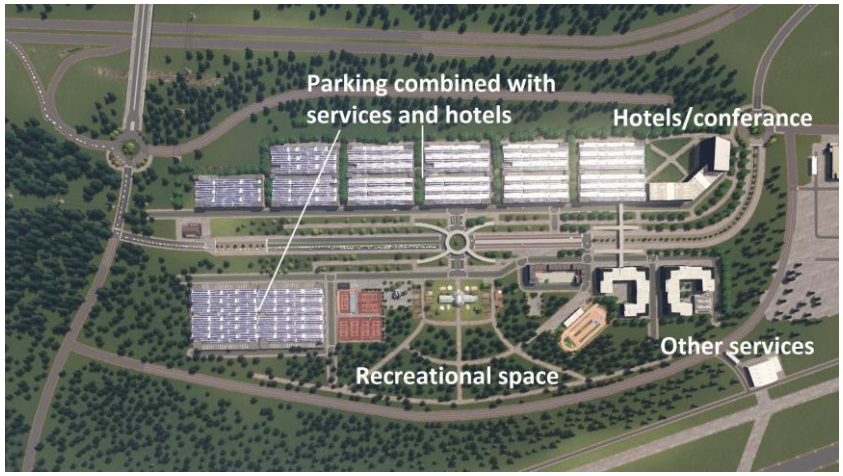

Figure 5.5. Alternative 2, view from above. (Berglund, 2017).

Figure 5.6. Alternative 2, view from north-east. (Berglund, 2017).

Figure 5.7. Alternative 2, view from south-east, with Arlanda Airport in the background. (Berglund, 2017)

5.3.3 Zero-alternative

The BETA parking lot is not expanded and *Park City* is not developed. Increase of passengers will generate more cars when BETA parking area is constantly used to its full capacity. Existing green areas and cultural remnants will remain as they are.

5.4 Baseline, impacts and mitigation measures

5.4.1 Air quality and climate change

5.4.1.1 Environmental baseline

The combustion of fossil fuels by cars is a contributing factor of greenhouse gas emissions as well as emissions of other pollutants that can affect the air quality. Inhalation of pollutants can cause severe health effects and reduce the life expectancy (Genberg, 2016). Since Swedavia exclusively use renewable sources for their electricity, the emissions of greenhouse gases are assumed to be small.

Pollutants commonly found in a parking lot are; VOC, particles, NO_x, SO_x, CO_2 and PAHs, O_3. The pollutants found in air that are the most dangerous to humans are some hydrocarbons, O_3 at ground level as well as pollutants that can be inhaled (Genberg, 2016).

NO_2 can cause damage on the respiratory tract (Svenska miljöinstitutet (IVL), 2004). The average level of NO_2 for Arlanda airport is below the limit for the national environmental quality goal (Swedavia 2017d). Yet the levels of NO_2 near the *Park City* are very close to the environmental quality standard for NO_2 (15 µg /m^3). The air quality measurement in the *Park City* area displayed an annual

average level of 14.7µg NO_2/m^3 (Swedavia, 2017d). NO_2 can react with O_2 resulting in NO^{3-} and HNO_3, that can cause eutrophication and acidification in soil and water bodies. Besides that NO_2 can react with VOCs resulting in ground level O_3 (Naturvårdsverket, 2017a). For an eight hours period the average level of O_3, should not exceed 120µg/m^3 according to the environmental quality standards (EQS) and 70µg/m^3 according to the national quality goal. Measurements carried out at Arlanda display that O_3 levels for the EQS and the national quality goal have been consequently exceeded during the summer for many years (Swedavia, 2017d). Ground level O_3 have negative impacts on vegetation and high concentrations can irritate the respiratory tracts of humans (Naturvårdsverket, 2017a). Of the VOCs that are analysed at Arlanda, benzene is the only compound that has an environmental quality standard and an environmental quality goal, none of these limits are exceeded. Particles occur in the outside air due to dust, traffic, combustion of oil- or bio fuel and particles is divided to categories according to their size. The environmental quality goals for particles are not exceeded (Swedavia, 2017d). The deposition of inorganic nitrogen in the area is lower than the national limit and deposition of acidic compounds is not considered to be a problem in the area (Swedavia, 2017d).

5.4.1.2 Impacts

Alternative 1

Construction phase

During the construction phase the use of electricity, diesel to machines used on the site, district - heating for barracks and the transport and production of waste material will require energy and result in emission of greenhouse gases. According to a study of the life cycle assessment for an apartment building, by the Royal Institute of Technology (KTH) the processes in the construction phase resulted in emissions of 478 418 kg CO_2 equivalents. The electricity, diesel and transport and production of waste material contributed with 37%; 25% and 35% of the emissions respectively (Liljenström *et al.*, 2014). Based on the study by KTH, the assumption is made that the construction of one car park will result in greenhouse emissions in the same magnitude as the apartment building. The total level of greenhouse emissions during the construction for the whole area will depend on the number of hotels and other facilities build.

The use of heavy machines during the construction will also negatively affect the air quality due to particles, dust and contaminants from exhausts (Genberg, 2016). There is a risk that the environmental quality standard for NO_2 is exceeded during the construction phase.

Operation phase

Cars moving in the area will be the main contributors of CO_2 and NO_2 emission (Swedavia, 2017d). The goal is to have zero emissions of CO_2 by 2020 for Swedavias own activities, which could be achieved by

using green electricity and being more self-sufficient on energy. Therefore the CO_2 emissions due to the activities emissions are assumed to be small. Besides CO_2, emissions of particles, hydrocarbon, NO_x and dust will be spread in the area due to the traffic. In the future, there will likely be more electrical cars and ad hybrid cars with lower emissions of CO_2 and NO_2, hence the effects on the climate and air quality will be reduced. There is a risk that the EQS for NO_2 and O_3 will be exceeded in the future with more cars moving in the area.

The green areas with vegetation absorb CO_2 for photosynthesis and particles can be removed from the air, being collected on leaves. How much CO_2 that is absorbed depend on the species, what the conditions are and how it is managed. There can be some reduction of particles and CO_2 by the trees and other vegetation in the area, thereby reducing the impact on climate change (Skogsstyrelsen, 2017). The increase in vegetation can reduce particles in the long term, a big tree can remove about 10 -20 kg of particles during the summer, catching particles on their leaves (Institutet för transportforskning (TFK), 2002). Alternative 1 will also include air filtration towers to reduce the emissions in the area, this could have a positive impact on the air quality for the rest of Arlanda as well.

Alternative 2

Construction phase

The type of impact will be the same as in alternative 1. Though with a larger area being developed the amount of greenhouse gases and air pollution due to the use of heavy machines will be higher during the construction phase. As a result the impact on the climate change and air quality can be more severe, increasing the risk of exceeding EQS for NO_2 and O_3.

Operation phase

Also in this alternative will cars be the main contributors of CO_2, due to Swedavias goal of zero CO_2 emissions the greenhouse gas emissions are assumed to be low. The green areas will decrease and with an increasing number of cars moving in the area, it is reasonable to assume that the levels of particles, NO_x and greenhouse gases will increase. Since there will be less green areas and vegetation that can filter and absorb particles and CO_2 as well as more cars, there is a risk that the air quality is negatively affected and that the EQS for NO_2, O_3 and particles are exceeded. This is likely even though the percentage of electrical cars and hybrid cars will increase in the future.

Zero alternative

The emissions of CO_2 and NO_2 as well as other emissions from cars would have negative effect on the air quality. The number of electrical cars and hybrid cars could increase as well as better technology in the future therefore later the air quality could become better.

5.4.1.3 Mitigation

More vegetation can remove CO_2 and absorb particles from the air and enhance the air quality in the area.

To reach the zero CO_2 goal it is a need to be more self-sufficient on electricity, produced by renewable sources.

5.4.1.4 Conclusion

All alternatives could result in an increase of emissions of CO_2, NO_2 and particles due to more cars moving in the area. There is a risk that the air quality is negatively affected and that the EQS for NO_2 and O_3 are not met. Since NO_2 and O_3 are known to be harmful to humans at high concentrations, hence the EQS, exceeding these standards would be considered as a negative impact.

5.4.2 Natural values and recreation

5.4.2.1 Environmental baseline

The different types of environments in the area

The most common soil types in the Arlanda Airport region are sand and gravel. This is due to that Arlanda Airport is located on one of the biggest soil ridge in the county. The soil type characterizes the flora and fauna in the area. Coniferous forest is the dominating vegetation and interspersed are wetlands. The area west of future *Park City* is cropland, and east has different types of pastures. The area close to the runways and other airport operations is dominated by fields, scrubs and open grasslands (Haglund *et al*., 2010).

Benstocken

Benstocken is the parking area where *Park City* is planned. In the entrance of Benstocken there are two old oaks (*Quercus robur*) which could have a significant natural value in the future. According to the Swedish classification of *Natural objects worth protection*, this is a class 2 (Haglund *et al*., 2010).

The Swedish Environmental Protection Agency has a classification of natural objects worthy of protection ranging from class 3 to class 1. Class 1 is the highest natural value with a natural interest for the nation. Class 2 is very high natural value with natural interest for the region and Class 3 is high natural value with natural interest for the county (Haglund *et al*., 2010).

In Benstocken there is an area called Little Benstocken which has a control zone for flights. The area is close to the runway and is therefore dominated by shrubs and some natural grasslands. In the north of area of Benstocken, the environment consists mostly of moist and tall grass vegetation. The most important natural value is an endangered plant species, littlepod false flax (*Camelina microcarpa*), listed as, vulnerable in the IUCN endangered species list (Svensson *et al*., 2006). According to SLU ArtDatabanken, littlepod false flax was found in a few places near the area between 1994 until 2005 and since then no records of the species is found (Haglund *et al*., 2010).
From the Ekologigruppen AB inventory in 2010, there is a wetland in the area but according to them it will most likely dry out and therefore not affect the great crested newt (*Triturus cristatus*) (Haglund *et al*., 2010). However, according to ArtDatabanken one specimen of great crested newts where found just near the Benstocken area in 2014 therefore the great crested newts could still be in the area. Great crested newt is listed as list of concern (LC) in Sweden but is protected according to Swedish law (Malmgren, 2012). Bird life is not significantly affected and no endangered butterflies were found

during Ekologigruppen AB:s inventory in the area (Haglund *et a*l., 2010).

According to the SLU ArtDatabanken, there are no species which are endangered in the area but several which are vulnerable. The vulnerable species need to be accounted for according to their importance to the environment.

From Benstocken to Drottningbacken, there is a ridge consisting of interesting geological formations. South of the ridge, where *Park City* will be located, the bird species European nightjar (*Caprimulgus europaeus*) is frequently seen (Haglund *et al*., 2010). The European nightjar has been listed back and forth as vulnerable species or a least concern species according to the IUCN list. In Sweden nightjar is listed as a least concern species since 2015 but protected according to Swedish law (Svensson & Tjernberg, 2010).

Deforestation would impact the surrounding environment, however according to Ekologigruppen AB who did a nature inventory in 2010 these woods were not significantly important for protection (Haglund *et al*., 2010). The area was from the beginning a nature reserve, but the reserve was relocated north of the airport when Arlanda expanded due to Arlanda being of national interest. The area could therefore still have important environmental qualities which should be considered and examined more.

Alternative 1 aims to create different sustainable implementations for *Park City*, which in this case, for natural values, focus a lot on biodiversity. Implementations which should be included in the construction of alternative 1 are:

- Green roofs and walls increases biodiversity in urban areas (Chiquet *et al.*, 2013).

- Open mixed-forest; several species in the area appreciate that type of environment.

- Preservation of wetlands, anthropogenic wetland or creating a dam; according to Bolund *et al*. (1999) and Constanza *et al*. (1997), wetlands are the most important feature per hectare in a urban area through a biodiversity- and ecosystem service perspective.

In the Arlanda region there are 600 different companies and over 17 thousand employees, which have poor access to recreational space (Swedavia, 2016). The ability to have access to green nature has a positive effect on mental well-being and reduce stress. According to The World Health Organisation by 2020 the most common ill-health source will be depression and depression-related illness. The relation between natural environment and psychological well-being has been well documented (Countryside Recreation Network, 2006).

Implementations in Alternative 1 to create recreational space in *Park City*:

- Cover the buildings with plants and art to create a better scenery in the area.

- Reduce disturbance as much as possible.

- Integration with nature.

5.4.2.2 Impacts

Alternative 1

Construction phase
During the construction, noise can disturb the European nightjar. If the disturbance occurs during nightfall it could affect the nightjar's breeding and food seeking due to the nightjar is most active during that time (Svensson & Tjernberg, 2010). Deforestation is needed for some parts of the area during construction due to space is needed for car parks and parks. The nightjar's habitat consists of natural open-space forest and some of the habitat will then be lost due to deforestation (Svensson & Tjernberg, 2010).

If wetlands currently remain in the area, they could be affected during the construction phase when the environment is disturbed. Changes in landscape affects the environment and therefore could negatively affect different species in the area.

Regarding recreation for employees and people, the effect from the construction should be minor due to the low usage of the area for recreation.

Operation phase
A remake of the area could have great positive impacts on recreation for employees and people. With green areas such as parks, the ability of connection with nature this will most likely increase both physical and mental health especially for the employees. Significant correlations between outdoors recreation and lowered blood pressure, reduction in stress and increase in physical health have been documented (Mowen *et al*., 2007).

Due to human impact and increase of human presence in the area, this could have a negative impact on several species in the area. However, studies indicate that wild animals in the category lizards, mammals and birds increase their tolerance to human presence with time. In the beginning wild animals could be disturbed by increase of human presence but with time become more tolerant (Samia *et al*., 2015)

Change in land use could affect wetlands (if they are still present). Biodiversity could increase with different implementations in the area, therefore it is also possible to preserve and increase the population of different species which exist in the area as well (Lindman, 2013)

Alternative 2

Construction phase
Building large multi-storey car parks in the area would create noise and disturbance for a long time and for a large area affecting several different species.

Large deforestation is needed and will most likely lead to habitat loss for different species and as well fragmentation of the landscape (Bennet & Saunders, 2010).

If there are still wetlands in the area, they could be affected during the construction phase when the environment is disturbed.

Regarding recreation for employees and people the effect from the construction should be minor due to the low usage of the area for recreation in the moment.

Operation phase
With more parking buildings and more cars in the area, the recreation quality will be lower due to disturbance and unpleasant scenery.
A large area will consist of parking buildings, one- and multi-level, this will lead to an increase of cars in the area. The increase of cars in the area could harm different populations of species due to the risk of being run over.

If the wetlands are preserved in the area, they could be affected by the increase of concrete area. The increase of storm water from the roads and roofs of buildings could most likely end up in the wetlands. The storm water could consist of nutrients and pollutants which will have negative effects on the wetlands and the animals depending on it. Great crested newts could be affected by the changed environment in the wetlands which is where they lay their eggs and where the juveniles grow (Malmgren, 2012).

Zero alternative

If there is no further exploitation of the area it will continue being without a recreational space. This has a significantly physical- and mental health effect on the 17 500 employees at Arlanda airport. In the moment the area consist of a smaller car park and coniferous forest but with no paths through it or other attractive features for recreation. This scenery is similar for other areas in the Arlanda airport area, a grey concrete landscape with low opportunities for recreation in a natural green landscape.

If the area is not further more exploited it will continue being a small gravel car park. The area will also continue consisting of coniferous forest which has no significant importance for the natural value.

With no capacity measures such increasing car parks or creating new facilities for the area, there will not be as high increase of cars or human presence in the area as the other alternatives. With either construction or operation the land use is not changed. However there could still be pollutants in the soil but with no intentions of creating new operations in the area the soil will most likely not be removed.

5.4.2.3 Mitigation

Alternative 1

Since there are some species in the area which are nocturnal they will be affected by the night disturbances, such as artificial lights and noise, close to its habitats and those impacts should be reduced in those areas. Natural-closed parks with bushes, typical understory vegetation and soil cover, combined with stony parts and open natural grass-marks. However, the grass-marks should not have green lawns characteristics for ordinary town-parks, when these environmental features mentioned are especially appreciated by bats, birds, butterflies etc. (ArtDatabanken, 2017). Some areas could be less accessible to humans to protect some species. In the park and open

forest it could be different size of walking paths, both paths for strollers but also smaller paths to decrease human access.

Alternative 2

Mitigation measures for alternative 2 could be installing green spaces between the car parks to create a greener scenery. Green pathways and small parks in the area creates habitat for some species and also some recreation. Implementing pathways for animals to decrease accidents. Impact measurements for alternative 2 could include some of the implementations of alternative 1.

5.4.2.4 Conclusion

Construction impacts from alternatives one and two are similar. Both alternatives require deforestation and other impacts on landscape when building different facilities.

The impacts which occurs for both alternatives during operation are; increase in human presence, cars and disturbance. Human presence is a larger impact in alternative one due to human presence will occur for longer time period for whole days. Meanwhile the impact from cars will be higher in alternative 2 due to larger areas are dedicated for car parks. However alternative one focus on sustainability, both with different implementations and mitigations to reduce environmental impact as much as possible. Therefor the impacts from alternative 1 will most likely not be as significant due to all implementations to reduce environmental impacts during operation. Currently the importance of natural values and recreational space in the area are almost none, therefore creating an environment improving these features will create a large positive impact than keeping the area as it is.

With this assumption, alternative 1 overall creates a major positive impact for natural values and recreation over weighing the negative impacts from construction and operation. For alternative 2 the impacts are overall major negative due to increase in disturbance, with few mitigation measures and with irreversible changes in landscape. For Zero alternative, there are no significant impacts.

5.4.3 Cultural values

5.4.3.1 Environmental baseline

There are three identified remains in the project area (figure 5.8) which include traces of settlements and markings, marked in the map below. According to the Swedish cultural environment law, it is forbidden to alter or remove remains without permission from the County Administrative Board (SFS 1988:950). The locations for the cultural remains have been reported by the Swedish national heritage board (Riksantikvarieämbetet, 2017).

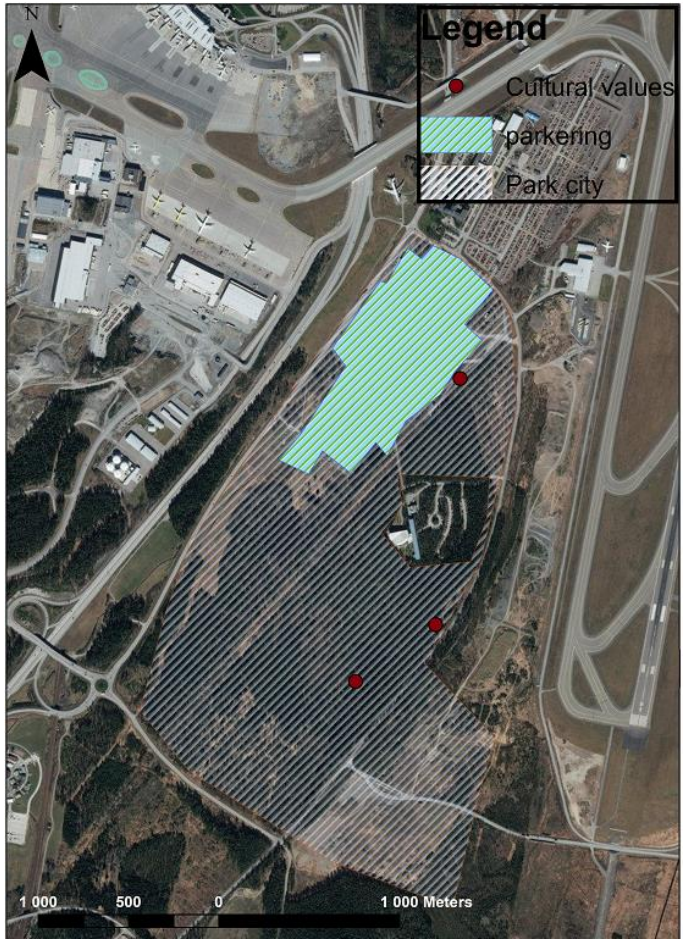

Figure 5.8. Cultural remains in Park City area. Background map © Lantmäteriet.

5.4.3.2 Impacts

Alternative 1

In alternative 1, the forest area is utilized by making the forest more available to people, while focusing on the natural and cultural values of the forest. The remains inside the project area might become more accessible to people, and could therefore inherit an increased cultural value. The risk of damage to the remains should be considered higher as more people visit the area.

Alternative 2

In alternative 2, the parking area is maximized, and little effort is made to make the remains accessible to the visitors. The remains could still be left untouched by building around the sites, leaving them as they are today. The remaining forest is utilized for recreation which also increases the cultural value of the area.

Zero alternative

In the Zero alternative, the remains and the surrounding area is left as it is, the remains are somewhat inaccessible to people at Arlanda airport but also untouched.

5.4.3.3 Mitigation

The cultural remains in the area might be difficult for passing people to identify, or recognize which may lead to unintentional damage. In both alternatives, some sort of marking is needed in order to highlight the location of the remains and their cultural value. By spreading this knowledge, unintentional damage could be avoided.

5.4.3.4 Conclusion

The remains in the area are today poorly available to the public. In alternative 1, the forest is utilized for recreation and cultural values are made more available to the public. The improved access would increase their prestige and importance, compared to current situation.

In alternative 2, in order to maximize the parking area, the forest is not utilized for recreation to the same extent as alternative 1, and the cultural values are left untouched and remain inaccessible.

5.4.3 Energy

5.4.3.1 Environmental baseline

According to Swedavia, Arlanda airport consumes roughly 250 000 MWh/year, equal to 14 000 electrically heated homes (Swedavia, 2013). The buildings which make up Stockholm Arlanda Airport are heated using district heating based on biofuels. Swedavia also purchases so called "green electricity certificates" equivalent to its entire electricity consumption at the airport. These certificates guarantee electricity production from exclusively renewable sources, which are wind, solar, hydropower and biofuels.

In the summer of 2009, Stockholm Arlanda also inaugurated the world's largest energy storage unit, an aquifer, in the nearby boulder ridge Brunkebergsåsen. The airport is both heated and cooled efficiently using the aquifer and, according to Swedavia, without any environmental impact during the summer or winter. (Swedavia, 2017e)

The diagram in figure 5.9 shows the amount of energy (in kWh/m^2) that reaches the ground from the sun, in the Stockholm region, per year.

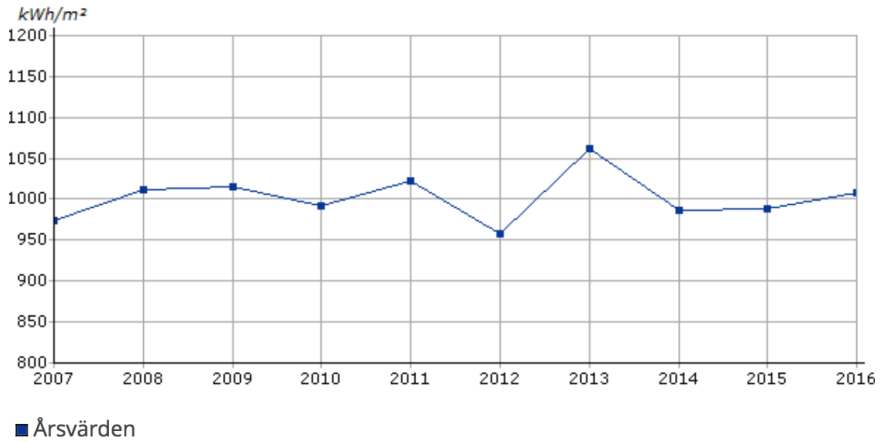

Figure 5.9. Diagram of solar energy reaching earth's surface in the Stockholm Region (Stockholms stad, 2017).

Assuming an efficiency rate of solar cells of 15 %, and 1000 kWh/m^2 per year of solar energy reaching earth's surface in the Stockholm region (value of 2016), gives us an electric production of 150 kWh/m^2 of solar panels per year. The manufacturing and operation of solar panels emits the equivalent of 40 g CO_2/kWh of installed effect (US Department of Energy, 2012). No reliable source stating the energy needed for automatic parking has been found.

5.4.3.2 Impacts

Alternative 1

Construction phase
Manufacturing solar panels for alternative 1 emits the equivalent of 90 tons of CO_2 in total, including the operation during the lifetime of solar panels.

Operation phase
By covering a total area of 15 hectares with solar panels (total footprint of parking buildings), there is a potential energy production of 2 250 MWh/year of electricity (0.9 % of Arlanda's electricity consumption).

The buildings are heated using geothermal heat from the nearby aquifer, and suffer small heat losses by using high-efficiency insulation. The electricity produced can therefore be used in services other than heating.

Alternative 2

Construction phase
Manufacturing panels for alternative 2 emits the equivalent of 228 tons of CO_2 in total, including operation during the lifetime of solar panels.

Operation phase
In alternative 2, half of the project area is covered with parking buildings, which gives us an area of 38 hectares suitable for solar panels. This equals a potential energy production of 5 700 MWh/year of electricity (2.3 % of Arlanda's electricity consumption).

Zero alternative

In the Zero alternative, the area stays the same, containing parking spaces and a few buildings which require electricity to function. The electricity consumption stays at current levels, which are not known as of now.

5.4.3.3 Mitigation

According to Swedavia, all of the electricity used by Arlanda Airport comes from renewable sources. When the electricity is considered clean, the next method of improvement is reducing the consumption of electricity which can be achieved by behaviour changes, increased efficiency and other factors.

5.4.3.4 Conclusion

The two alternatives could make *Park City* partly self-sufficient in energy, although the lack of information regarding the local electricity consumption in *Park City* today and in the future might make the resulting figures somewhat non-informative. The future need for electricity to recharge electric vehicles is not known, however alternative 2 will probably demand more energy as it has higher capacity of parking spaces. Nonetheless there is a potential of locally produced electricity that could reduce the area's need for electricity from the grid. Alternative 1 will probably produce less energy by solar panels but also use other energy sources as geothermal heating and lower the energy consumption by effectively isolated building.

5.4.5 Noise, vibration and magnetic fields

5.4.5.1 Environmental baseline

All traffic (cars, busses, trucks, trains and especially airplanes) at Arlanda generates noise pollution and vibrations (Trafikverket, 2017a) and the operations at Arlanda needs electricity which generate magnetic fields. 2 of the 16 environmental quality objectives are of concern, "A good built environment" regarding noise and vibrations (Naturvårdsverket, 2017b) and "A safe radiation environment" regarding magnetic fields (Naturvårdsverket, 2017c). In regard to the EQS regulation (2004:675) under the environmental code 5 chapter. 2 § (Naturvårdsverket, 2017d) Arlanda have been given an environmental permission in May 25th 2015 (Swedavia, 2017) in accordance of regulation (2015:216) (Naturvårdsverket, 2017e) stating the level of noise the operations cannot exceed.

Traffic to and from Arlanda airport passes the project area on road 273 and Arlandaleden with travellers, employees and transport of goods daily. Internal logistics of Arlanda connecting the different areas and operations on runways, particularly runway 3, affects the project area as well. The project area is within the 55 dB during the day (L_{DEN}), however the east side and the south west part of the project area are on the border to 60 dB. During the night (L_{NIGHT}) only a small part of the area, east side, are within the 55 dB area (figure 5.C and 5.D in the appendix 5.1). This is according to Swedish transport administration survey in 2011 (Trafikverket, 2017b). Most of the project area is not built at this time, but are green areas that have the effect of absorbing noise pollution (Trafikverket, 2017c).

Across the project area there's a 1.5 km 700 kV power line in a south-north direction (Sigtuna kommun, 2009) with a width of 35-45 m. The estimated minimum distance between a 700 kV power line and place of work is 30m (Sigtuna kommun, 2009), however there aren't any within this area.

5.4.5.2 Impacts

The expansion of parking possibilities and development of *Park City* will generate more noise and vibrations in the project area but might reduce noise pollution from roads to/from Arlanda when transport of people and employees from *Park City* reduce traffic on roads.

More people and vehicles will be in the project area generating noise pollution, but the magnitude might not be of significance compared to noise pollution from surrounding operations e.g. aircrafts. Increased traffic on runways and possibly transport of goods and travellers on

road will generate more noise pollution than at this time if not the use of electric and hybrid vehicles increase or other new quiet technology can compensate this effect.

With the expansion of Arlandastad, south of the project area, the powerline will be placed under ground (Sigtuna kommun, 2009). It is reasonable to assume that the part crossing the project area will be as well, either in part of that project or the development of *Park City* and thereby removing or greatly decreasing the health risk of the magnetic field. If placed under ground it will make it possible to build on this area. If powerline remain above ground the magnetic field will limit the development and placement of hotels and shops and also lower the aesthetics regarding recreation areas.

Alternative 1

Construction phase

During development noise pollution will increase but can be minimized by planning, different machines and their positioning can reduce noise pollutions (Naturvårdsverket, 2017f). Transport of materials to and from the area and the building process in the area will all generate noise pollutions.

Operation phase

With more activity and movement, when people not only travel thru the project area, will generate more noise. The demand of services and functions of e.g. ventilation, transport of goods and general human presence will be higher and increase noise pollution. The human presence will be higher than in alternative 2 because more hotels, shops and recreation opportunities are present.

The large area of greenery will work as a noise barrier (Trafikverket, 2017c) when placed strategically around hotels, shops and other places where people work or occupy. Vegetation on building's facade will lower the noise pollution.

Alternative 2

Construction phase

During development noise pollution will increase but can be minimized by planning, different machines and their positioning can reduce noise pollutions (Naturvårdsverket, 2017e). Transport of materials to and from the area and the building process in the area will all generate noise pollutions and compared to alternative 1 this will be more extensive since a larger area will be built, more materials will be moved to and from the area and less of the greenery will be left untouched. By building parking buildings in sections, noise pollution can be concentrated to a limited area and be more easily contained. Most of the existing green area will disappear and the noise level will increase in the area due to loss of noise barrier and possibly expand the existing area with noise level of 60 dB.

Operation phase

Parking buildings can work as noise barrier by placing them along road 273 and/or runway 3. Hotels must be placed surrounded by parking buildings, vegetation or other barriers to lower the noise levels. The loss of green area might permanently expand the existing area with noise level of 60 dB if not other measures to reduce noise pollution from aircrafts are implemented.

Zero alternative

Increasing number of travellers will generate more noise pollution in the project area on both runways and roads because of more movements and higher demands of services and goods at Arlanda. The parking abilities will not be sufficient and thereby possibly increasing the traffic to and from Arlanda with travellers by car or public transport.

5.4.5.3 Mitigation

Speed limit and planning of roads can reduce the noise pollution if traffic flows smoothly without unnecessary stops, acceleration and deceleration. Material and size of particles when paving the road also have an effect on noise pollution, a smaller size reduce noise pollution (Trafikverket, 2017d). The facade and windows on buildings can be adjusted to minimize noise inside with choice of material (Trafikverket, 2017c) and possibly vegetation on buildings in alternative 2. To use buildings and existing topography as barriers to minimize the distribution of noise and green areas that absorbs noise both within and outside the project area.

5.4.5.4 Conclusion

All alternatives will probably experience an increase of noise pollution in the project area from increased movements on both runways and roads due to the increase of travellers.

Alternative 1 and 2 will probably also experience an increase of noise pollution due to expanded activity within the area. Alternative 1 will have a higher noise pollution during operation while Alternative 2 will have it during construction. Noise pollution from activities within the area will however be non-significant compared to noise pollution from operations surrounding the project area. The possibilities to reduce noise pollution are greater in alternative 1 with higher proportion of green areas and vegetation.

5.4.6 Geology and soil

5.4.6.1 Environmental Baseline

Soil

The soil of the Park City area is dominated by postglacial sand with patches of postglacial and glacial clay. The eastern part is characterized by the Stockholm esker ridge (figure 5.10), which is an important groundwater resource as it is serving as a cooling and heating system for the airport (Swedavia, 2017c).

The esker causes an elevation difference of 20 meter from west to the east (Google maps, 2017) and the soil cover is quite shallow with an overall thickness of 0 - 10m and a maximum thickness of 20 meters (figure 5.B in appendix 5.1).

Geology

A common feature within the area is exposed bedrock. The bedrock consists of sandstone and greywacke with a string of

intrusive rhyolite that cuts through the sedimentary rock in the middle of the area (figure 5.A in appendix 5.1).

Soil contamination

No information is given or found of present soil contamination, but possible contamination sources could be:

- The nearby runway 3 can be a source of glycol
- The parked cars of ALFA and BETA parking lots can be source of past and current leakage of oil and gasoline from the vehicles
- Car rental and car service facilities - past and current diesel or gasoline leakage from vehicles and contaminated wastewater from car wash.

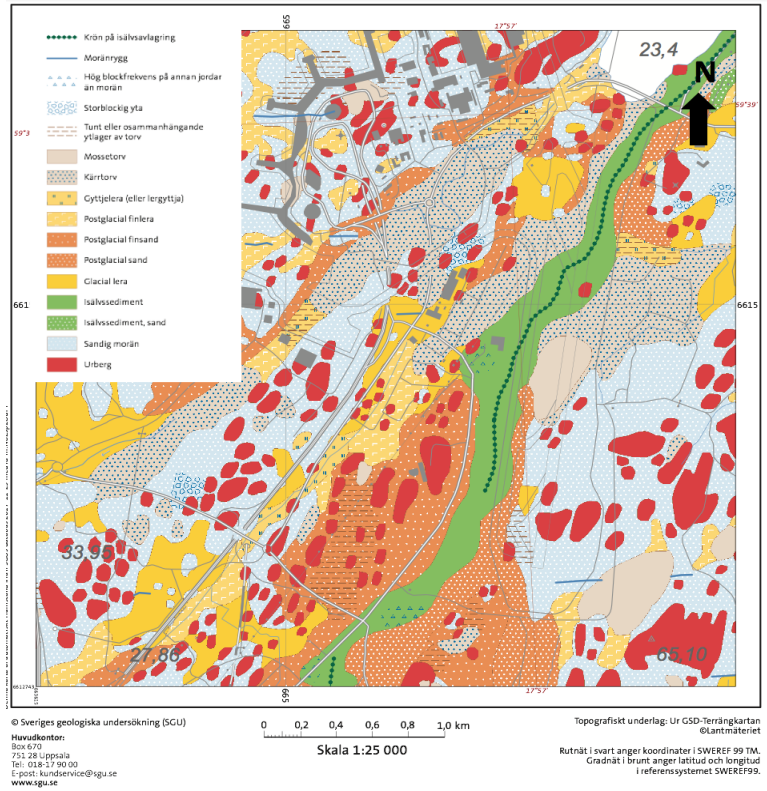

Figure 5.10. Soil types in Benstocken area (SGU, 2017).

5.4.6.2 Impacts

Alternative 1

Construction phase

Due to the exposed rock in the area, the surface bedrock needs to be removed in order to flatten out and create an even surface for buildings. The esker in the south-east part might need to be flatten out as well, which will affect the water reservoir underneath. Possible soil contamination will be stirred up to the surface when working with the soil, which in that case must be decontaminated before construction of buildings. The first alternative will lead to preparation of the soil and bedrock in the mid part of the area to make way for the new green facilities and park areas.

Operation phase

The present large parking lot will partly be replaced with green areas, which might affect the soil in a positive way - the oil spill etc. from cars will no longer contaminate the soil, because the cars will not stand directly on the ground but in multi-story parking lots with cleaning systems. The forest of the mid part of the area will be cut down and will be exposed to erosion, and the forest will be replaced by both green facilities and recreation areas. The permeability will be a but higher due to the increased area of greenery, which will take care of the increasing precipitation in the future.

Alternative 2

Construction phase

Due to the large amount of multi storey parking facilities in this Due to the large amount of multi storey parking facilities in this alternative, extensive blasting of bedrock will be needed and the soil needs to be flatten out due to the 20 meters difference in the topology from east to west in the area. The elevation difference is due to the esker that cuts through and are considered to be a sensitive area.

The trees in in the south will be cut down, which might not affect the soil that much since it mostly consists of coarse and steady material.
The extensive processing of the soil will stir up eventual contaminants to the surface and must be removed if the contamination is vast. The soil is most likely contaminated to some extent so this will be a likely scenario. The construction vehicles are likely to contribute to some leakage of diesel or oil.

Operation phase

The permeability will be decreased due to the larger hard surface areas and could cause flooding in the future. When removing the forest, the soil will be exposed to erosion.

Zero alternative

If no actions are to take place in the Park City area, the topography will be unchanged; the soil, bedrock and esker will be left untouched. In time, the ALFA and BETA parking lots will be very crowded due to increasing number of travellers and always used to its full capacity.

With more cars in circulation in the area the possibility with leakage of oil into the soil is higher.

The occurring pollutants could remain in the ground and will most likely build up or infiltrate to ground water due to the increasing car activity. The hard surfaces will prevent the precipitation from penetrate into the soil and will get easily flooded due to the climate change in the future.

5.4.6.3 Mitigation

- have greenery alongside hard surfaces, allowing the water from precipitation to escape and penetrate the soil
- use the latest technology to clean the contaminated soils
- use fossil free vehicles during construction
- re-use the blasted bed rock in the consutruction of concrete and asphalt etc

5.4.6.4 Conclusion

The two alternatives will have quite similar negative impacts on the soil and bedrock, by both the construction and operation phases. Deforistation will occur and the soil will be stirred and processed in both alternatives, which will lead to exposure of erosion in both cases but the second alternative will also include blasting of the bed rock.

5.4.7 Waste disposal

5.4.7.1 Environmental baseline

The Benstocken area, which is to be developed, consists mostly of parking lots and semi-natural habitats. Thus, the amount of waste produced is negligible, when compared to other parts of the airport.

5.4.7.2 Impacts

Alternative 1

Construction phase

Prior the new constructions, the asphalt and gravel from the parking area shall be removed. At least 70 % of such demolition waste is supposed to be reused or recycled (Naturvårdsverket, 2017f). Asphalt from pavement is regularly recycled into new asphalt mixtures or used as aggregate in unbound layers, with well developed routines (Arm et al., 2014). Gravel can be contaminated by oil, gasoline and other chemicals washed off the cars. In such case, it has to be decontaminated. Both asphalt and gravel can be reused for the new constructions in the area, decreasing the need of new aggregates.

Operation phase

With development of the Park City and increased amount of people in motion will waste production increase accordingly. Amount of both solid waste and of sewage will depend on the size and function of the new facilities. Hotels and conference centres with many visitors and high people turn-over are expected to produce high amount of waste. Compared to them, shops and offices will produce less and parking

houses minor fraction of the total waste amount. Efficient system to separate and recycle in major proportion on solid waste would be crucial in order to keep the negative effects as low as possible.

New sewerage system shall be constructed in the *Park City* and connected to the available one, with capacity optimized for the planned facilities. An alternative could be to build own, small-size sewage plant just for *Park City*. In both cases, there are clear instructions available how to construct sustainable sewerage systems (Naturvårdsverket, 2017g).

Alternative 2

Construction phase

Even in the Alternative 2, asphalt and gravel will have to be removed in the places of new constructions and can be reused in them. Depending on the final project, certain parking slots might be kept in their current form, resulting in less amount of demolition waste compared to Alternative 1.

Operation phase

If mainly high-capacity parking houses are projected in the *Park City,* the majority of passengers will just quickly pass the area on their way to the terminals. In such case, the amount of waste would remain low, compared to Alternative 1. Major waste source would be the few hotels accompanying the parking houses, though producing lower amount of waste than the larger lodging facilities proposed in Alternative 1.

Zero alternative

If the *Park City* is not developed, the amount of waste will remain low or slightly increase with increased consumption patterns. Even such slight increase would not have significant environmental effect.

5.4.7.3 Mitigation

Demolition waste, mainly asphalt and gravel in this case, can be decontaminated and reused in the new constructions, decreasing the need of both landfilling and of extraction of new aggregates. Sewage shall be handled in a modern, stage-of-the-art sewerage plant. In ideal case, the facilities are built with separate plumbing system for greywater and blackwater (toilet water), simplifying their cleaning. Amount of solid waste can be decreased by diverse means, based on good management and reduce-reuse-recycle principle. Both hotels and companies may induce policy aspiring to zero waste status and use it as their positive trademark to attract customers. Organic waste from hotel restaurants (and optimally even from black sewage water) can be used in a local biogas plant, producing biogas for airport transport or heating. It should be also easy for visitors and employees to separate the waste. Numerous well marked and easily accessible trash-bins for collecting recyclables will help them to properly separate cans, plastics, newspapers, glass and batteries, leaving only negligible amount of other waste. That can be burnt for heat production.

5.4.7.4 Conclusion

Demolition waste, consisting mainly of asphalt and gravel, will be produced prior new development in both alternatives, but it can be reused in the built constructions. As number of employees and passengers will grow, amount of waste will increase accordingly, dependent also on duration of their stay.

More waste is expected to be produced in Alternative 1 with broader spectra of facilities and activities, compared to Alternative 2, when the majority of people will park their cars and directly continue to Sky City. If the mitigation measures are implemented, the increase of waste amount would not have highly negative effect. Moreover, it could be used to produce energy in form of heat and biogas.

5.4.8 Hydrology

5.4.8.1 Environmental baseline

The area of *Park City* is located in *Märstaån* catchment. The precipitation in the parking lot area will go to surrounding drainage and ditches and later to the stream *Märstaån* ending in lake *Mälaren* (figure 5.11). *Mälaren* is used as a drinking water supply for 2 million people living in the surroundings (Mälarens vattenvårdsförbund, 2017). Contaminants from the surface on the pavement and cars can be picked up by the water and transported by the surface water as well as the groundwater. Contaminants usually found in parking lots originates both from the pavement, like PAHs, and oil, hydrocarbon, antifreeze, metals, rubber particles, nitrous oxides from cars (EPA, 2008).

Ground water

An impervious material like pavement reduces the infiltration capacity, hence the recharge of groundwater is inhibited in the area. Because of the poor infiltration contaminants on the pavement are led to the storm water system rather than being transported to the ground water (EPA, 2008). In general, the groundwater in the area is found in bedrock or soil with low transmissivity (Vatten och samhällsteknik, 2011). The majority of the *Park City* area is located next to the Stockholm esker, and a small part of the area is located on the esker.

The southern part of the esker, at Ströms gård, is used as a back-up water resource for the drinking water supply (Länsstyrelsen, 2017a). The *Park City* area borders to the protected area for the groundwater resource at Ströms gård (Bryntesson, 2014). The company Norrvatten is responsible for the back-up water resource. They have assessed that the groundwater in the airport area does not affect the water resource at Ströms gård (Vatten och samhällsteknik, 2011). Yet, measurements between 2013 to 2016 display that the groundwater in Stockholmsåsen – Arlanda do not meet the requirements for a good chemical status, due to exceeding the target value for perfluoroalkyl substances, PFAS, see figure 5.11 with water bodies (Länsstyrelsen, 2017a).

Surface water and storm water

About 14% of the *Park City* area have impervious surface, which have the ability to create up to 2 -6 times more surface runoff than a natural

surface (EPA, 2008). The surface runoff and storm water from the parking area reaches *Märstaån* (Swedavia, 2017d). The storm water from the *Park City* area goes to stream *Benstockenån* close to the parking lot, the water is then led to a basin for detention and later to stream *Halmsjöbäckens* storm water tunnel, which ends in *Märstaån* (figure 5.11). Measurements of P, N, and organic material in the storm water from the Benstocken area displayed that the levels are lower than the limits for storm water (Vatten och samhällsteknik 2011).

The recipient *Märstaån* is affected by surrounding agriculture areas and has high levels of N and P (Swedavia AB, 2017). The levels of As, U and PFAS in *Märstaån* exceeds the limits for surface water according to the National Environmental Protection Agency and the National Sea and Water Authority (Swedavia, 2017d). *Märstaån* do not fulfil the requirements for a good chemical status due to high levels of Hg, PBDE, PFOS and Ni. Regarding the ecological status *Märstaån* reach an average status, based on the amounts on diatoms and benthos (Länsstyrelsen, 2017b). The County board in Stockholm predict that *Märstaån* will not reach the requirements for the environmental quality standards or a good ecological and chemical status in 2021 respectively in 2027, due to high levels of Hg, PBDE, PFOS and Ni (Länsstyrelsen, 2017b).

Figure 5.11. Park city area with its recipients, *Benstockenån* and *Märstaån* as well as parts of the groundwater supply of the Stockholm esker. Background map © Lantmäteriet.

5.4.8.2 Impacts

Alternative 1

Construction phase

The construction of multi-storey car parks and facilities can negatively affect the groundwater and the surface water due to contaminants and sediments from machines and materials during the construction. Contaminants used in the construction phase that can contaminate both surface water and groundwater are diesel, fossil fuels, solvents and toxic substances.

The sediments and contaminants from the construction phase can have a negatively impact on *Benstockenån* and also aggravate the already poor chemical and ecological status of *Märstaån* (figure 5.11). Due to lack of data for the current groundwater level in the area, it is difficult to assess the impact on the groundwater level during the construction phase.

Operation phase

The amount of green area will be reduced and the impervious surface will increase. The number of cars in the area will increase, resulting in more emissions of oil, hydrocarbon, antifreeze, metals, rubber particles and nitrous oxides to the surroundings (EPA, 2008). Yet, the cars will be stored inside, reducing the contaminants from cars to the surface during the parked phase. These contaminants could be transported to recipients or groundwater. Today there is no known contaminants in the area that can affect the groundwater. Since the dominating soil type in the area is sand with high infiltration capacity, there is a risk that potential contaminants in the soil are transported to the groundwater and later to recipients. Today *Märstaån* does not fulfil the requirements for the EQS or the national goal for flourishing streams and lakes and do not achieve a good chemical and good ecological status (Länsstyrelsen Stockholms län, 2017 b).

According to Duan et al. (2011), anthropogenic wetlands are a profitable alternative to conventional sewage plant. An example is from Kalmar where wetlands has been introduced to the city. Wetlands both contribute with removal of nitrogen and increase in biodiversity in the area. A wetland was constructed near Karlmar's airport to reduce the urea transport from the airport, that emits urea to the nearby stream. (Thorén, 2003). By constructing a wetland in the park city area, the status for Märstaån could be enhanced.

Another way of decreasing the amount of nutrients in the water is by constructing strips of vegetation with a low slope, the storm water can be filtered and 50- 80 % of the N and the P, as well as 30 – 65% of the metals can be removed (EPA, 2008). This improves the storm water from the area that enters the common storm water system for Arlanda and could have a positive impact on the recipient *Märstaån* (EPA, 2008). The green area with green paths, roofs and walls can increase the infiltration of precipitation at a local scale, hence also the recharge of groundwater, reduction of storm water and diminish the risk of flooding (EPA, 2008). The risk of flooding has not been assessed in the area, though with a larger surface of impervious material the volume of storm water can increase and thereby also the risk of flooding (MSB, 2010) & (EPA 2008). By using the rational equation, described in appendix 1.3 the peak discharge (the highest flow) was estimated. The peak discharge relates to the surface runoff from an area and has

been estimated to increase with 190 to 310 % due to the expansion of impervious surface. This could increase the risk of flooding for the nearby stream Benstocksån, especially in the future when heavy precipitation is estimated to happen more frequently (Intergovernmental panel on climate change (IPCC, 2013). Yet, the constructed wetland in the area could also reduce the risk of flooding in the future (EPA, 2008).

Alternative 2

Construction phase

The impacts by machines and materials are the same as in Alternative 1. Due to developing a larger area the magnitude of contaminants and sediment are higher in this alternative. The higher developing level also increases the potential impact on the ground water in the area.

Operation phase

In this alternative the total green area will be reduced to 20% of the area. The larger area of impervious material will negatively affect the infiltration of precipitation and the recharge of groundwater (EPA 2008). Yet, compared to the current state the green spaces can be more evenly distributed in the area, resulting in a positive effect on infiltration of precipitation and an increased groundwater recharge at a local scale.

The benefit with a larger area of impervious surface is that if there are contaminants in the soil they could be prevented from being spread to the ground water. The large amount of parking spaces will result in a higher number of cars moving in the area and even though the contaminants will decrease from the parking phase, due to cars being parked inside. The amount of contaminants from the cars that can enter the storm water and its system and later end up in *Märstaån* can increase. Even with an improved storm water management by the green patches, described in Alternative 1, removing some of the contaminants the levels of contaminants to *Märstaån* could be higher. This can negatively affect *Märstaån*, increasing the risk of not achieving a good chemical and ecological quality is not met in the future. By using the rational equation described in appendix 1.3) the peak discharge for the area has been estimated to increase with 230 to 380 % due to the larger area of impervious surface.

Zero alternative

The amount of metals, oil, antifreeze etc. would probably remain at a similar level as today and could be transported by the storm water to the recipient. The area of impervious surface will remain the same, this can be problematic due to that the precipitation in the area as well as the amount of precipitation for one day is expected to increase in the future (IPCC, 2013). A higher precipitation will result in an increase of runoff as well as storm water running to Märstaån, which could increase the risk of flooding. The risk of flooding for Märstaån have not been assessed by the Swedish civil contingencies agency, yet there is a big risk of flooding in Mälaren in the future, that can have big consequences on sewage system, industries, agriculture land and infrastructure (MSB 2010).

5.4.8.3 Mitigation

Due to expansion of impervious surface as well as an increase in heavy precipitation in the future, there can be need to extend and increase the capacity of the current storm water system, to avoid flooding.

5.4.8.4 Conclusion

Both Alternative 1 and Alternative 2 can have a minor negative impact in the construction phase due to more contaminants from machines operating in the area as well as the increase of sediments to the recipients. During operation phase both Alternative 1 and Alternative 2 would result in more cars moving in the area. More cars can lead to an increased risk of contaminant transport to the recipient *Märstaån* that already has a poor ecological and chemical status. Yet, since the cars will be parked inside the contaminants from the parking phase will be less than today. The green patches in the area filtering N, P and metals from the surface water will reduce the contaminants in the storm water. For Alternative 1 the filtering could cancel the effect of more cars in the area and therefore have no impact.

Due to the higher capacity of parking spaces and more cars moving in alternative 2, this alternative could have a more severe impact on Märstaån. Despite the filtering by green patches could the contaminants reaching the recipients increase and have a minor negative impact.

Even though there are green patches in the area, reducing the volume of the storm water. The expansion of impervious surfaces, increase the risk of flooding in the area by 190 to 310% and 230 to 380% for alternative 1 respectively alternative 2. The risk of flooding is also likely to increase in the future due to more heavy precipitation. If flooding occurs can the water quality and the ecological quality decrease, due to more sediments and risk for disturbance of the storm water and the wastewater system. This could have a minor negative impact in both alternatives. For the hydrology in the area, a minor negative impact could be expected for Alternative 1 due to the risk of flooding and reduced contaminants reaching recipients. For Alternative 2, the hydrology could experience a major negative impact. Being negatively affected both by a increase in the contaminants and a higher risk of flooding.

5.5 Results

5.5.1 Causal loop diagram (CLD)

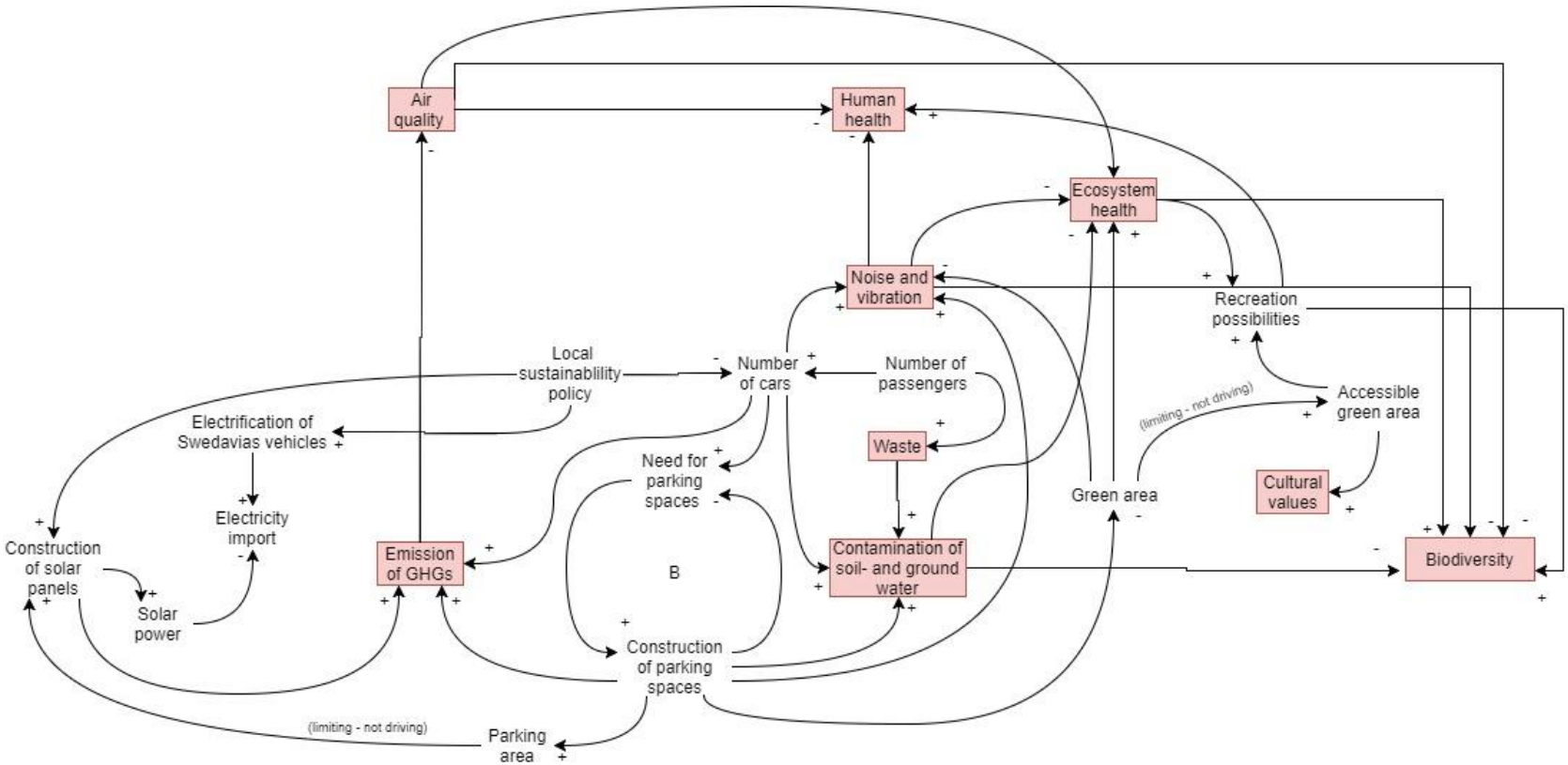

Figure 5.12. Causal loop diagram (CLD), with the assessed impacts marked red.

The CLD of figure 5.12 can be read accordingly:

- An increase in *Number of passengers* will lead to an increase in *Number of cars.*

- An increase of *Number of cars* will increase *Emissions of GHGs*, *Noise and vibration, Contamination of soil- and groundwater* and *Need for parking spaces.*

- An increase in the *Need of parking spaces* will increase the *Construction of parking spaces* which in turn decreases the *Need for parking spaces* as a feedback.

- The *Construction of parking spaces* will increase the *Parking area* which enables the *Construction of solar panels* - this will increase *Solar power* produced - which reduces the amount of *Electricity import*.

- The *Construction of solar panels* and *Construction of parking spaces* both lead to *Emissions of GHGs*.

- *Emissions of GHGs* will reduce the *Air quality* which in turns reduces both *Human health* and *Ecosystem health* - which are also reduced additionally by *Noise and vibration.*

- The *Number of cars* and amount of *Waste* increases the *Contamination of soil- and groundwater.* The *Local sustainability policy* will reduce the *Number of cars* and increase the *Construction of solar panels* and *Electrification of Swedavia's vehicles.*

- The *Electrification of Swedavia's vehicles* increase the *Electricity import* which is reduced by *Solar power*.

- The *Construction of parking spaces* reduces *Green area*, which is needed for both *Ecosystem health* and *Accessible green area.*

- *Accessible green area* increases *Cultural values* and *Recreation possibilities* which in turn increases *Human health.*

- *Biodiversity* would decrease by increase in *Contamination of soil- and groundwater,* poor *Air quality* and *Noise and vibration. Biodiversity* would increase with *Ecosystem Health* and *Recreation possibilities*.

5.5.2 Impact assessment matrix

In the matrix (table 5.3) the impacts that are considered in this EIA are listed. The method for this matrix is presented in chapter 2.3.

Table 5.3. Impact assessment matrix. The aspects that are investigated in this EIA are listed in the very left column. The impacts of the aspects are listed in the following column for each alternative.

Aspect	Alt 1	Alt 2	0-alt
Air and climate change	Increasing emission of CO_2. Risk of exceeding the EQS for NO_2 and O_3.	Increasing emission of CO_2. Risk of exceeding the EQS for NO_2, O_3 and particles.	The maximum capacity of cars could result in higher emissions of CO_2, NO_2 and O_3.
Natural values and recreation	Implementations to increase biodiversity and recreation, leads to major positive impact. Increase in human presence creates disturbance.	Increase in cars and human presence will create large disturbance with few mitigation measures causing irreversible impacts. Few implementations for recreation and biodiversity.	No changes in landscape however the present environment does not promote biodiversity and recreation.
Cultural values	Remains in the area are made more accessible to people, without being physically altered.	Remains in the area are left as they are today.	Remains in the area are left as they are today.
Energy	A small amount of electricity is produced. A relatively small amount of electricity is consumed from green sources for services other than heating.	A significant amount of electricity will be produced by solar cells, but a big amount (if not the total) is used for heating.	Electricity consumed, from green sources, amount not known.

Noise and vibration	More activities generating noise pollution and vibration, however more vegetation to absorb noise pollution. A non-significant increase compared to surrounding operations.	Fewer activities than alternative 1 but less vegetation to absorb noise pollution. A non-significant increase compared to surrounding operations.	Majority of noise and vibration outside the area, little built and high vegetation area minimize noise pollution from surrounding operations. More passengers will however increase noise in surrounding operations.
Geology and soil	Exposure of possible contaminants and some processed soil. Deforistation.	Extensive bedrock blasting and flattening of the esker. Exposure of possible contaminants. Deforistation.	Increasing amount of cars will lead to increasing contamination of the soil
Waste disposal	Increased amount of both solid waste and sewage, depending on type of facilities.	Slightly increased amount of waste, mainly from hotels, less from parkings.	No significant changes in waste amount.
Water	Risk of increased peak discharge due to a larger area of impervious surface and a higher risk of flooding.	More cars can result in an increase of pollutants that can reach Märstaån. Risk of increased peak discharge due to a larger area of impervious surface and a higher risk of flooding.	Pollutants transporting to recipients will not significantly change. The risk of flooding could increase in the future due to more heavy precipitation.

5.6 Discussion

5.6.1 Analysis of impact assessment matrix

The results from the matrix illustrates that the impacts from Alternative 1 are more positive than from Alternative 2 and the Zero alternative. There are also fewer negative impacts for alternative 1 than Alternative 2. Alternative 2 has also several great impacts which are irreversible. However, further evaluations and modifications are needed to assess the impacts. Both negative and positive impacts can occur within the same topic therefore with this matrix it is difficult assessing which impacts are most important. Another method should be included to assess the impacts further and their importance from another angle.

5.6.2 Comparison of alternatives

The largest difference between the two alternatives is the amount of greenery they provide for the area. Alternative 1 will provide the area with 40 % green areas in form of large parks, mixed open forest, green roofs and facades, and more. The focus is on integrating sustainability and recreation with parking facilities. Alternative 2 focuses mainly on parking facilities and the amount of green spaces will be 20 % in the area.

Preserving 40 % of the area for greenery with focus on sustainability could create significant positive impacts for recreation and natural values such as biodiversity. In the moment there are few or none recreational spaces in Arlanda airport region. The area of Park City consists of few natural values therefore creating Park City into a space with focus on recreation and biodiversity this could have great positive impact for the whole Arlanda airport. Constructing and changing the landscape into a space where increase in human presence will occur could have impacts on the environment and species. However, study shows that species could coexist with humans. The assumption is, when creating *Park City* with a sustainable focus this would have over weighing positive impacts, for especially natural values and recreation, compared to the negatively impacts of changes in the landscape and increase in environmental impacts.

The remains in the area are today poorly available to the public. In A1, the forest is utilized for recreation and cultural values are made more available to the public. The improved access would increase their prestige and importance, compared to current situation. Alternative 1 focus on recreation which increases the cultural value to high extent. In order to maximize the parking area in Alternative 2, the forest is not utilized for recreation to the same extent as in Alternative 1. This leads to that the cultural values are left untouched and remains poor available. Implementations to increase the recreation are also not done for Alternative 2. In order to integrate cultural values and create fewer impacts, Alternative 1 is the best option for Park City through a cultural value perspective.

Both alternatives include parking facilities which is a requirement from Swedavia. With both Alternative 1 and 2 there will be an increase in vehicles in the area therefore the alternatives could result in an increase of emissions of CO_2, NO_2 and particles.

There is a risk that the air quality is negatively affected and that the EQS for NO_2 and O_3 are not met. Since NO_2 and O_3 are known to be harmful to humans at high concentrations, exceeding these standards would be considered as a negative impact.
In the Zero alternative, the parking spaces will be used to its full capacity, therefore a minor negative impact could occur.

Implementations to increase air quality would be included in Alternative 1 and also preserving more green areas could have a positive affect on the air quality. Therefore Alternative 1 could then have lesser environmental impact than Alternative 2. In the Zero alternative, the parking spaces will be used to its full capacity, therefore a minor negative impact could occur.

According to the impacts on the soil and bedrock, both Alternative 1 and 2 will have similar low impacts with no major impacts in any of the construction or operation phases. However constructing recreational space will most likely have less impact on the soil rather than constructing a parking facility.

Alternative 1 and 2 could have a minor negative impact during the construction phase. During the operation phase both alternatives will result in an increased number of vehicles in the area. More vehicles could lead to an increased risk of leaching contaminants to the recipient, *Märstaån*, which already have a poor ecological and chemical status. Alternative 2 focus on higher capacity of parking spaces which will most likely result in increased number of vehicles, which could have a more severe impact on *Märstaån*. Since the cars would not be parked directly on the ground, the contaminants from the parked cars will be less than today.

The green patches in the area filtering N, P and metals from the surface water will reduce the contaminants in the storm water. For alternative 1, the filtering could potentially cancel the effect of more cars in the area and therefore lower the impact. Implementing wetlands in the area could also have a positive impact for the water quality by removing nutrients, decreasing the amount of storm water to the nearby stream and reduce the risk of flooding.

Alternative 1 focus on implementation for sustainability and biodiversity. An implementation to decrease the amount of storm water is to construct wetlands in the area. According to Duan *et al*. (2011), anthropogenic wetlands are a profitable alternative to conventional sewage plant. An example is from Kalmar where wetlands have been introduced to the city. Wetlands both contribute with removal of nitrogen and increase in biodiversity in the area. A wetland was constructed near Kalmar's airport due to the airport emits 40 tons of urea per year to the nearby stream. The emission from the airport contributed to most of the total nitrogen emission to the surrounding area therefore a system of wetlands was implemented for urea transformation (Thorén, 2003). This indicates that Park City could construct a wetland to decrease the negative impacts on the environment from the surrounding airport. Park City's aim is to be a flagship in sustainability for Arlanda airport therefore constructing a wetland would contribute to this aim in water quality and biodiversity.

With an increase of impervious surfaces, the risk of flooding in the area can grow by 190-310% and 230-380% for Alternative 1 respectively Alternative 2. The risk of flooding is also likely to increase in the future due to more frequent heavy precipitation.

If flooding occurs, the water quality and the ecological quality can decrease in nearby recipients, due to more sediments and risk for disturbance of the storm water and the wastewater system. This could have a minor negative impact in both alternatives.

Both Alternative 1 and 2 will probably experience an increase of noise pollution from the surrounding area with the increase in capacity for Arlanda airport. Noise pollution from activities within the area will however be non-significant compared to noise pollution from operations surrounding Park City. The possibilities to reduce noise pollution are better in Alternative 1, with higher proportion of green areas and vegetation.

According to energy consumption, the two alternatives could somewhat make Park City self-sufficient of energy. However, there is lack in information regarding the local electricity consumption in Park City today and in the future. Alternative 2 would have more solar panels on the roofs than Alternative 1, due to the alternative has other facilities on the roofs as well. This would generate more energy for Alternative 2. However Alternative 1 consists of different implementations to generate and preserve energy through geothermal heating, high efficient isolation etc. Facilities in Alternative 1 would then not need as much energy due to its efficiency.

For both alternatives, demolition waste (consisting mainly of asphalt and gravel) will be produced prior with new developments. Alternative 1 is expected to produce more waste due to the broader spectra of facilities and activities. Compared to Alternative 2, the majority of people will park their cars and directly continue to Sky City creating less of an impact regarding waste. If the mitigation measures are implemented, the increase of waste amount would not have a significant negative effect. Moreover, it could be used to produce energy in form of heat and biogas.

5.6.3 Main environmental impacts

The main risk with the exploitation of the future Park City is the increasing emissions of GHG's and the exceeding of the EQS for NO2 and O3. Removal of the current forest area will probably lead to increasing noise and vibrations during the construction phase. The processing of the soil will lead to exposure of contaminants and the flattening of the esker will have negative impacts on groundwater and the aquifer below. More waste will be produced as result of increased visitor numbers. Due to the larger impervious area that is planned, the risk of flooding is increased. Flooding is more likely to occur in the future when the precipitation will increase due to climate change.

5.6.4 Limits and uncertainties

The stakeholders that were contacted within this project had no or very poor information to provide when asked questions that were not available in any official documents. This has led to many assumptions and guessing. For example, no data were available from stakeholders about possible contamination in the soil or groundwater in the project area. Neither was any given number of present parking lots given, so an estimation of the capacity is difficult to generate.

Future development of cars is hard to forecast. Therefore, uncertainties in assumption of the amount of electrical and hybrid cars in the future remain, and thereby the level of emissions from cars moving in the area.

Fast development of self-driving cars can lead to decreased need of parking places, as it would be more convenient to send the car back home then to pay for long-term parking. Similarly, increased environmental awareness and connected behaviour changes, when e.g. more people would travel to Arlanda by public transport, carpool or fly less, would also result in decreased need for parking possibilities. Given these uncertainties, future demand for parking places in the *Park City* cannot be accurately estimated with the current knowledge.

5.6.5 Monitoring

The expected negative impacts with significant effect should be monitored under both construction and operation phase, in order to prevent environmental damage. More detailed suggestions for the monitoring shall be provided in subsequent EIAs, when exact form, purpose and positions of the new constructions will be known.

5.6.5 The influence by Sigtuna Municipality

The municipality of Sigtuna calls themselves an ECO-municipality which means working towards long term sustainable development in economics, ecological, social and democracy. The urban planning must include future generations when meeting the demands for today. Economic sustainability means economic growth cannot happen at the expense of the environment or the society. Economy should therefore focus on investing in resources which are sustainable towards the environment and society. Ecological sustainability includes everything concerning the environment and nature. Focus is therefore on biodiversity, decreasing energy consumption and decreasing waste (Sigtuna kommun, 2017). Several of the municipality's strategies are; *Develop Arlanda*, *Plan for ecological endurance*, *Attractive and social sustainable, Create a more available* and *More efficient and more sustainable transport system.* Therefore Alternative 1 of *Park City* is well in line with both Sigtuna municipality's sustainable approach and strategies.

5.6.6 Influence of Environmental Objectives

Several of the 16 environmental objectives would be affected by the realisation of Park City. These are: *Reduced Climate Impact, Clear Air, Natural Acidification only, A Non-toxic Environment, Zero Eutrophication, Flourishing Lakes and Streams, Good Quality Groundwater, Sustainable Forests, A Good Built Environment, A safe radiation environment and A Rich Diversity of Plant and Animal Life.*

At the current stage, the named objectives are mainly negatively affected by the road traffic in the area. If any of the alternatives will be realized and proposed mitigation measures are implemented, the final effects to the majority of these objectives might remain unchanged or even become less negative, compared to Zero Alternative.

"*A Good Built Environment*" objective would receive the most positive impacts, especially if Alternative 1 is realized.

Impacts on *Clear Air, Sustainable Forests* and *A Rich Diversity of Plant and Animal Life* are expected to be negative, as parts of the forest will be cut and replaced by new constructions. Extend of these impacts will depend on how much of vegetation remains and whether it is kept in its semi-natural status or changed into urban-like parks with cut lawns and lowered availability of original habitats.

Even in this case, Alternative 1 would provide more benefits, compared to Alternative 2. Alternative 1 focuses mainly on sustainability therefore implementations to increase air quality and biodiversity will be realized.

Resulting impacts to car-traffic connected objectives, i.e. *Reduced Climate Impact, Clean Air, Natural Acidification only, A Non-toxic Environment, Zero Eutrophication, Flourishing Lakes and Streams* and *Good Quality Groundwater* are challenging to forecast, given the fast development of alternative car engines. In case of fast transition to electric, or at least hybrid cars, the negative effects will diminish even if the total amount of cars in the area increases. On the contrary, the negative impact would be enhanced if combustion engines dominate even in future. Fewer cars in Park City are projected in Alternative 1; thus, Alternative 1 is favourable even in this case.

Moving parking places from open-air area to multi-story houses will positively affect *A Non-toxic Environment, Flourishing Lakes and Streams* and *Good Quality Groundwater* objectives, as pollutants will not as much leak or be washed-off by rain from cars to the soil without any purification. The new buildings in both alternatives will produce electricity by incorporated solar-cells which will be in line the *Reduced Climate Impact* objective. In Alternative 1 however the facilities will consume nearly zero-energy (Boverket 2017) through different implementations.

5.6.7 Cumulative and indirect effects

Park City will be only a minor part of the enlarged Arlanda airport and Arlandastad. Together with all the other development in the whole Arlanda area, the negative effects of the constructions will be enhanced compared to if only *Park City* would be built. This document therefore recommend to imply all the mitigation measures to decrease the negative impacts as well as to enhance the positive ones to the large possible extend.

Increased rainfall is expected in the future as a consequence of climate change. It might result in higher frequency of flooding events, which would in turn increase the level of pollutants in soil and water. Vegetation removal and enlargement of paved surfaces will decrease evapotranspiration and water-carrying capacity of soil, while it will increase heat reflectance by the surfaces, leading to changed microclimate in the area. Increased traffic and human presence, connected with higher noise levels, will further disturb animals, adding to the pressure given by habitat removal. Higher energy and service consumption will deplete remote resources as well as produce GHG emissions, adding to the climate change.

5.7 Conclusion

- The main impacts could be increasing emissions of GHG's and the exceeding of the EQS for NO_2 and O_3. Increasing noise and vibrations during the construction phase. Exposure of contaminants and negative impacts on groundwater and the aquifer below if there is impingement in the esker. More waste and increased risk of flooding.

- The proposed alternative is *Sustainable parking and recreation*, which is the better alternative due to the lower quantity of negative impacts and the amount of positive impacts.

- The planning of *Park City* must take climate change in consideration to constrain e.g. flooding from increased precipitation.

- The airport must meet the demands of the increasing amount of travellers in the future and their need of parking services.

- The planning of *Park City* is yet in its earliest stages, which results in many uncertainties and due to this, this document will me be more of a SEA than an EIA.

Altogether, *Park City* can become a model example of environmentally and socially sustainable part of future airport designs, that positively balance otherwise negative effects of aviation.

5.8 References

Airport City Stockholm (2013) *Stadsbyggnadsstrategi Airport City Stockholm.* Urban design strategy. Available at: http://www.spacescape.se/wpcontent/uploads/2015/05/projektrapport_airportcity_130301.pdf [Retrieved 2017-12-05]

Airport City Stockholm (2014) *An assessment of current and future economic contributions.* Available at: http://www.connectsweden.se/wp-content/uploads/2014/06/ACS-08032014.pdf [Retrieved 2017-12-11]

Airport City Stockholm (2017) *Sustainability and social benefits.* Available at: http://www.airportcitystockholm.com/en/sustainability-and-social-benefits/ [Retrieved 2017-12-11]

ArcDaily (2010) *1111 Lincoln Road / Herzog & de Meuron.* Available at: https://www.archdaily.com/59266/1111-lincoln-road-herzog-de-meuron [Retrieved 2017-12-13]

ArcDaily (2017) *Park 'n' Play / JAJA Architects.* Available at: https://www.archdaily.com/884956/park-n-play-jaja-architects [Retrieved 2017-12-13]

ArchitypeReview (2017) *Santa Monica Civic Center Parking Structure* Available at: http://architypereview.com/project/santa-monica-civic-center-parking-structure/ [Retrieved 2017-12-13]

Arm, M. *et al.* (2014). *Evaluation of the European recovery target for construction and demolition waste.* Report of ENCORT-CDW project. Available at: http://norden.diva-portal.org/smash/record.jsf?pid=diva2%3A724760&dswid=8135 [Retrieved2017-12-14]

Artdatabanken (2017) *Nattskärra.* Available at: https://artfakta.artdatabanken.se/taxon/102118 [Retrieved 2017-12-14]

Bennett, A.F. & Saunders, A. (2010) *Habitat fragmentation and landscape change*. I: Sodhi NS & Ehrlich PR (red.). Conservation Biology for all, ss. 88-104. Oxford University Press, Oxford. [Retrieved 2017-12-13]

Bolund, P. & Hunhammar, S. (1999) *Ecosystem services in urban areas*. Ecological Economies 29: 293-301. [Retrieved 2017-12-11]

Boverket (2017) *Införande av nära nollenergi regler i svenska byggregler.* Available at: https://www.boverket.se/sv/om-boverket/publicerat-av-boverket/nyheter/inforande-av-nara-nollenergiregler-i-svenska-byggregler/ [Retrieved 2017-12-14]

Chiquet, C., Dover, J. W., & Mitchell, P. (2013) Birds and the urban environment: the value of green walls. *Urban Ecosystems*, *16*(3), 453-462. [Retrieved: 2017-12-18]

Costanza, R. *et al.* (1997) *The value of the world's ecosystem services and natural capital*. Nature 387: 253-260. [Retrieved: 2017-12-15]

Countryside Recreation Network. (2006) *A Countryside for Health and Wellbeing: The Physical and Mental Health Benefits of Green Exercise*. Available at: http://www.thehealthwell.info/node/3900 [Retrieved: 2017-12-07]

Duan, N. *et al*. (2011) *Evaluating the environmental impacts of an urban wetland park based on energy accounting and life cycle assessment: A case study in Beijing Wetlands in China*. Ecological Modeling 222: 351–359. [Retrieved 2017-11-15]

Genberg, J. (2016) *Environmental objectives – clean air.* Naturvårdsverket, 2016. Avaliable at: http://www.miljomal.se/Environmental-Objectives-Portal/Undre-meny/About-the-Environmental-Objectives/2-Clean-Air/ [Retrieved 2017-11-29]

Google maps (2017) Available at: http://www.sk6lk.se/elev_path.html [Retrieved 2017-12-05]

Haglund, A., Allmér, J. & Nilsson, M. (2010) *Naturinventering Stockholm Arlanda Airport*. Ekologigruppen AB. [Retrieved 2017-11-29]

Institutet för transportforskning (TFK) (2002) *Översikt av åtgärder för bättre luftkvalitet.*TFK. Report: 2002:9 Available at: https://www.trafikverket.se/contentassets/58c6bc42486b4eefaa8f1aea0cd732e8/oversikt_av_atgarder_for_battre_luftkvalitet_tfk_rapport_2002_9.pdf [Retrieved 2017-12-13]

Intergovernmental panel on climate change (IPCC) (2013) *Climate change 2013 the physical science basis – summary for policymakers.* Intergovernmental panel on climate change (IPCC). Available at: http://www.ipcc.ch/report/ar5/wg1/ [Retrieved2017-12-13]

Liljenström, C. *et al.* (2014) *Byggproduktionens miljöpåverkan i förhållande till driften. Livscykelberäkning av klimatpåverkan och energianvändning av ett nyproducerat flerbostadshus i betong med lågenergiprofil.* IVL rapport C32. Available at: http://www.ivl.se/download/18.343dc99d14e8bb0f58b76c4/1445517730807/B2217_ME.pdf [Retrieved 2017- 12-13]

Lindman, T. (2013) *A natural garden - a design proposal built on biodiversity.* Självständigt arbete vid LTJ-fakulteten, SLU. Available at: https://stud.epsilon.slu.se/6266/1/lindman_t_131031.pdf [Retrieved 2017-12-09]

LMNO engineering (2015) The rational method Available at: https://www.lmnoeng.com/Hydrology/rational.php [Retrieved 2017-12-15]

Länsstyrelsen Stockholms län (2017a) *Stockholmsåsen -Arlanda* Avaliable at: http://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA76799326 [Retrieved 2017-11-29]

Länsstyrelsen Stockholms län (2017b) *Märstaån.* Available at: http://viss.lansstyrelsen.se/Waters.aspx?waterMSCD=WA23364451 [Retrieved 2017-11-29]

Malmgren, J. (2002) *Triturus cristatus, Större vattensalamander.* ArtDatabanken, SLU. Available at: https://artfakta.artdatabanken.se/taxon/100141 [Retrieved 2017-12-05]

Mowen, A. et al. (2007) *The Role of Park Proximity and Social Support in Shaping Park Visitation, Physical Activity, and Perceived Health Among Older Adults.* Journal of Physical Activity and Health, 4, 167-179. Available at: https://www.researchgate.net/publication/6266107_The_Role_of_Park_Proximity_and_Social_Support_in_Shaping_Park_Visitation_Physical_Activity_and_Perceived_Health_among_Older_Adults [Retrieved 2017-12-10]

Myndigheten för samhällsskydd och beredskap (MSB) (2010) *Konsekvenser av översvämning i Mälaren – Bilagarapport.* Myndigheten för samhällsskydd och beredskap (MSB). Publication number: MSB407 - maj 2012. Available at: https://www.msb.se/sv/Produkter--tjanster/Publikationer/Publikationer-fran-MSB/Konsekvenser-av-en-oversvamning-i-Malaren---bilagerapport/ [Retrieved 2017-12-13]

Naturvårdsverket (2017a) *Luftföroreningar och dess effekter.* Available at: http://www.naturvardsverket.se/Sa-mar-miljon/Klimat-och-luft/Luftfororeningar/ [Retrieved 2017-12-07]

Naturvårdsverket (2017b) *God bebyggd miljö.* Available at: http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Sveriges-miljomal/Miljokvalitetsmalen/God-bebyggd-miljo/ [Retrieved 2017-12-06]

Naturvårdsverket (2017c) *Säker strålmiljö.* Available at: http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Sveriges-miljomal/Miljokvalitetsmalen/Saker-stralmiljo/ [Retrieved 2017-12-06]

Naturvårdsverket (2017d) *Buller.* Available at: http://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledningar/Buller/Miljokvalitetsnorm-for-buller/ [Retrieved 2017-12-06]

Naturvårdsverket (2017e) *Buller från vägar och järnvägar.* Available at: http://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledningar/Buller/Buller-fran-vagar-och-jarnvagar-nybyggnation/ [Retrieved 2017-12-10]

Naturvårdsverket (2017f) *Buller från byggplatser.* Available at: https://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledningar/Buller/Buller-fran-byggplatser/ [Retrieved 2017-12-10]

Naturvårdsverket (2017g) *EU's återvinningsmall för byggavfall.* Available at: http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Uppdelat-efter-omrade/Avfall/Avfallsforebyggande-program/Bygg--och-rivningsavfall/EUs-atervinningsmal-for-byggavfall/ [Retrieved 2017-12-14]

Naturvårdsverket (2017h) *Avlopp*. Available at: http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Uppdelat-efter-omrade/Avlopp/ [Retrieved 2017-12-14]

Riksantikvarieämbetet (2017) *Fornsök*. Avaiable at: http://www.fmis.raa.se/cocoon/fornsok/search.html [Retrieved 2017-12-01]

Samia, D. S. M., Nakagawa, S., Nomura, F., Rangel, T. F., & Blumstein, D. T. (2015) *Increased tolerance to humans among disturbed wildlife*. Nature Communications, 6, 8877. Available at: http://doi.org/10.1038/ncomms9877 [Retrieved 2017-12-10]

SFS Kulturmiljölagen (1988:950) [Retrieved 2017-12-01]

Sigtuna kommun (2009) *Detaljplan för Femte stadsdelen inom Arlandastad omfattande del av fastigheten Norslunda 50:1 i Sigtuna kommun, Stockholms län*. Available at: http://www.sigtuna.se/Global/Bygga_bo_trafik/Planering/Detaljplaner/Program%20och%20detaljplaner/M%C3%A4rsta/Femte%20stadsdelen/U_Planbeskrivning%20Femte%20stadsdelen.pdf [Retrieved 2017-12-05]

Sigtuna kommun (2017) *Sigtuna kommun utvecklas på ett hållbart sätt.* Available at: http://www.sigtuna.se/Hallbarhet/ [Retrieved 2017-12-18]

SGU (2017) *Kartgeneratorn.* Available at: http://apps.sgu.se/kartgenerator/maporder_sv.html [Retrieved 2017-12-27]

Skogsstyrelsen (2017) *Skogen lagrar kol.* Available at: https://www.skogsstyrelsen.se/miljo-och-klimat/skog-och-klimat/skogen-lagrar-kol/ [Retrieved 2017-12-06]

Stockholms stad (2017) *Miljöbarometern*. Available at: http://miljobarometern.stockholm.se/klimat/klimat-och-vaderstatistik/solinstralning/arsvarden/?start=2007&end=2016 [Retrieved 2017-12-16]

Svensson, M. & Tjernberg, M. (2010) *Caprimulgus europaeus, Nattskärra.* ArtDatabanken, SLU. Available at: https://artfakta.artdatabanken.se/taxon/1708 [Retrieved 2017-12-05]

Svensson, R., Svensson-Wigren, M. & Edqvist, M. (2006) *Camelina microcarpa, Sanddådra.* ArtDatabanken, SLU. Available at: https://artfakta.artdatabanken.se/taxon/1708 [Retrieved 2017-12-05]

Swedavia (2013) *Presentation*. Available at: https://www.google.se/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&ved=0ahUKEwi60f7M04HYAhUHQpoKHb93ANIQFgg2MAI&url=http%3A%2F%2Fwww.aaarea.nl%2Finformatiebank%2Fstudiereizen%3Fcms%255Bcm736%255D%255Bdownload%255D%3D455&usg=AOvVaw3D_G8ovhEYMwQLOISjrhB- [Retrieved 2017-12-02]

Swedavia (2017a) *Stockholm Arlanda Airport sets new passenger record.* Available at: https://www.swedavia.com/arlanda/press/stockholm-arlanda-airport-sets-new-passenger-record/#gref [Retrieved 2017-12-12]

Swedavia (2017b) *Grannar.* Available at: https://www.swedavia.se/arlanda/grannar/#gref. [Retrieved 2017-12-01]

Swedavia (2017c) *Akvifären.* Available at: https://www.swedavia.se/arlanda/miljo/akvifaren/#gref [Retrieved 2017-12-01]

Swedavia (2017d) *Miljörapport 2016 Stockholm Arlanda Airport.* Document number: D 2017-01674. Available at: https://www.swedavia.se/globalassets/miljotillstand-arlanda/miljorapportering/miljorapport-arn-2016.pdf [Retrieved 2017-12-02]

Swedavia (2017e) *Environment*. Available at: https://www.swedavia.com/arlanda/environment/#gref [Retrieved 2017-12-01)]

Swedavia (2016) *Om flygplatsen.* Stockholm Arlanda Airport. Available at: https://www.swedavia.se/arlanda/om-flygplatsen/#gref [Retrieved 2017-11-30]

Swedish Environmental Code (1998:808) [Retrieved 2017-11-29]

Thorén, A-K. (2003) *Ureaomvandling och dess betydelse för kvävereduktion i en våtmark: fallet Kalmar Dämme slutrapport Juni 2003*. Luftfartsverket institutionen för biologi och miljövetenskap. [Retrieved 2017-12-15]

Trafikverket (2017a) *Mått för ljudnivåer.* Available at: https://www.trafikverket.se/for-dig-i-branschen/miljo---for-dig-i-branschen/buller-och-vibrationer---for-dig-i-branschen/Fakta-om-buller-och-vibrationer/matt-for-ljudnivaer/ [Retrieved 2017-12-06]

Trafikverket (2017b) *Bullerkartor - väg, järnväg och flyg.* Available at: https://www.trafikverket.se/for-dig-i-branschen/miljo---for-dig-i-branschen/buller-och-vibrationer---for-dig-i-branschen/kartlaggning-och-atgardsprogram-for-bullerenligt-eu-direktiv/bullerkartor---vag-jarnvag-och-flyg/ [Retrieved 2017-12-10]

Trafikverket (2017c) *Fakta om buller och vibrationer.* Available at: https://www.trafikverket.se/for-dig-i-branschen/miljo---for-dig-i-branschen/buller-och-vibrationer---for-dig-i-branschen/Fakta-om-buller-och-vibrationer/ [Retrieved 2017-12-11]

Trafikverket (2017d) *Buller från vägtrafik.* Available at: https://www.trafikverket.se/for-dig-i-branschen/miljo---for-dig-i-branschen/buller-och-vibrationer---for-dig-i-branschen/Fakta-om-buller-och-vibrationer/buller-fran-vagtrafik/ [Retrieved 2017-12-11]

US Department of Energy: National Renewable Energy Laboratory (2012) *Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics.* Available at: https://www.nrel.gov/docs/fy13osti/56487.pdf [Retrieved 2017-12-01]

United States Environmental Protection Agency (EPA) (2008). *Green parking lot resource guide.* United States Environmental Protection Agency Office of Solid Waste and Emergency Response. Report: EPA-510-B-08-001. February 2008. [Retrieved 2017-12-01]

Vattenmyndigheterna (2016) *Inriktiningsbeslut PFAS (summa 11), grundvatten 2016-10-25.* Available at: http://viss.lansstyrelsen.se/ReferenceLibrary/54106/Inriktkningsbeslut%20riktv%C3%A4rde%20PFAS.pdf [Retrieved 2017-11-29]

Vatten och samhällsteknik (2011) *Miljökonsekvensbeskrivning för ansökan om nytt tillstånd enligt miljöbalken -kap 7. Påverkan på vattensystem.* Stockholm Arlanda Airport. Version 1.0. 2011-04-20 Available at: https://www.swedavia.se/globalassets/7-paverkan-pa-vattensystem.pdf [Retrieved 2017-12-02]