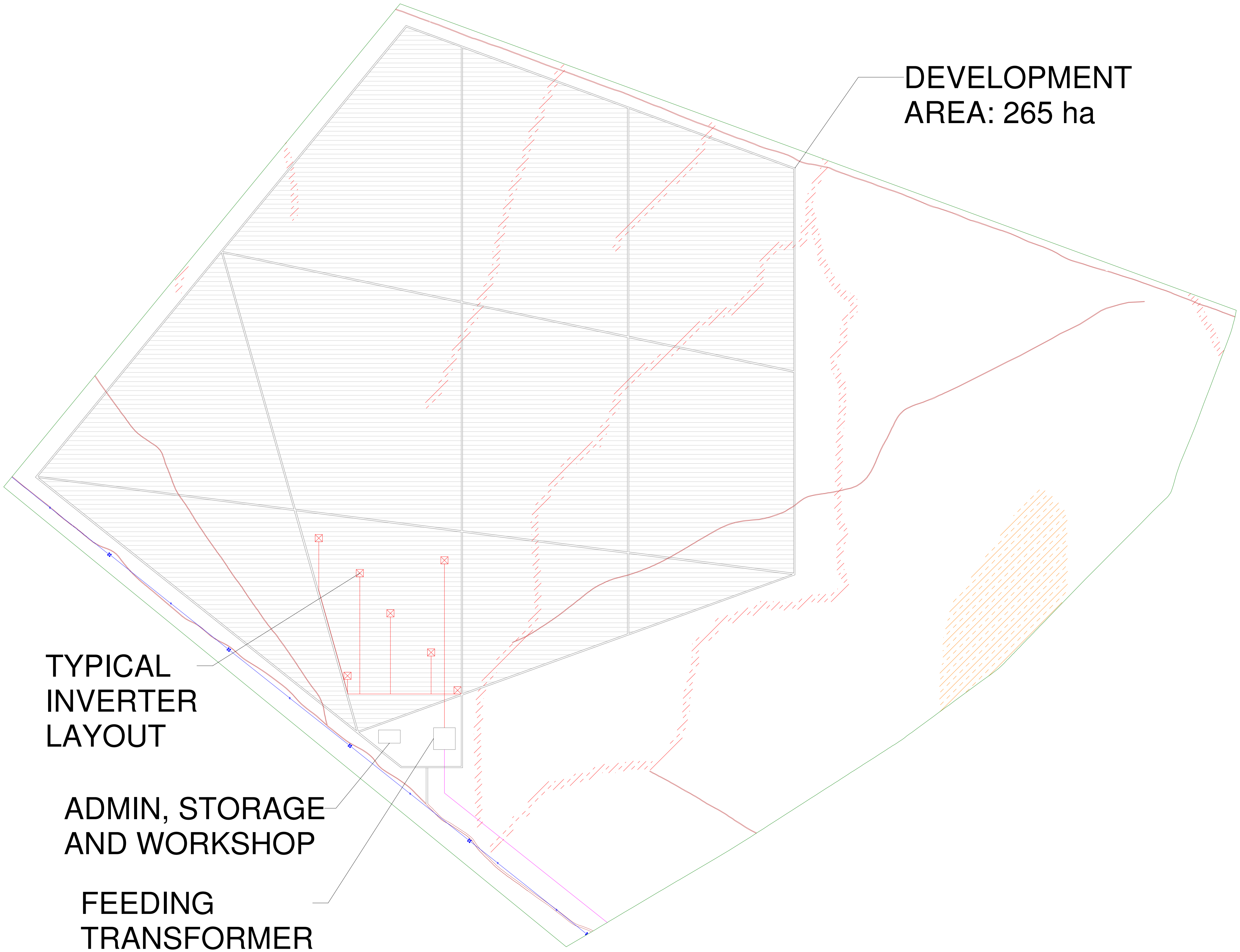
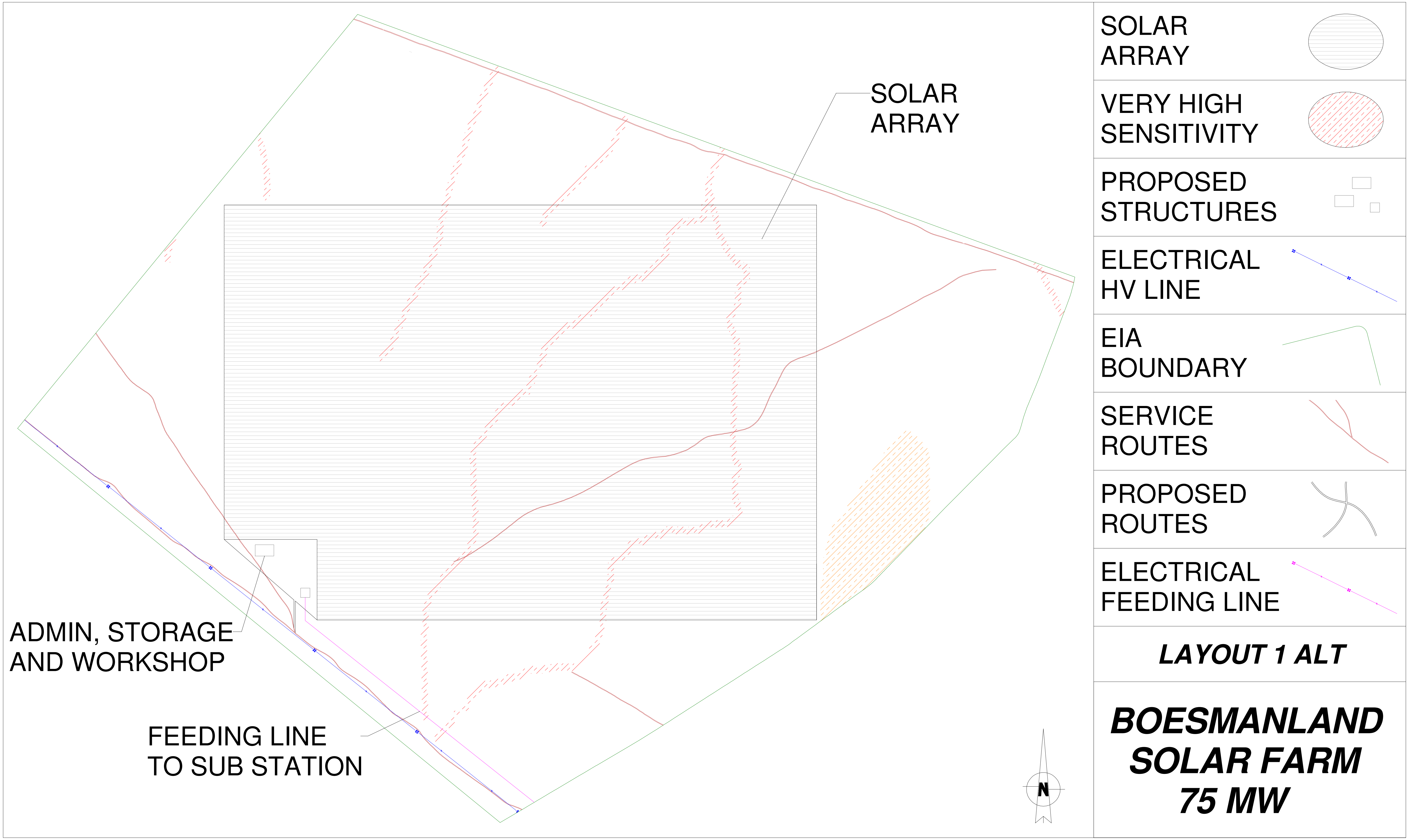


- SOLAR ARRAY
- SENSITIVE AREAS
- ELECTRICAL FEEDING LINE
- ELECTRICAL HV LINE
- INVERTER AND CONNECTION
- SERVICE ROUTES
- INTERNAL ROUTES
- PROPOSED STRUCTURES

PREFERRED LAYOUT

BOESMANLAND SOLAR FARM 75 MW


SOLAR ARRAY
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EIA BOUNDARY
SERVICE ROUTES
PROPOSED ROUTES
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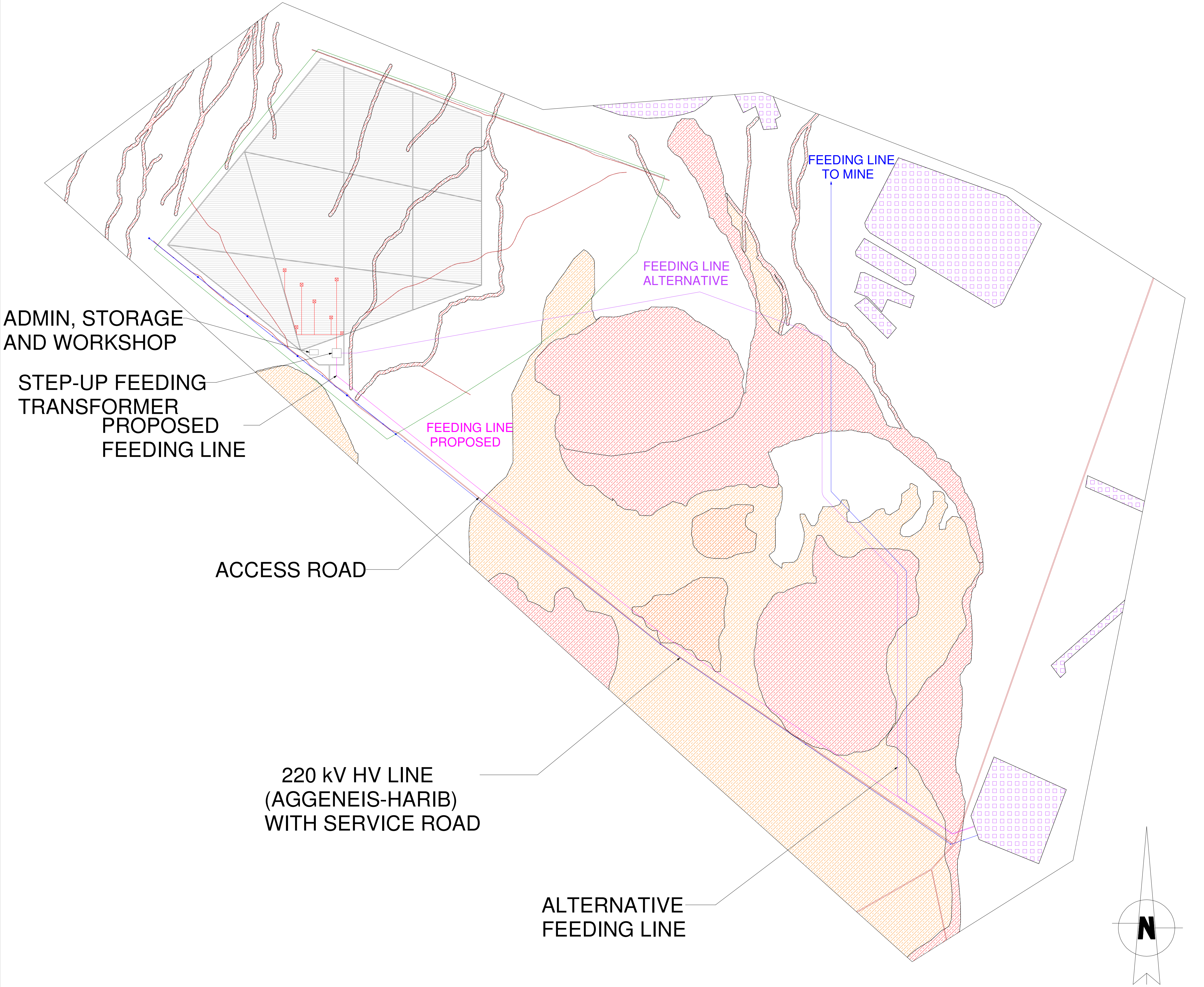
LAYOUT 1 ALT
BOESMANLAND SOLAR FARM 75 MW



EIA SITE BOUNDARY	
HIGH SENSITIVITY	
VERY HIGH SENSITIVITY	
DEVELOPED AREA	
SOLAR ARRAY	
ACCESS /SERVICE ROADS	
ELECTRICAL HV LINES	
FEEDING LINE A-PREFERRED	
FEEDING LINE B-ALTERNATIVE	

ELECTRICAL FEEDLINE LAYOUT

BOESMANLAND SOLAR FARM 75 MW

Boesmanland Solar Farm

May 18

2012

Facility Layout Report pertaining to the Boesmanland Solar Farm. Compiled by Solek (Renewable Energy Engineers)

Layout Report

Contents

List of Figures

Boesmanland Solar Farm 75MW

The Figure below shows the aerial view of the proposed 75MW Solar Facility. The section indicated in red is a 500 hectare on a portion of Farm 62, Zuurwater, in the Khai-Ma District in the Northern Cape Province. (Please note that all images refer to North as the top of the page unless otherwise specified)

Figure 1: Areal view of proposed site for PV facility and surroundings

The potential 500 hectare area was identified due its level surface, general characteristics of the substrate and the close proximity to the Aggeneis 220/66 substation, as indicated in Figure 1 above. The low concentration of nutrients in the soil also means that vegetation is not very dense or high, eliminating the chances of casting shadows on the solar arrays or having an effect of food security.

After further studies into the environmental matters applicable to the Aggeneys area and alternatives surrounding solar farm construction, it was decided to move the focus to the middle section of the identified area. It should be noted that the proposed solar arrays would be facing north to yield the best possible performance, influencing the shape of the proposed focus area.

Figure 2: Focus areas for the final 75 MW Solar Site

Preferred Layout

The solar arrays are put together with strings of solar modules connected in series and mounted onto single axis tracking systems. These frames are installed with the single tracking axis in an east-west direction to maximise the systems output. Each of the arrays is controlled individually and standardised systems are preferred for economic and practical reasons. The standardised length would be between 50 and 200m long. The single axis tracking system poses an enormous advantage over a fixed frame in that the tracking system would yield the maximum possible power for a period of time during every day of all seasons.

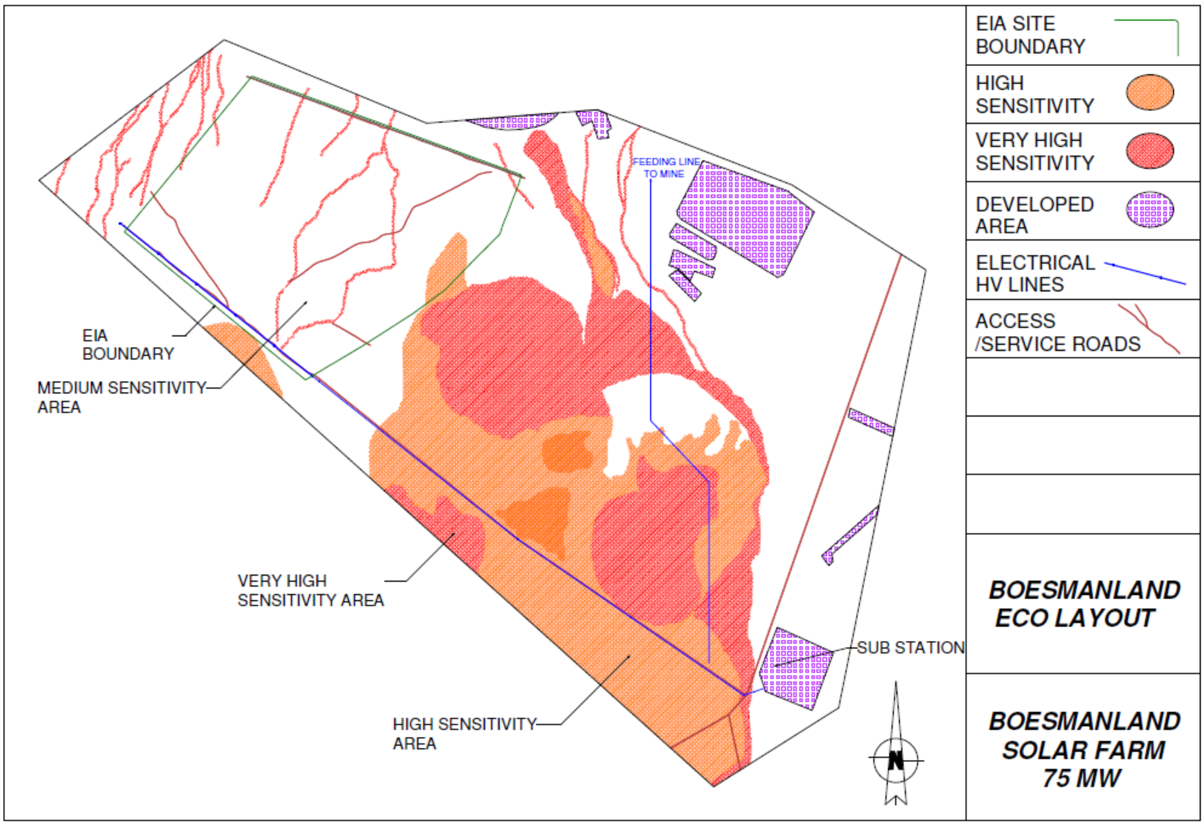


Figure 3: Ecological map of the specified area

Due to the small amount of washes and sensitive areas, any location on the identified area is suitable for utilisation for the solar facility. However, as indicated in the following figure the solar arrays will be placed in such a way that it would have the least influence on the washes while avoiding the ecological sensitive areas where practically possible. Although the annual rainfall within this region is extremely low the drainage lines were carefully considered and the most viable alternative selected.

Because of the relatively dry climate and low rainfall natural vegetation tend to be more dense in the drainage washes, thus the layout which has the smallest impact on the washes would generally also have the smallest impact on the vegetation.

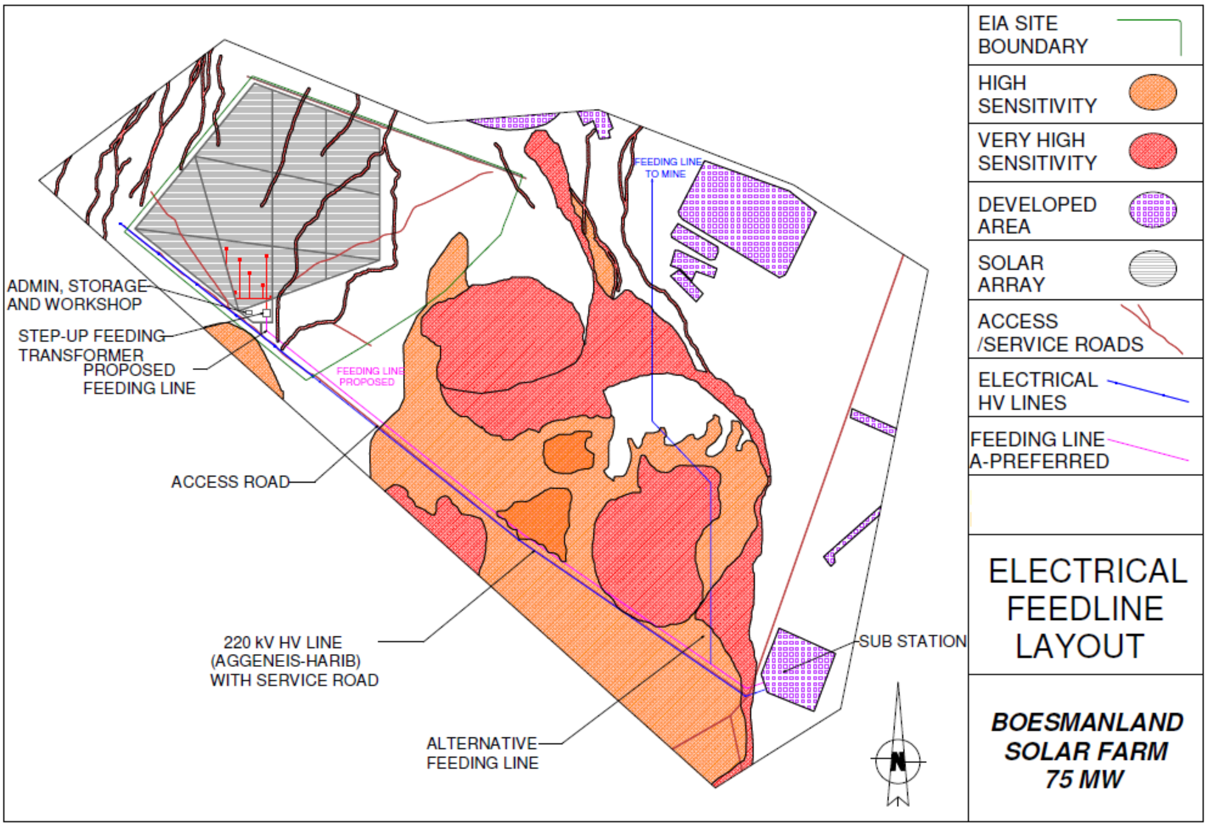


Figure 4: Preferred layout of solar arrays

The Figure above is the layout proposed for the 75MW Solar Farm within the 500 hectare accessed area. The infrastructure of the solar facility is to be less than 270 hectare and is aimed at having the lowest possible environmental impact while still keeping the project economically viable.

Site size

The two Figures below gives a zoomed-in image of the proposed facility within the EIA boundaries. The solar arrays will cover an area of approximately 270 ha. The image gives a typical indication of how the buildings and inverter layout would look. Figure 6 gives an indication of the approximate sizes of the various sections of the layout.

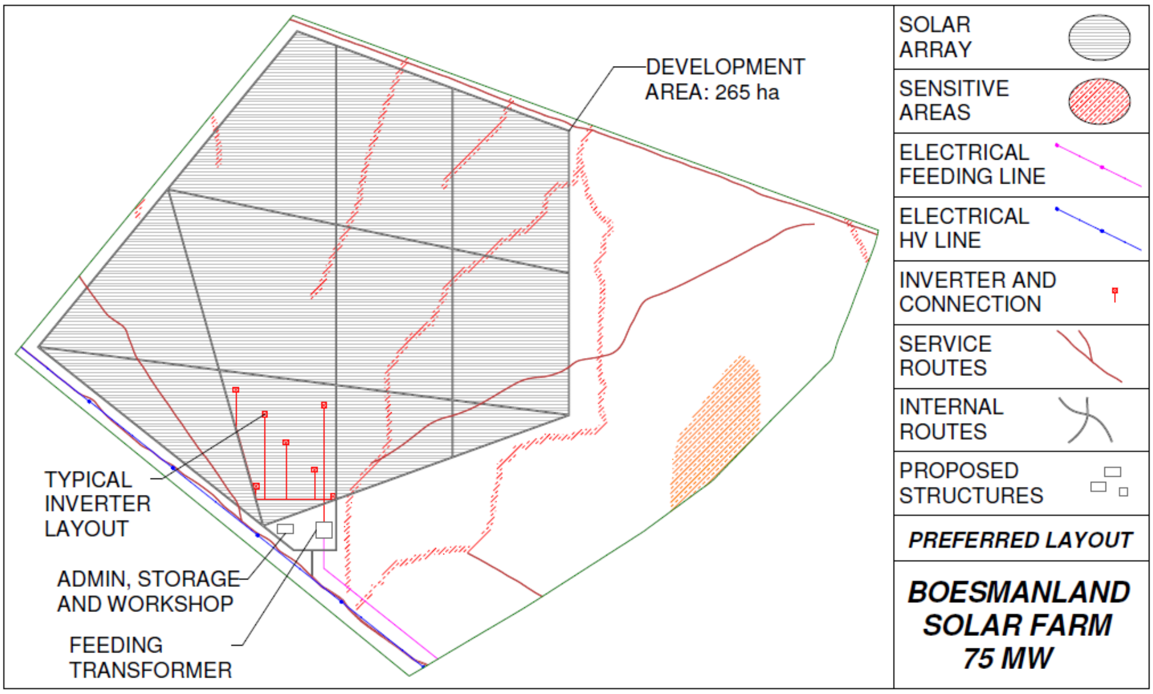


Figure 5: Preferred layout with sensitive areas indicated

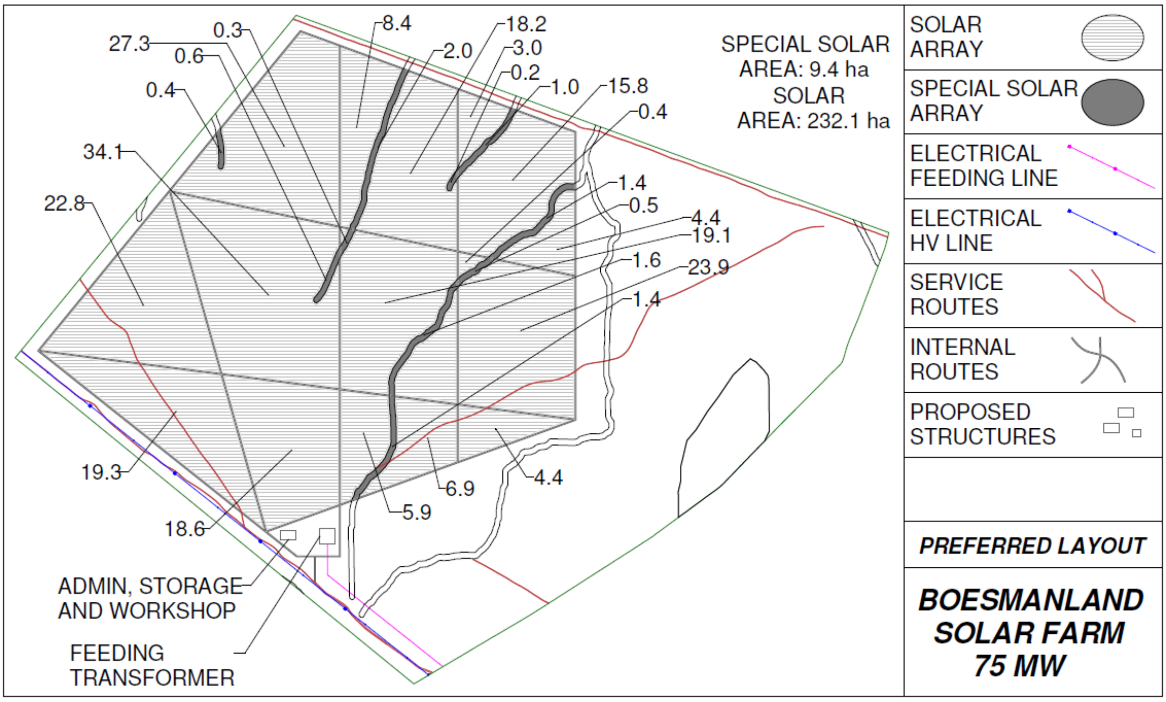


Figure 6: Preferred layout with sensitive areas and the relevant area sizes indicated

Technical aspects

The preliminary electrical design was done using modular layouts of 1 megawatt each. Thus each solar panel string capable of generating 1 megawatt of electricity would be connected to an inverter before being connected to the 75 MVA-transformer as shown in Figure 5.

The solar frames will be installed using a ramming method which would have the minimum impact on the environment. As far as practically possible the ramming poles would be driven as far as possible from all washes and according to the ecological constraints. This eliminates the need for the use of cement or polymeric products which could have a significant long term effect on the biology of the surrounding area. This method also allows the frames to have a very small mounting footprint which would avoid any obstructions to natural water flow. During the operation of the proposed plant the area would be patrolled regularly and any potential blockage could be removed swiftly as a precautionary measure avoiding the risk of erosion. Personnel would also be trained to identify early signs of erosion and how to mitigate the potential risks.

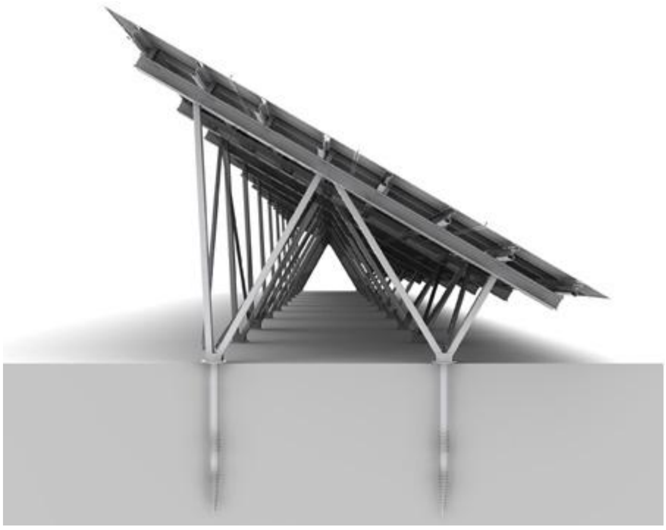


Figure 7: Rammed or screwed mounting method on fixed frame (image www.expo21xx.com)

The physical process of ramming the anchors into the ground is done using yellow equipment (construction equipment, typically on tracks). In the case where earth screws or rock anchors would be more suitable the rammed pole would be replaced by one of the former. The effect on the environment would be similar for any of the selected processes. Figure 8 below shows that equipment being used in the ramming process. Some of the ground covering in the medium sensitivity area will be cleared to do the frame installation accurately. Although the site is very flat, some minor excavation may be necessary in certain medium sensitivity areas.

In the areas of high sensitivity vegetation would be left in place to avoid the risk of erosion. In the unlikely case where brush or trees are high enough to cast shadows it would be trimmed to size. As far as practically possible these borders will be kept undisturbed.

Figure 8: (Image from www.aceinfra.com and www.kaska.eu)

The electrical feeding line would run parallel to the existing power lines, to minimise the effect on the environment. This electrical line would be kept above ground and would feed into the Aggeneis-substation (Sub-station feeding the Town of Aggeneys).

A 75MW installation would most probably make use of 75 inverting stations for converting the power produced to such a form that it could be fed into the electricity grid though the Aggeneys substation. These inverting stations are connected to a series of arrays and would be placed along the service roads to give quick and easy access. The final placement of the inverting stations would take the ground conditions into considerations, meaning that suitable areas having a minimal impact on the environment would be preferred. Interconnecting cables may be trenched where practically possible but in areas of high sensitivity cables would be mounted to the structure avoiding excessive excavation works and clearing of vegetation. These inverter stations would typically be built into a transportable container measuring 10 x 2.5m, having a footprint of 25 square meters.

The preferred inverting stations would not make use of excessive air conditioned cooling and would house a dry solid transformer. This reduces the threat of environmental risks associated with oil cooled transformers. By using advanced cooling methods air condition noise could also be limited.

The main storage, workshop, ablution and admin facilities are indicated to the south to avoid shadows being cast onto the solar arrays. The final storage and admin areas would also be selected to minimise its impact on the environment by considering the ground conditions and the ecology of the surrounding areas. Since this area may host more human activity than most other parts of the solar facility, it is important to take the surrounding habitat into consideration. The structure erected should not be more than 2000 square meters in area and is referred to in the preceding drawings as the Storage and Admin facility. Water to the facilities will be supplied by ten 10kl water tanks. These tanks will also be used as redundant water for operation of the plant.

In the case where access roads cross the washes or are in the close vicinity of the washes special care and precautionary measures must be taken to mitigate the risk of erosion due to ground disturbances. By incorporating precast concrete infrastructure into the construction of these roads the risk of the roads acting as water channels could be avoided. Special attention to drainage, water flow and erosion will be given and potential risks mitigated by applying appropriate building methods.

Alternatives Considered

Layout Alternatives

During the planning phase of the project numerous layouts and technologies were taken into consideration before the preferred proposal was decided upon. Three of the major points which lead to the preferred proposal are:

- Minimal disturbance to water washes and highly sensitive areas
- Minimum distance to the substation
- A uniform area of around 265 ha to ensure the project would be economically viable

The factor having the single biggest influence on point number one is the mounting technology. The preferred technology allows arrays to be constructed over the wash lines and high sensitivity areas while having a minimal effect on the vegetation, mitigating the chances of erosion.

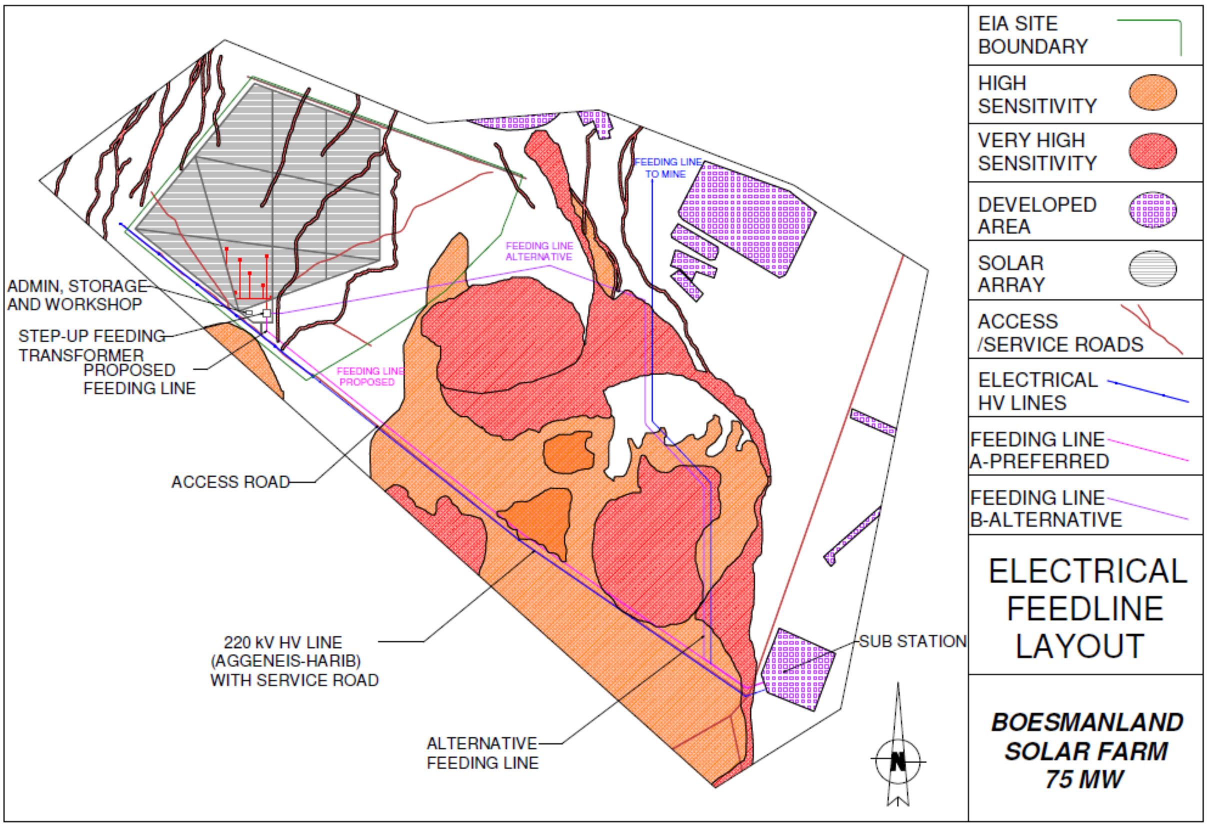


Figure 9: Alternative Electrical feed line layouts

Preliminary uniform layout

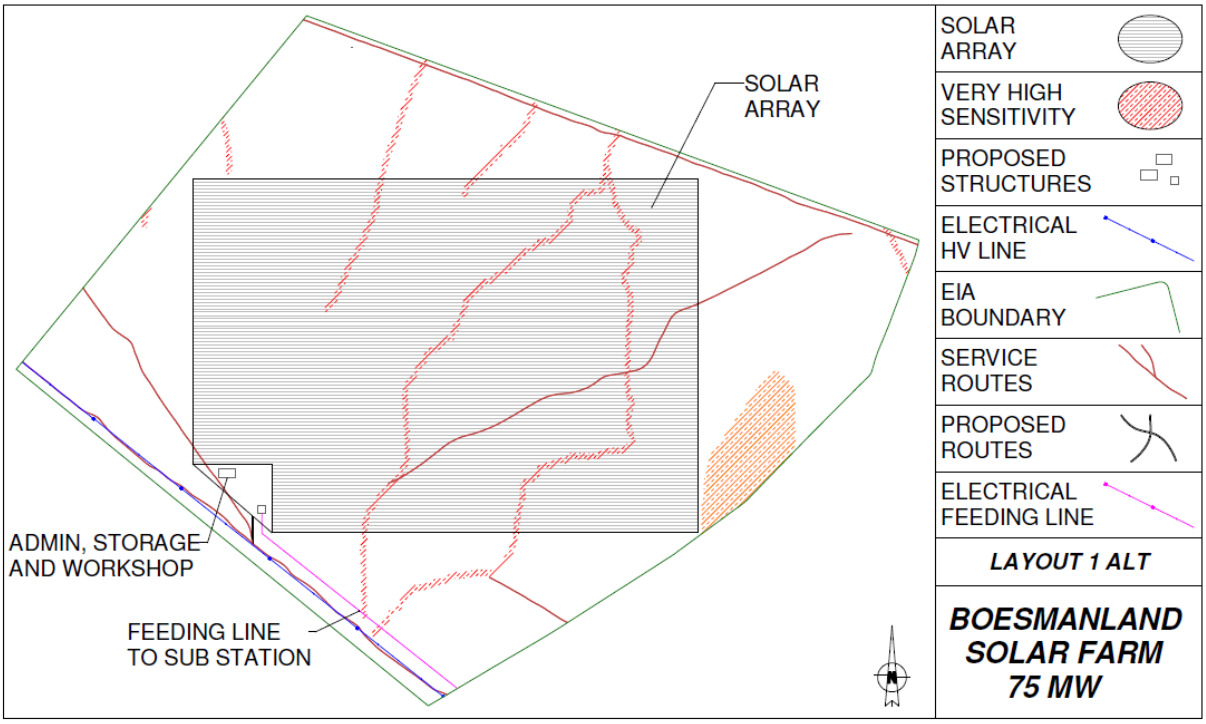
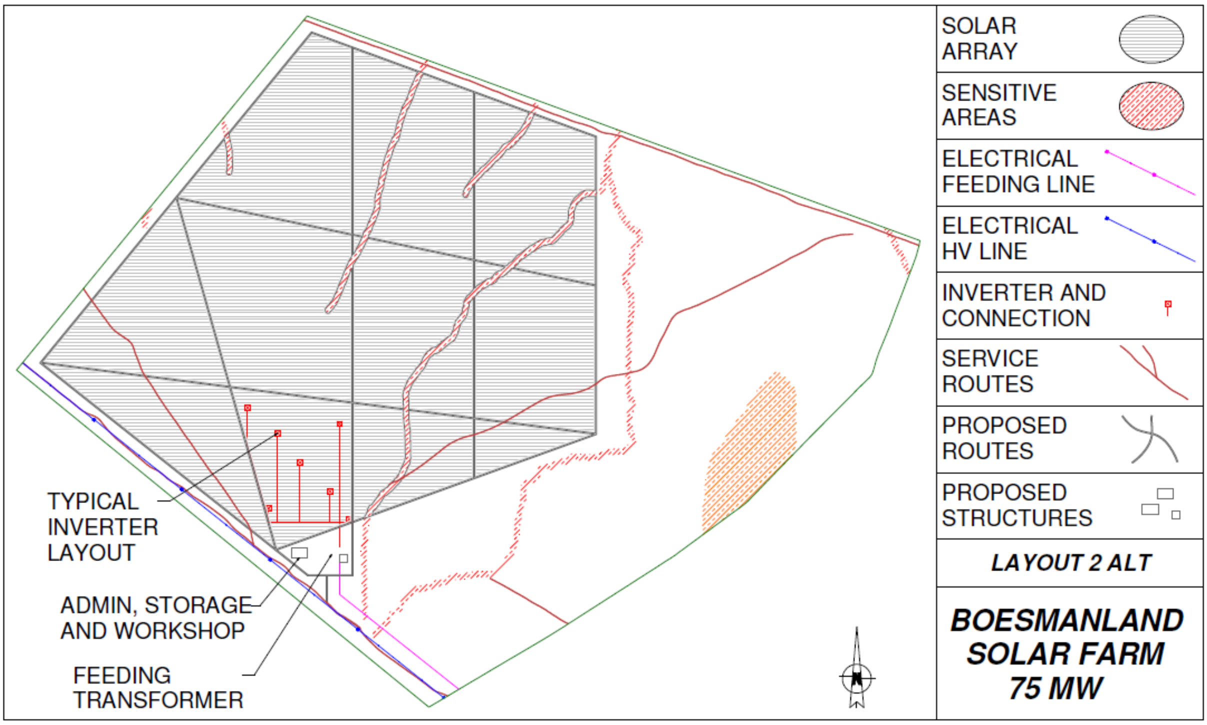


Figure 10: Original uniform layout

Scattered 5m wash boundary



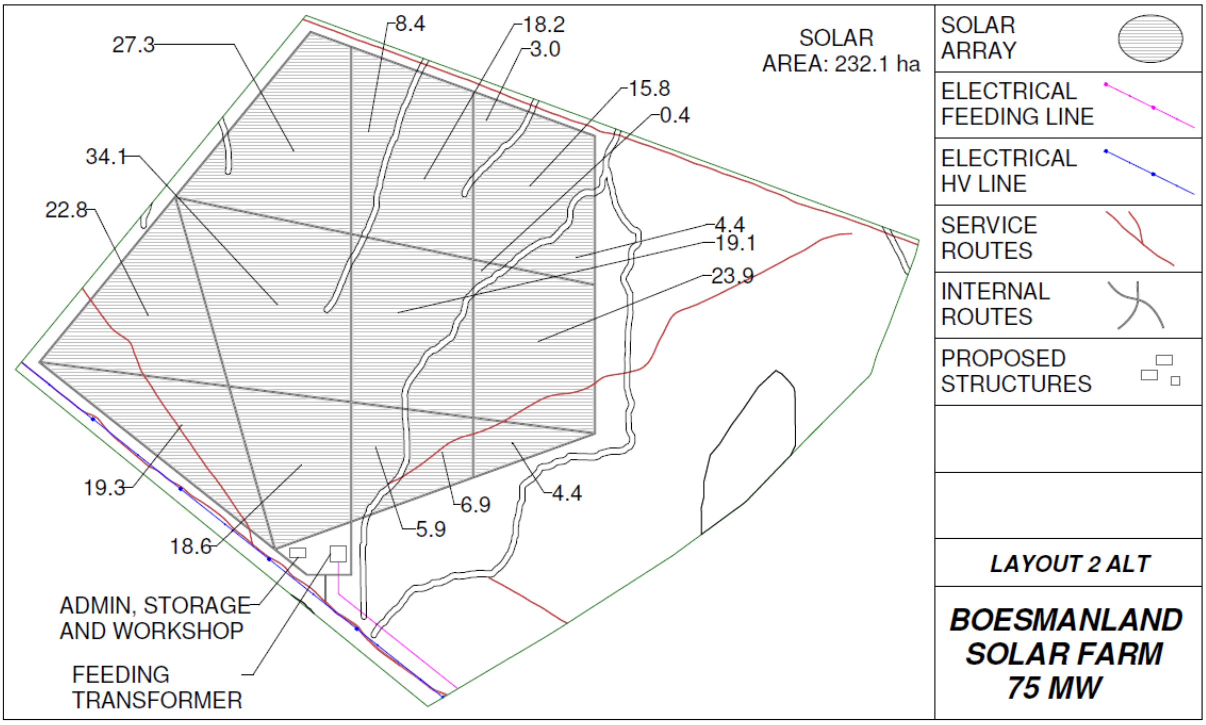


Figure 11: Layout keeping a 5m buffer from any indicated wash, with possible area sizes indicated

When the layout is scattered towards the west the development would have a slightly smaller impact on the high sensitive areas. This decreases the risk of erosion and shifting sands, and in turn the need for more expensive building techniques and equipment.

By scattering the solar arrays the modular or bulk engineering principles are essentially lost. This means that custom solutions would be required to avoid all buffers significantly increasing the price and reducing the amount of panels that would fit into the focus area. This might reduce the peak power rating of the plant to fall below the 75 MW mark.

If the layout were to be moved further east, the layout would have an increased effect on the more sensitive mountainous areas while also being more exposed to the water washes. This would have a definite decrease in usable land area, an increase in construction cost, and a higher impact on the environment due to possible erosion. All of this would also lower plant efficiency which dampens financial gain.

Alternative Solar Technology

Double Axis tracking

Two axis tracking systems were investigated due to the high yield and efficient operation of the technology. Systems incorporating this technology are very effective due to sun being tracked in more than once axis. This allows maximum radiation over the whole solar module.

Figure 12: (image from www.treehugger.com)

From the Figure above one could easily see that a much larger ground area is required due to the elevated angle combined with the rotational axis, casting very long shadows. The wind loading on this type of structure plays a much larger role when compared to the single axis technology preferred. The foundation required by this system requires steel reinforcing and a significant amount of concrete.

Due to the complexity of the control system required to operate a system like this, it is not adequately suited to isolated areas where spare parts and technicians are few and far between. Therefore more spares must be kept to keep the plant in a running condition and increasing capital layout costs.

A single axis tracking system yields maximum available power for a certain period of everyday throughout the year while stationary system would only yield the maximum available power for a certain period of time in a single season. Although the double axis technology increases this highly efficient time of the day the capital input is difficult to justify unless vast areas of land is available at a very low cost.

Thin Film Solar Modules

Opposing the thick film or multi crystalline solar modules which forms part of the preferred proposal is thin film technology (amorphous silicon or cadmium telluride). This technology is not suited to the conditions of the Northern Cape Province due to its inferior performance at high temperatures. With ambient temperatures regularly exceeding 40 °C, the proposed thick film technology easily outperforms the alternative to such an extent that any financial benefit can be disregarded.

Anchoring Alternatives

Cast Foundations

The most common foundation used for anchoring single axis tracking solar frames is concrete cast foundations. This type of foundation requires a foundation trench which is filled with concrete and reinforcing steel. Once the concrete has cured the frame could either be welded or bolted to protruding reinforcing steel, of could have been left to cure with the concrete.

This technology is much more suitable to European conditions and not for the extremely hard surfaces of the proposed site unless the concrete is castes on the surface using shutters. This process poses the risk of concrete spillages which could have long term negative effects. Further drawbacks applicable the proposed site is the negative influence on water flow, increasing the risk of erosion.

Figure 13: Shuttered foundation with double axis tracking (image www.tradekorea.com)

Precast Footing

One of the alternatives considered for the mounting of the frames is pre-cast concrete footing. This is based on the same principle as the on surface foundation casted using removable shutters. The pre-cast concrete feet could be manufactured off site, reducing the risk of concrete spillages and the need for exorbitant amounts of water in during the construction phase of the project.

The main drawback associated with pre-cast footing is the large physical footprint required to keep the structures stable. Further it may also be required that these footings are bolted or grouted to the ground surface for stability. This large footprint also increases the risk of having a negative effect on water flow increasing the risk for erosion.

Figure 14: Precast footing on tilted single axis tracker (image www.ens-newswire.com)