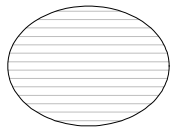
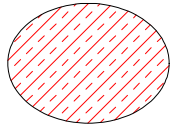
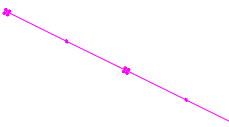
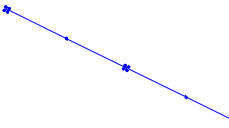


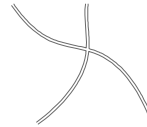

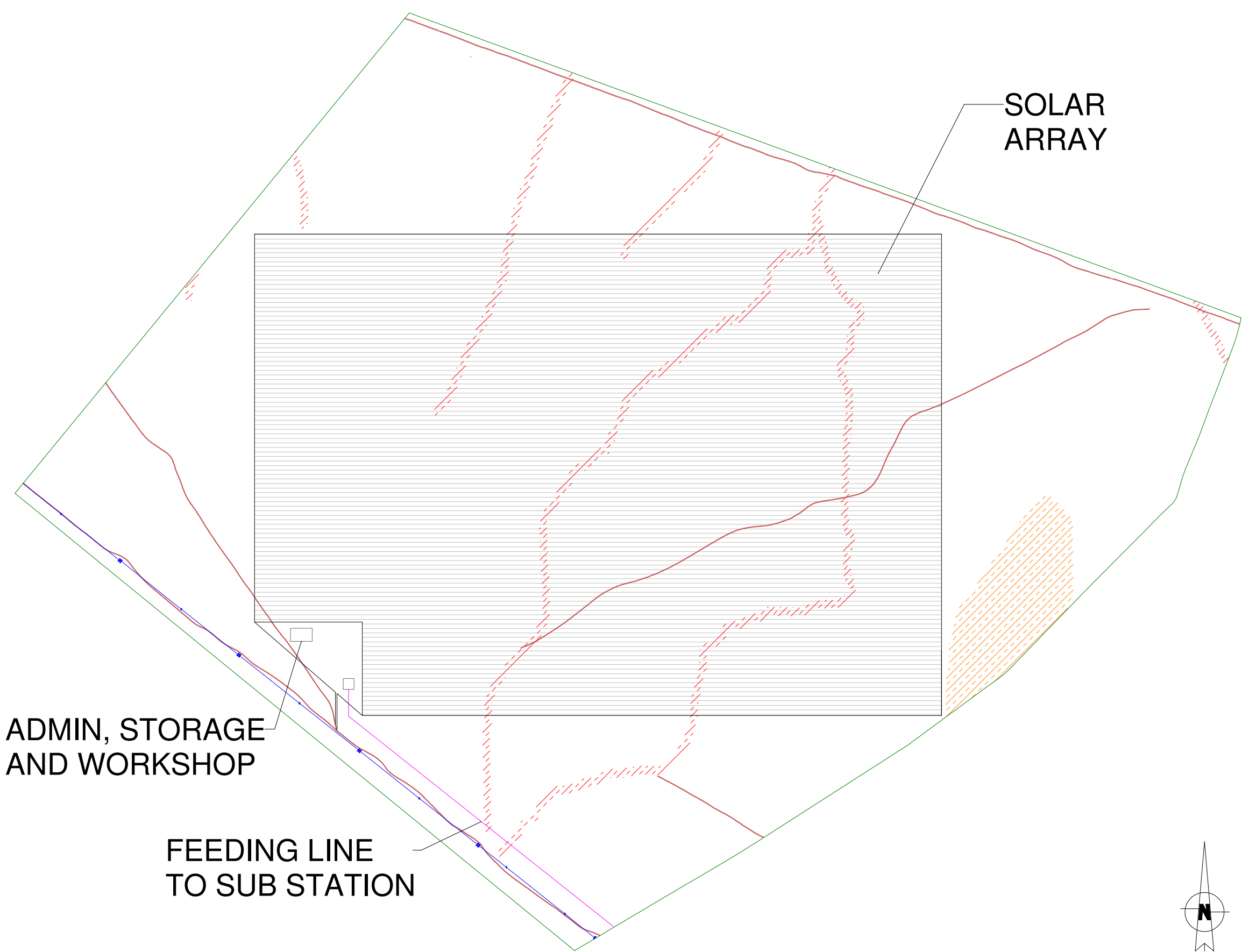
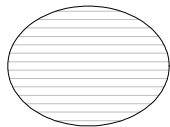
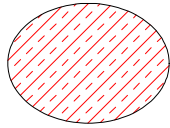

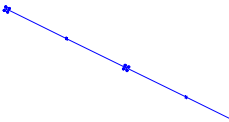

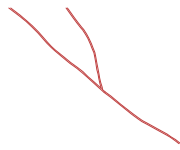
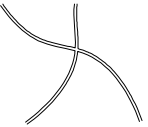
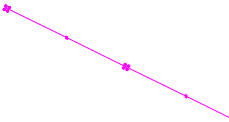
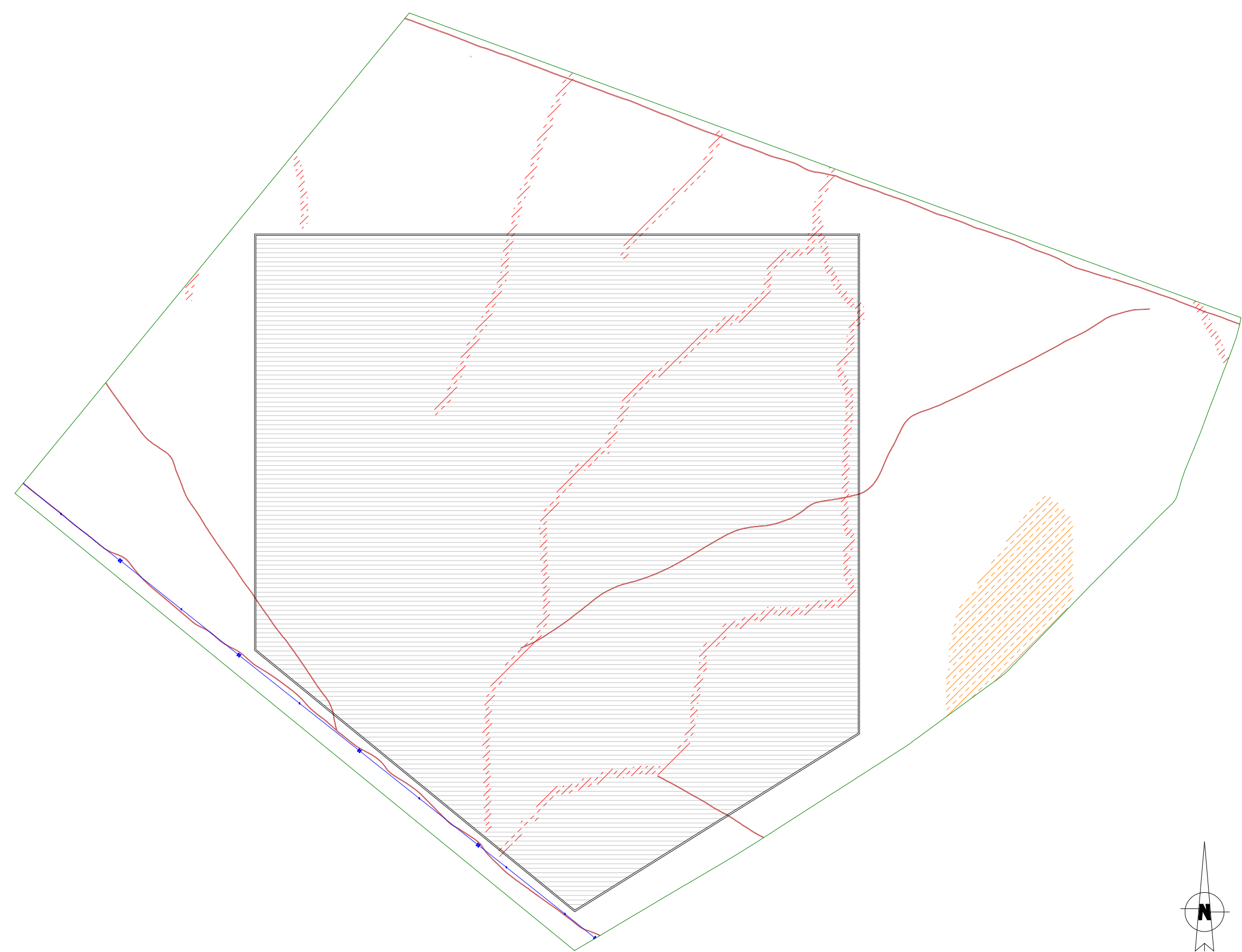
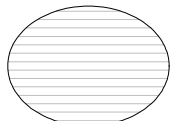
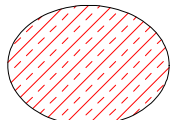
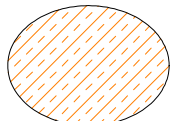
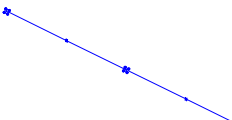

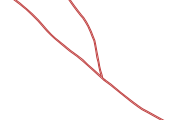
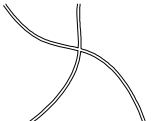
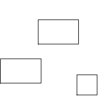


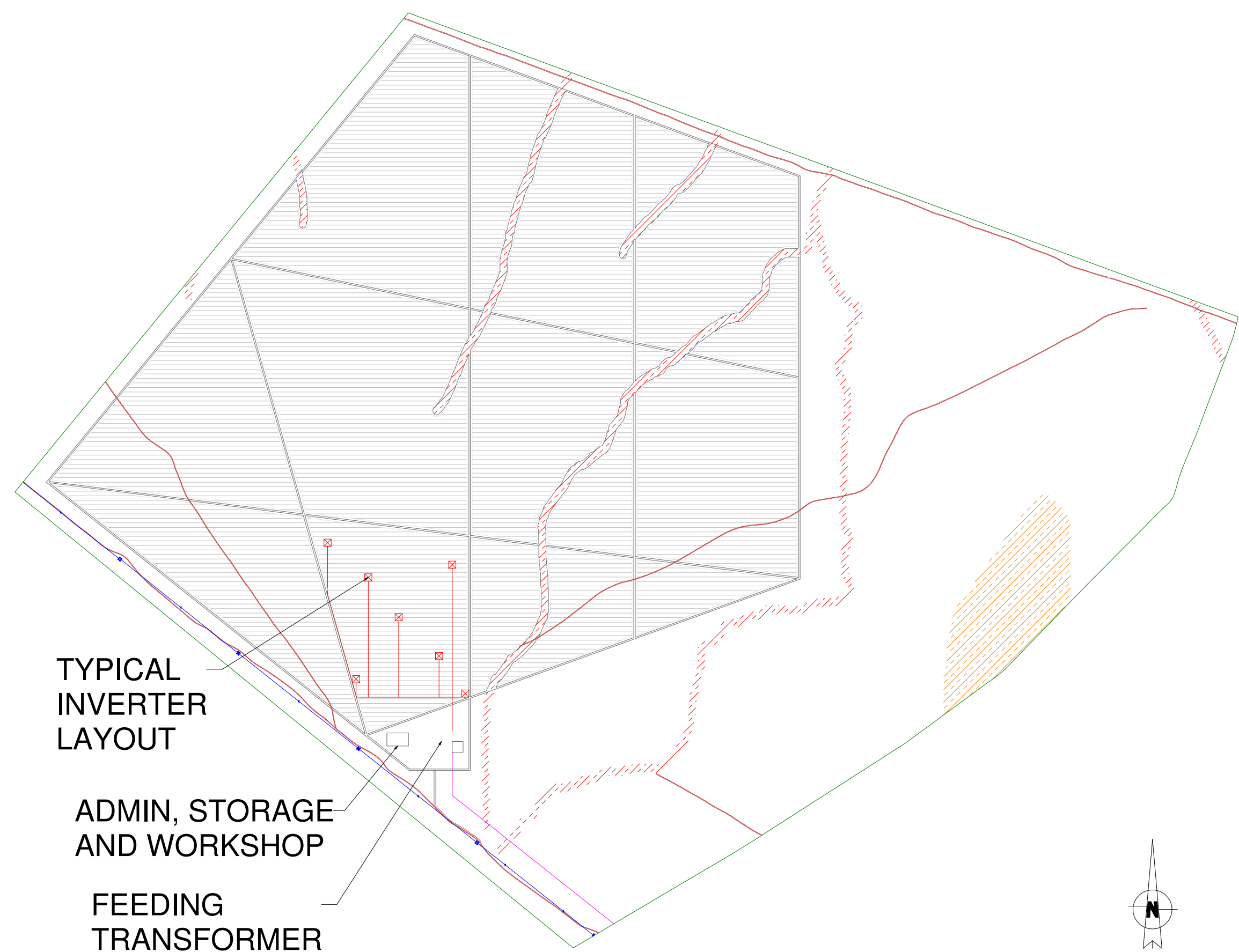
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SENSITIVE AREAS	
ELECTRICAL FEEDING LINE	
ELECTRICAL HV LINE	
INVERTER AND CONNECTION	
SERVICE ROUTES	
INTERNAL ROUTES	
PROPOSED STRUCTURES	
PREFERRED LAYOUT	
BOESMANLAND SOLAR FARM 75 MW	



SOLAR ARRAY	
VERY HIGH SENSITIVITY	
PROPOSED STRUCTURES	
ELECTRICAL HV LINE	
EIA BOUNDARY	
SERVICE ROUTES	
PROPOSED ROUTES	
ELECTRICAL FEEDING LINE	
LAYOUT 1 ALT	
BOESMANLAND SOLAR FARM 75 MW	



SOLAR ARRAY	
VERY HIGH SENSITIVITY	
HIGH SENSITIVITY	
ELECTRICAL HV LINE	
EIA BOUNDARY	
SERVICE ROUTES	
PROPOSED ROUTES	
PROPOSED STRUCTURES	
LAYOUT 3 ALT	
BOESMANLAND SOLAR FARM 75 MW	

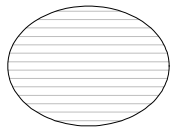


TYPICAL
INVERTER
LAYOUT

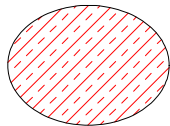
ADMIN, STORAGE
AND WORKSHOP

FEEDING
TRANSFORMER

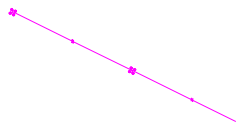
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ARRAY



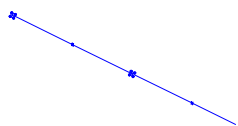
SENSITIVE
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ELECTRICAL
FEEDING LINE



ELECTRICAL
HV LINE



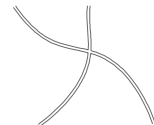
INVERTER AND
CONNECTION



SERVICE
ROUTES



PROPOSED
ROUTES

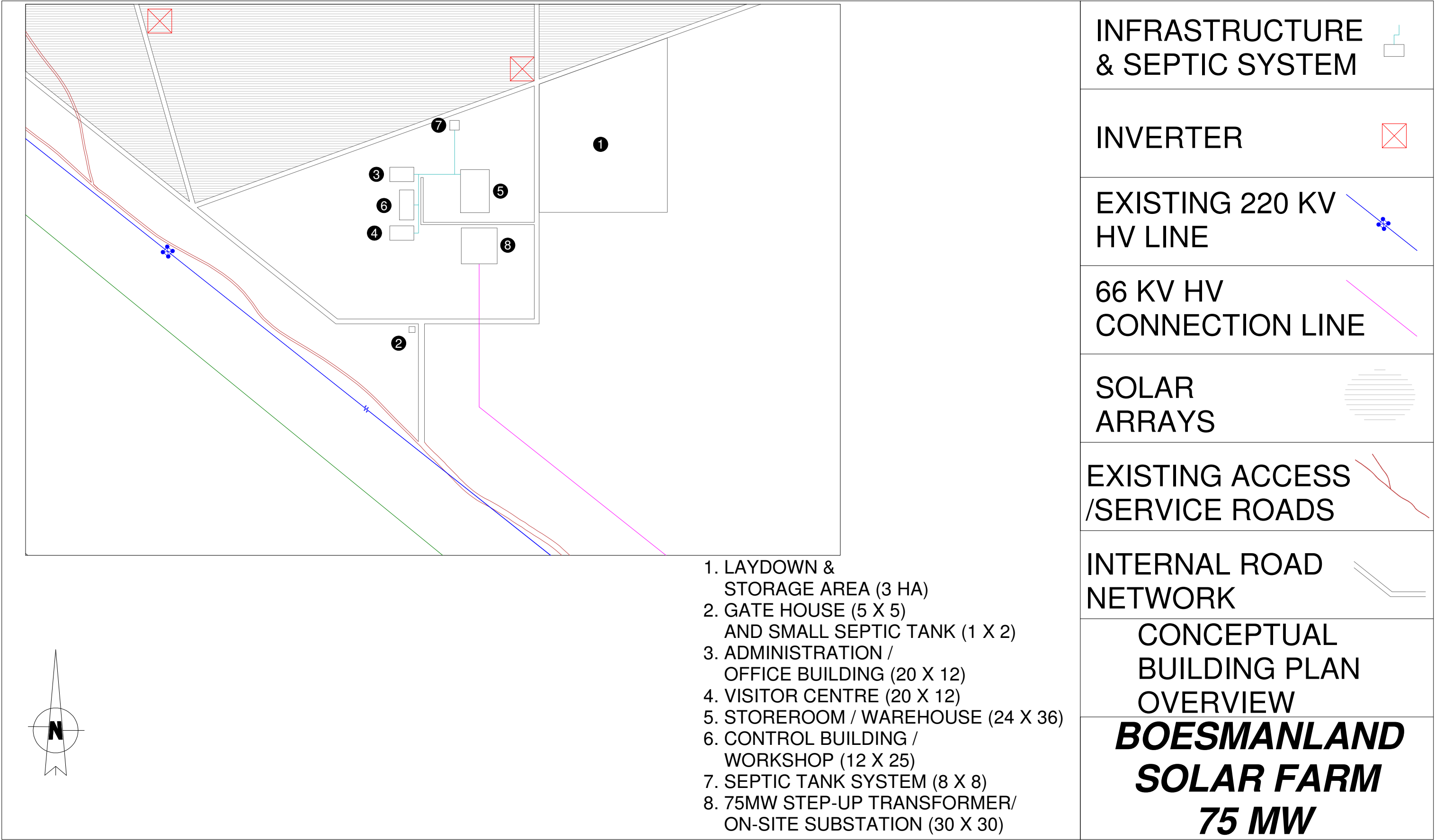


PROPOSED
STRUCTURES



LAYOUT 2 ALT

**BOESMANLAND
SOLAR FARM
75 MW**



Boesmanland Solar Farm

September

2012

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

Layout Report

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1. Boesmanland Solar Farm 75MW

The Figure below shows the aerial view of the area considered for the Boesmanland 75MW Solar Facility. The section indicated in red is approximately 500 hectare area 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)

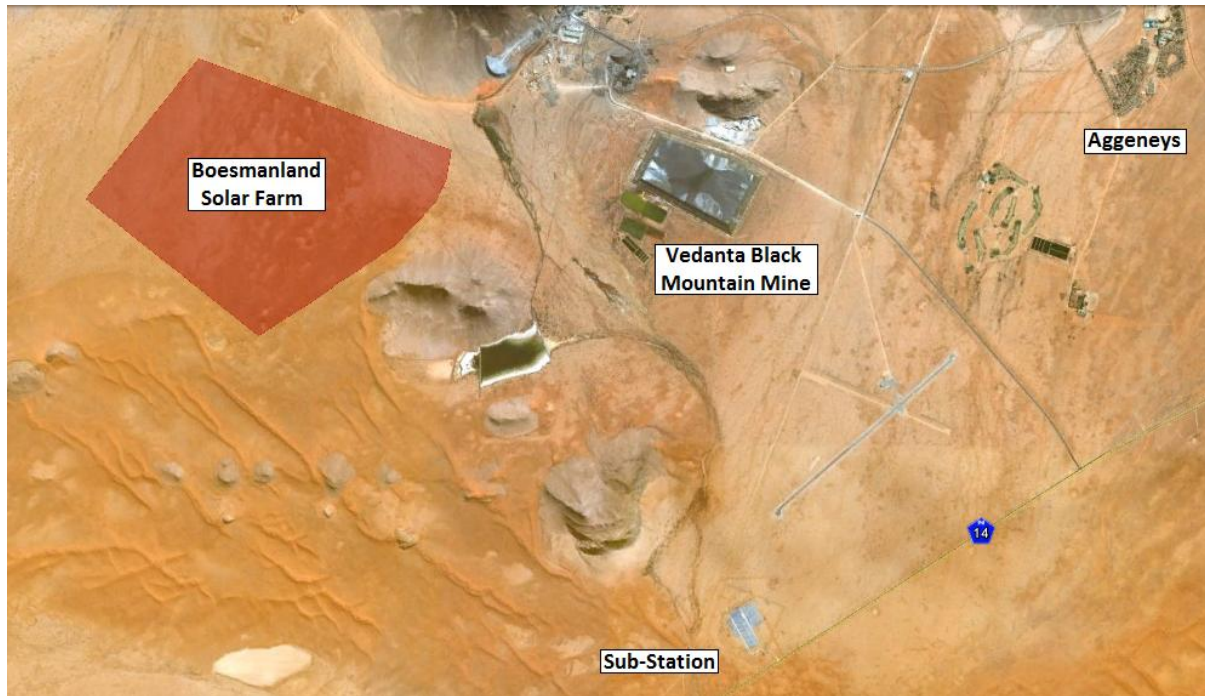


Figure 1: Areal view of proposed site for PV facility and surroundings

The 500 hectare area was identified due its level surface, general characteristics of the substrate and the close proximity to the Aggeneys 220/66kV 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 (poor agricultural potential).

After further studies into the environmental matters applicable to the Aggeneys area and alternatives regarding solar farm construction, it was decided to move the proposed development footprint to the North West 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 and layout of the proposed focus area.



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

2. 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.

The Ecological Sensitivity Map, as developed by the appointed Ecological Specialist based on his assessment of the study area (Todd, 2012), was used to inform the placement and design of the preferred layout (see figures below). The Ecological Sensitivity Map shows areas of Very-High-Sensitivity (red) delineated over the ridgelines / koppies, small 'washes' / drainage lines, as well as the large drainage and dam system arising from the Mine. Areas of High-Sensitivity (orange) have been delineated over the red sand dunes located to the south-east of the proposed solar development area (EIA study area).

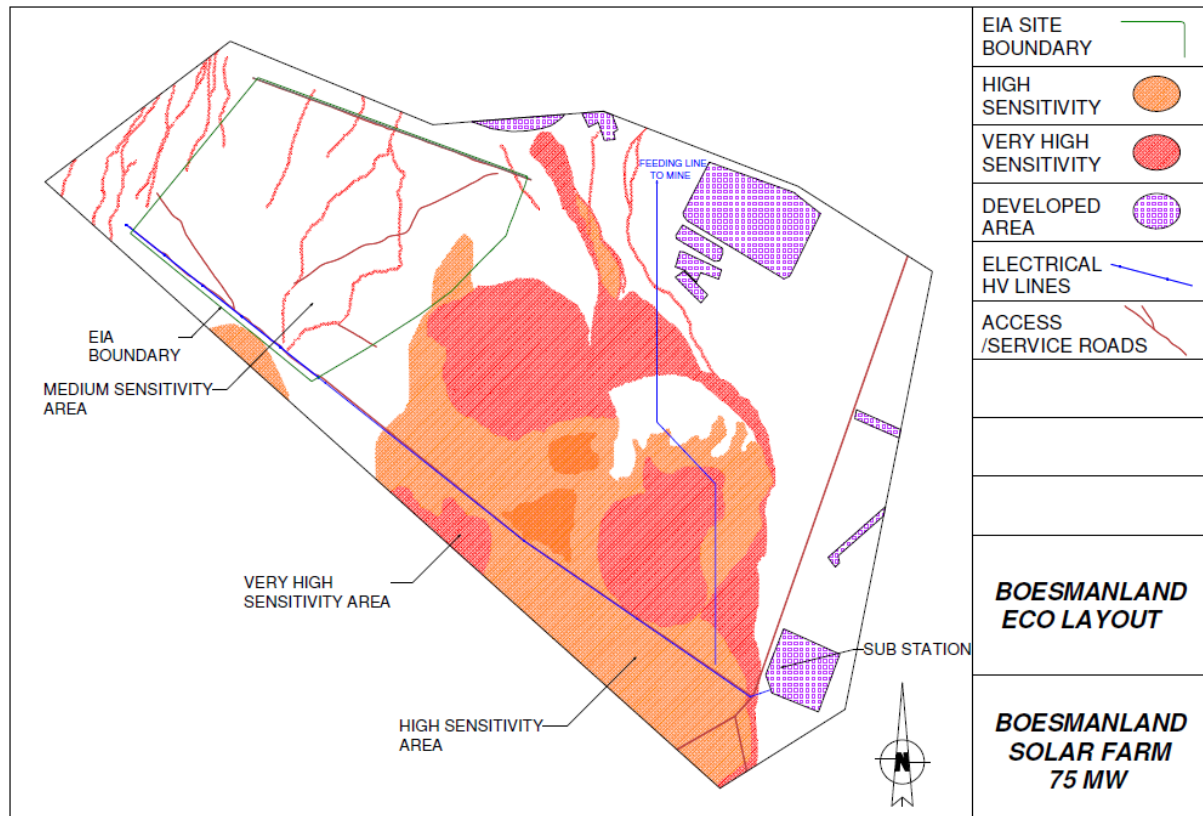


Figure 3: Ecological map of the specified area

Due to the small amount of washes and sensitive areas within the 'EIA study area', any location on the identified area is suitable for utilisation for the solar facility. However, as indicated in **Error! Reference source not found.** below, the proposed Preferred Layout for the solar arrays has been placed within the western quadrant of the greater study area, as this placement and layout shape will allow the solar arrays to have the least influence on the washes, while avoiding the ecological sensitive areas to the southeast, where practically possible. Although the annual rainfall within this region is extremely low the drainage lines were carefully considered and the most viable technological option selected to protect their integrity (see discussions on preferred 'Ramming / Driven' Founding Method / Structures in Section 2.2 below, and alternative anchoring options in Section 3.2.3 below).

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

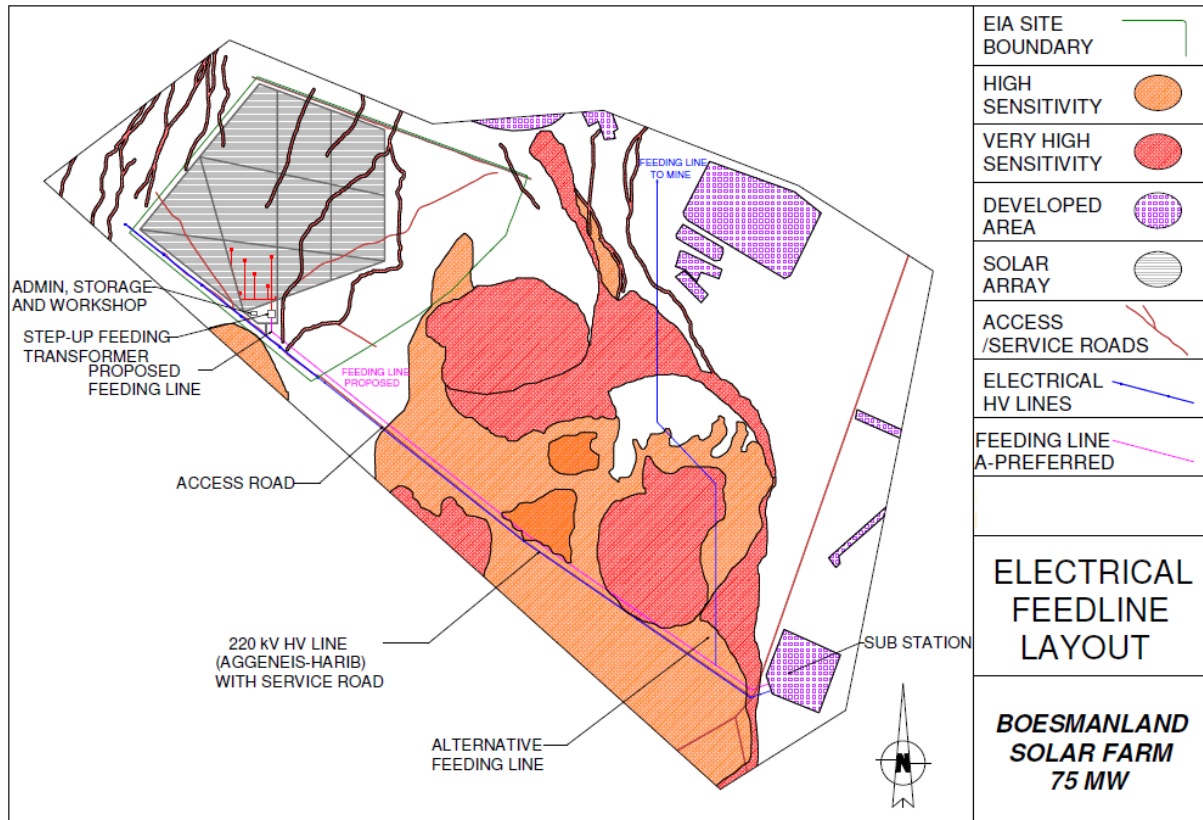


Figure 4: Preferred layout of solar arrays

The Figure above is the Preferred Layout proposed for the 75MW Solar Farm within the 500 hectare assessed 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.

2.1 Site Size

The Figure below provides a zoomed-in image of the proposed facility within the EIA boundaries. The solar arrays, and associated auxiliary buildings, will cover an area of approximately 270 ha. The image gives a typical indication of what the buildings and inverter layout would look like.

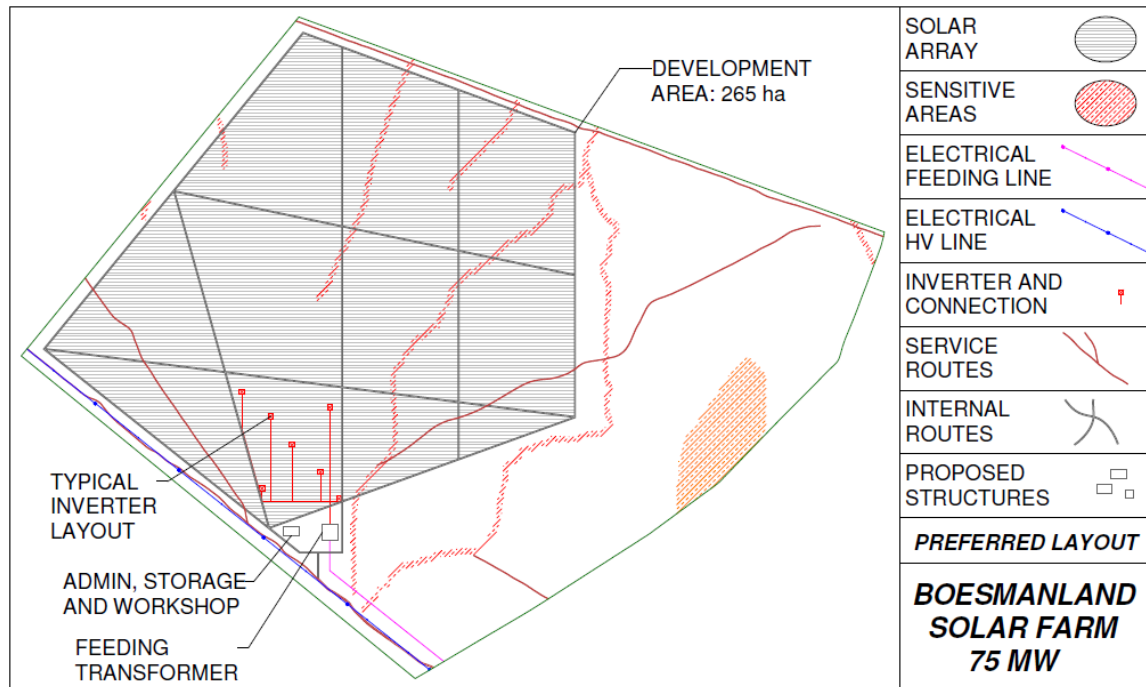


Figure 5: Preferred layout with sensitive areas indicated

2.2 Technological & 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 feeding-transformer (transmitting approximately 75 MW) as shown in **Error! Reference source not found..**

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 minimises 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 and equipment damage. Personnel would also be trained to identify early signs of erosion and methods of mitigation to the potential risks.

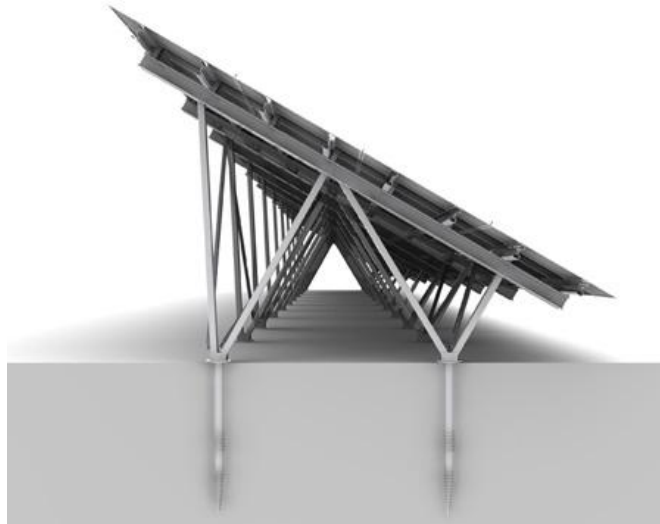


Figure 6: Rammed or screwed mounting method on fixed frame (image: www.expo21xx.com)

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. **Error! Reference source not found.** below shows that equipment being used in the ramming process. Some of the ground covering vegetation 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 (minor washes), 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 7: Construction and equipment (image: 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 Aggeneys-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 (to Alternating Current – AC) that it could be fed into the electricity

grid through the Aggeneis substation. These inverting stations are connected to a series of arrays and would be placed along the service roads (internal road network) 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 structures avoiding excessive excavation works and clearing of vegetation. These inverter stations would typically be built into a purpose built 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 placement of the storage and admin areas would also be selected to minimise their 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 storage tanks. These tanks will also be used as redundant water for operation of the plant.

The laydown area for construction material and would also be in this area as indicated in **Error! Reference source not found..** This area would be used during the construction period to store equipment and material before it is installed or used during the development stage of the project. The area would be adjacent to the workshop and office areas to avoid excessive traffic during this period while conveying equipment and materials.

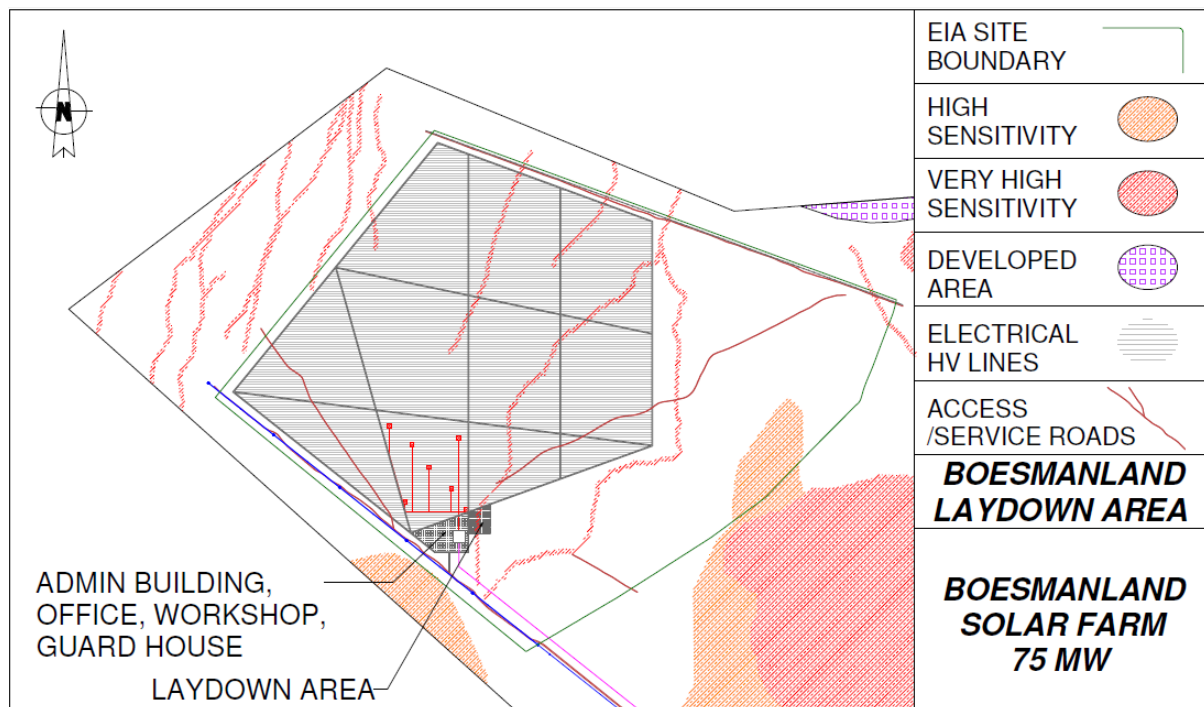


Figure 8: Laydown area during construction

In the case where access roads cross the washes, or are in the close vicinity of the washes, special care and precautionary measures will be taken to mitigate the risk of erosion due to ground disturbances. By incorporating precast concrete infrastructure (causeways, drifts or culverts) 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. Further, it should be noted that all the boundaries around the highly sensitive areas will be physically demarcated by an ecologist before any construction is started.

2.2.1 Preferred Access Road & Transmission Line Alignments

The preferred road access route from the N14 Highway to the solar site is via the existing Aggeneys Road, then via the existing mine gravel road behind the Aggeneys Airstrip and Aggeneis Substation, then along / parallel to the existing track which aligns parallel to the existing 220kV transmission line between Harib and the Aggeneis Substation (see Road Report by BVi Consulting for further details).

The preferred alignment of the overhead transmission line to connect the Boesmanland Solar Farm to the Aggeneis Substation would run parallel to the existing 220kV line, which runs along the south-western boundary of the solar facility (see Figure 9 below for alternative electrical feed options).

3. Alternatives Considered

3.1 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.

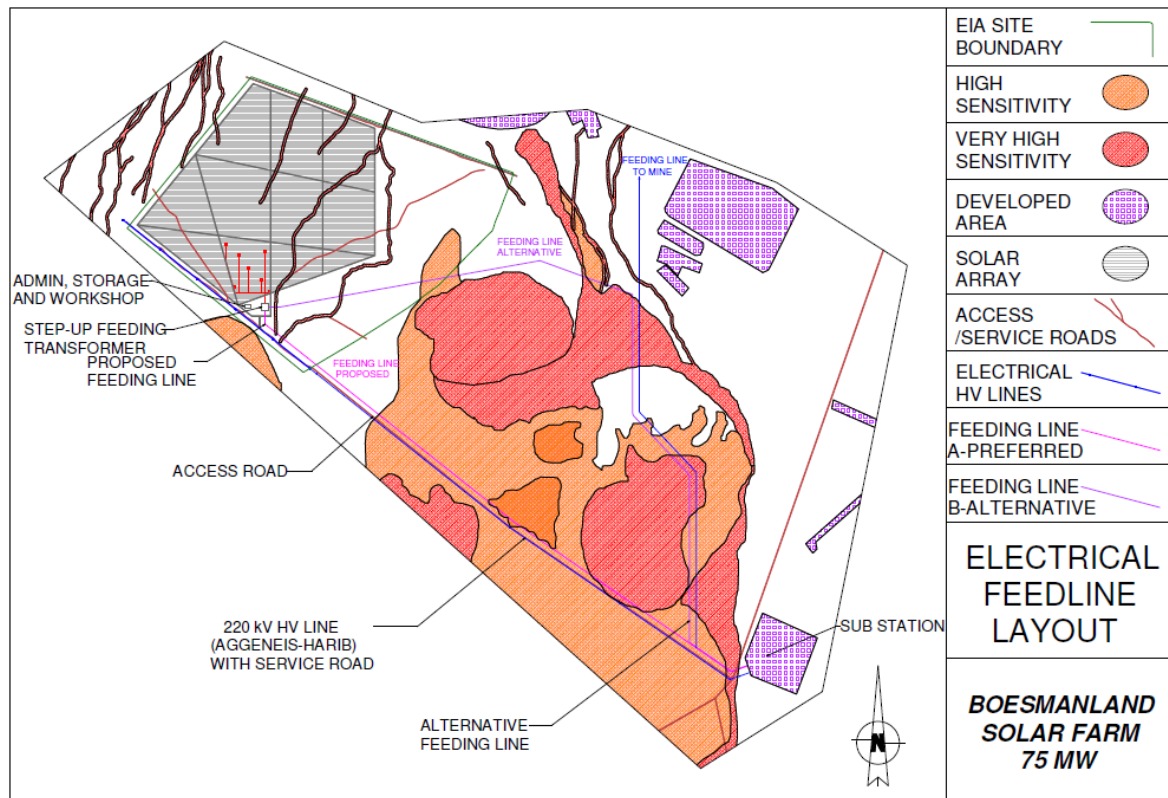


Figure 9: Alternative Electrical feed line layouts

The following alternative solar array layouts were considered and discarded in the development of the preferred layout (**Error! Reference source not found.**), which accommodates the least environmentally invasive technological options and avoids the highly sensitive ecological areas as far as possible.

3.1.1 Initial Uniform Layout

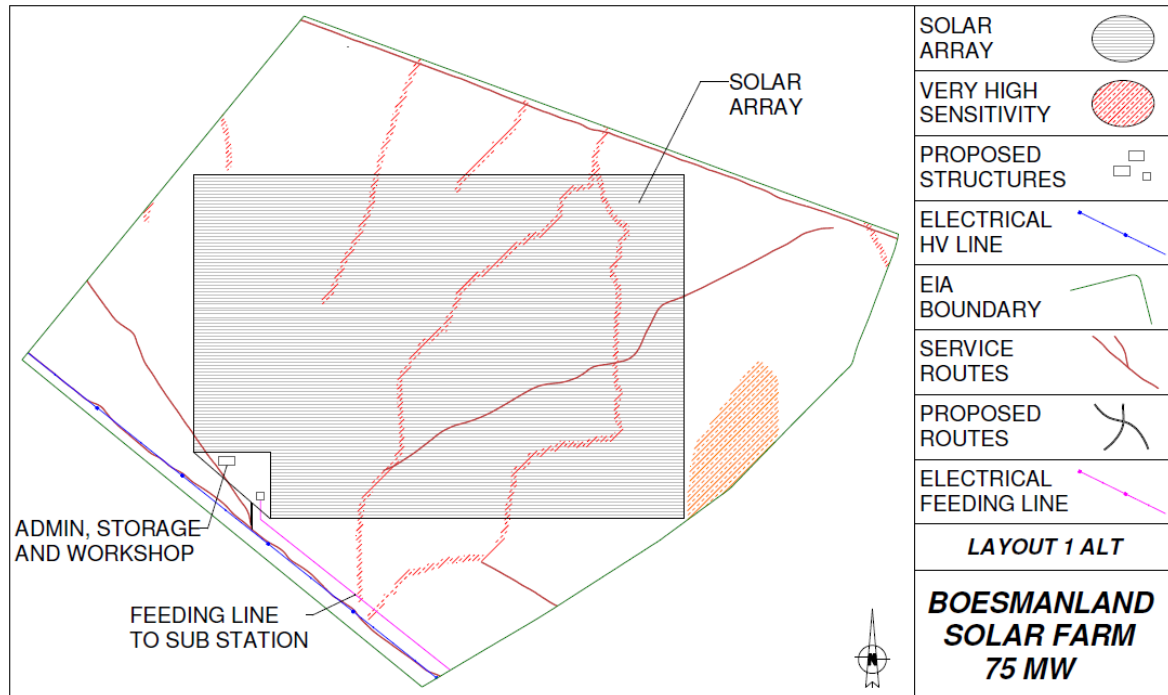


Figure 10: Initial uniform layout

3.1.2 Eastern Layout Alternative

If the layout is moved to the eastern quadrant of the EIA study area to allow closest access to the proposed transmission line and access road, the layout would have an increased effect on the more sensitive mountainous areas to the southeast, while also impacting on more of the washes / small drainage lines. 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 damps financial gain.

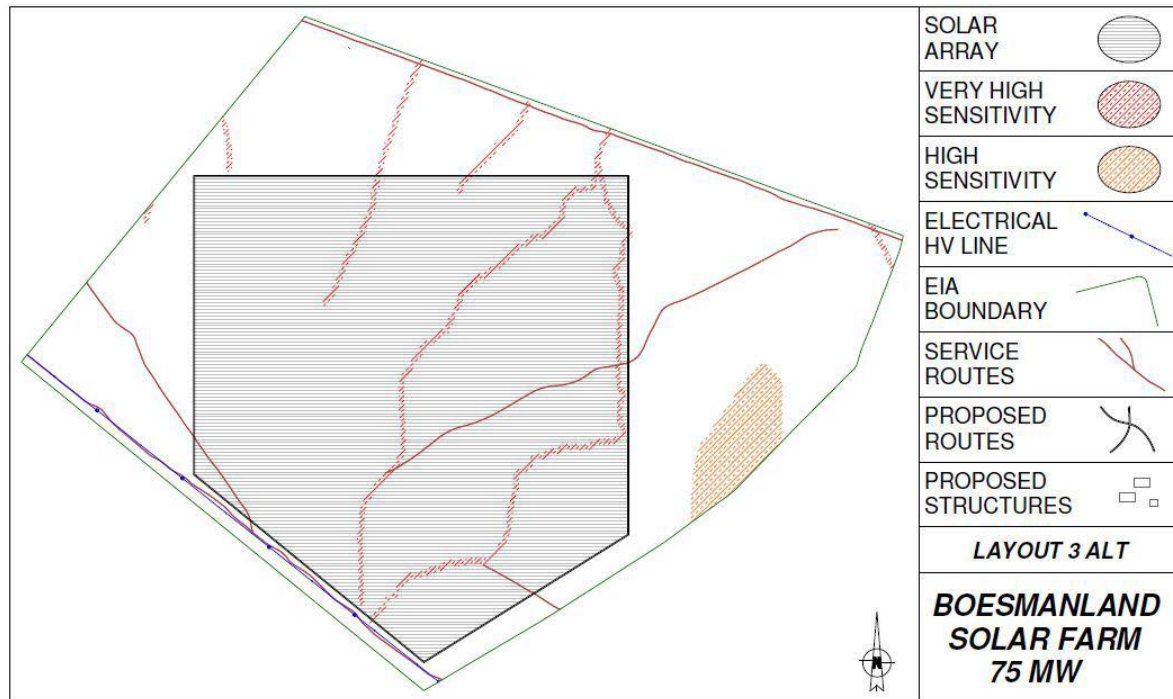


Figure 11 Eastern Layout Alternative

3.1.3 Scattered 5m wash Alternative

When the layout is scattered towards the west, the development would have a slightly smaller impact on the high sensitive areas. However, by scattering the solar arrays, to exclude / avoid the 5m buffers around the washes, the modular or bulk engineering principles are essentially lost. By this it is meant that custom solutions would be required to spilt / separate the solar modules 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 (AC) mark.

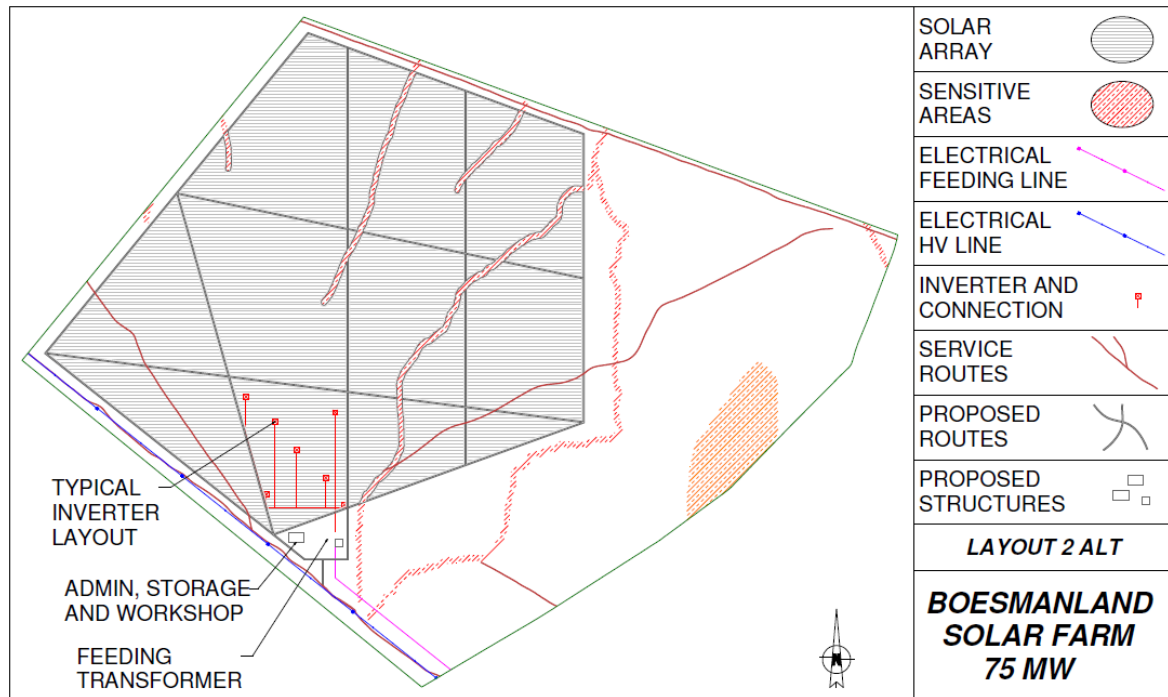


Figure 12 Wash boundary of 5m (scattered)

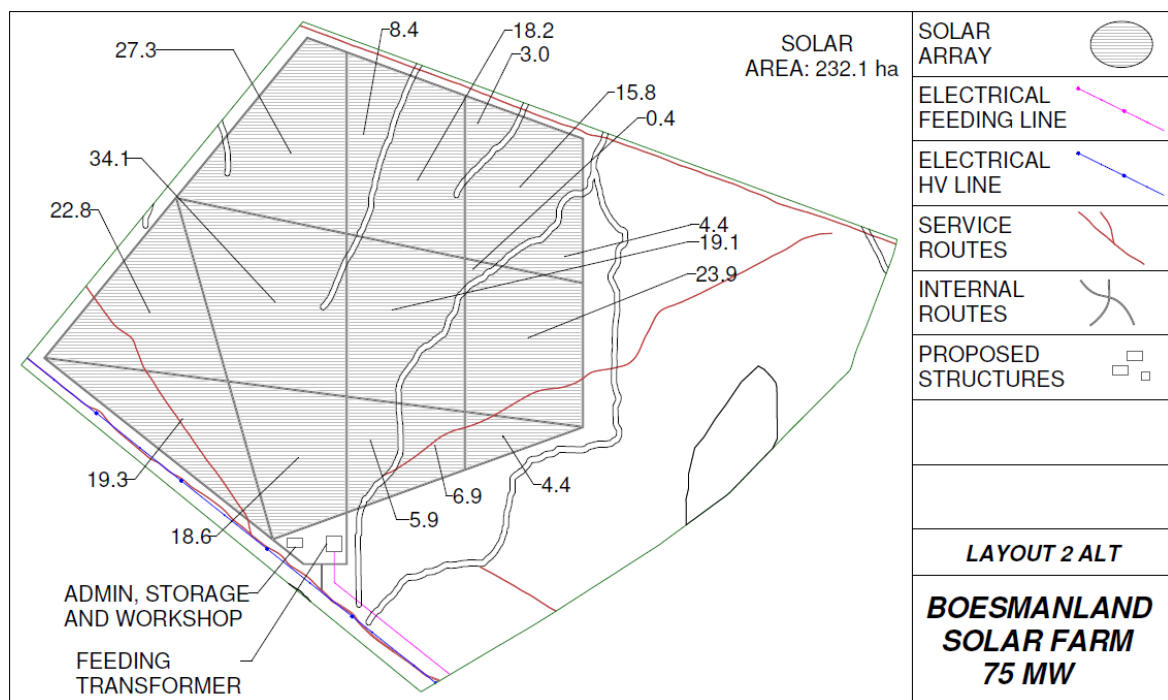


Figure 13: Layout keeping a 5m buffer from any indicated wash, with reduced area sizes indicated

The above three alternative layout options have thus been excluded from the on-going environmental process.

3.2 Alternative Solar Technology

3.2.1 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 14: Double axis tracking (image: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 to ensure that it could stand up to the expected wind loading.

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 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 in terms of money and the environment.

3.2.2 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.

3.2.3 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, or the frame could be 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 casted on the surface using shutters. This process poses the risk of concrete spillages which could have long term negative effects. Further drawbacks applicable to the proposed site include the negative influence on water flow, increasing the risk of erosion.



Figure 15: 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 16: Precast footing on tilted single axis tracker (image: ens-newswire.com)