Figure 3-4: Vibrators & recorder truck

The "live" section of spread is generally about 12km in length. This is the only part of the spread where signal is recorded for any given source position. The live spread is moved (controlled by the recording truck operator) as the vibrators move up. As spread becomes redundant behind the vibrators (back end of line) it is picked up and transported to the front end of the line. This cycle continues until the line is completed. The recording truck may move once or twice during the day to keep pace with the spread.

All operational vehicles stay on the prepared line. Non-operational vehicles are required to park off line to avoid causing noise on the spread and interference with line traffic. Non-operational vehicles include:

- Parked vehicles;
- Spare vibrators;
- Vibrator service truck; and
- Instrument truck.

Along any single line, the following vehicle passes can be expected to occur during normal operations:

- Vibrators 1 pass for each truck
- Instrument truck 1 pass
- Light vehicles 15-20 passes in total
- Vibrator service truck 1 pass.

### *3.3.3 Camp Sites and Associated Supplies*

There are generally only two campsites in operation, line preparation/survey camp and main camp. The former is briefly explained in the line preparation section. The main camp houses the recording crew, crew management team and the recording and mechanical back up teams.

Proposed main campsite locations are shown on Figure 3-6. These locations have received CLC clearance and have been chosen based on the following factors:

- Preference for pre-disturbed area wherever possible.
- Avoidance of clay pans or salt lakes.

- Located as near as practical to existing tracks or roads to avoid the need for clearance of native vegetation and subsequent disturbance fauna habitats.

Figure 3-5: Typical main camp

2D projects result in frequent camp moves but with tenure lasting only a few days. This camp often houses approximately 40 personnel and contains approximately 20 trailers and 36 vehicles.

The access routes from camp are clearly defined to restrict wheel track impact which results from vehicles transit to and from camp to the adjacent road at least once per day. Some campsites may require multiple access routes to minimise the potential of bull dust creation. Vehicles are restricted to the perimeter of the camp and parking areas are also defined.

Potable water is planned to be sourced from Alice Springs. Santos estimates water usage to be approximately 160 litres per person per day. Based on this assumption water use for the line preparation crew would be approximately 2,240 litres per day, and recording crew usage of approximately 5,120 litres per day. If suitable existing ground water can be located closer to the crew location and a commercial arrangement agreed with the local pastoralist, some of the usage may be sourced locally.

Wastewater from laundry, showers and kitchen is piped to an irrigation area about 50m outside the camp. Sewage management practices at all camps consist of the use of port-a-loos and grey water capture and disposal to a ground pit with the aim to minimise any risks to human health or the environment.

Wastepaper, cardboard and food scraps are disposed of into sealed bins set up adjacent to the camp area. The sealed bins are transported regularly for waste disposal at a licensed landfill. Recyclable materials, including tyres, are segregated on camp and regularly transported to a licensed waste depot in Alice Springs.

To minimise or eliminate the potential for spills fuel drums are stored within portable bunding and bulk fuel is stored within tankers, which have safety features such as double-skins (or temporary bunding), safety cut-off valves, top accessing etc. Spill leak and drip trays are used to address minor drips and spills resulting from re-fuelling operations. Any uncontained spillage will be treated in situ, and impacted areas remediated.

Once the campsite has been vacated, rehabilitation is undertaken including removal of rubbish and any man made items. When necessary, and terrain permitting, the area is tyne ripped to remove

compaction and wheel tracks. Photopoints are established at each campsite to document pre-disturbance and post-restoration condition (see Section 7.5).

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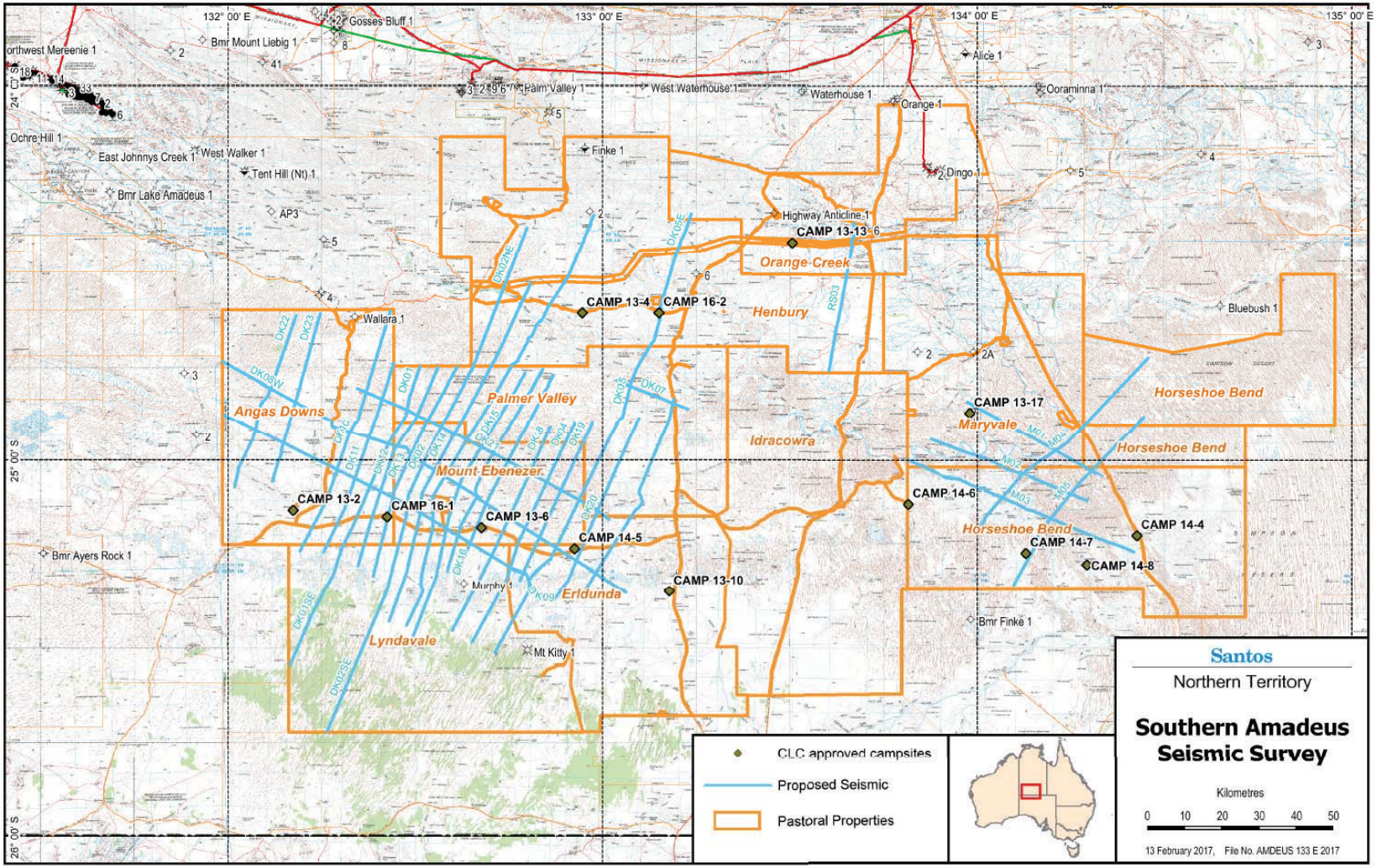


Figure 3-6 CLC Cleared Camp Locations

### 3.3.4 Line/Access Track and Campsite Restoration

The majority of seismic lines and access tracks and camp sites do not require restoration work, as one of the main objectives is to prepare and utilise them in a way that will facilitate rapid natural recovery. However, instances that can require restoration are:

- Wheel ruts caused after wet periods;
- Windrows not fully removed by grader;
- Windrows that have been created at intersection of lines and public tracks;
- Compaction of top soil at camp sites;
- Compaction of shoulders on public access tracks;
- Heavily trafficked routes between camp sites and nearest public track;
- Access tracks that have turned to bulldust due to extensive seismic traffic.

Normally a single dozer or grader or one of each is all that is required to carry out the restoration work. Methods used for rehabilitation include:

- Ripping of compacted areas with bulldozer rear tynes;
- Windrow material pushed onto line and smoothed;
- Public road shoulders reinstated;
- Wheel rut material used to infill affected areas; and/or
- Affected watercourse channels and creek banks reinstated.

### 3.3.5 Post Survey Monitoring and Auditing

Prior to the commencement of any survey, photopoints are established at nominally 5 km intervals. By establishing such a large number of photopoints it provides a balanced representation of the various landform and vegetation types encountered and enables rehabilitation success to be effectively monitored.

Photopoints are GPS coordinated prior to the start of line preparation and photographs are taken at each locations along the proposed line direction to give a view of the terrain prior to line-preparation. All photographs are digital for consistent comparison. The process is repeated after line preparation and again after recording. The revisit intervals are generally one year, two years and four years although the return period is determined by weather/road conditions and current activity in the region. Revisits may also be targeted, with emphasis on sensitive areas and areas potentially subject to erosion such that environmental impact of re-accessing remote locations is minimised.

A summary of the monitoring program is presented in Section 7.5.

Figure 3-7: Dune cut immediately after recording and four years after recording

### 3.3.6 Long-term Rehabilitation

Whilst the majority of areas will naturally regenerate following restoration works, there is the possibility that specific areas (sensitive areas or areas subject to erosion) may need additional rehabilitation following the first wet-season. Areas identified in post-survey photopoint monitoring, or by subsequent landholder liaison, as requiring additional rehabilitation works will be re-visited and rehabilitated accordingly.

Following completion of the final photopoint revisit and any required additional rehabilitation, Santos will submit the final Environmental Line Reports to DME along with the application to release the long-term Rehabilitation Security. It is anticipated that the final rehabilitation assessment and endorsement will be conducted by an appropriately qualified third party. Reporting requirements are discussed in Section 8.

## 3.4 Timeframe

Based on current seismic crew availability, Santos would expect to commence line preparation for the project in May 2016, with the seismic recording commencing approximately 3 weeks later. Recording for this project is expected to take approximately sixteen weeks to complete.

On-ground conditions, initial line preparation, wet weather, equipment and operator availability and delays in obtaining required approvals and consents may delay the commencement date and / or extend the duration of the planned works.

# 4 ENVIRONMENT DESCRIPTION

## 4.1 Physical Environment

### 4.1.1 Climate

The Southern Amadeus seismic survey is located within the arid zone of Central Australia that experiences low and variable rainfall and high diurnal and seasonal temperature fluctuations.

Table 4-1 shows a summary of climate records for Alice Springs Airport (Station 015590), which is located approximately 140 kilometres (km) north of the Program area (Bureau of Meteorology [BoM] 2014).

The mean annual rainfalls for Alice Springs and Mereenie are 284 mm and 300 mm respectively, with the majority of rainfall in summer. Temperatures vary from very hot in summer to below freezing in winter, and frosts occur regularly during the winter months.

Average evaporation exceeds average rainfall for each month of the year and by some 1000% over an average year. The mean annual evaporation rate at Alice Springs is 3066 mm. The dominant wind directions are southeast to northeast with little seasonal variation.

Table 4-1 Temperature and rainfall records for BoM Station #015590

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature | | | | | | | | | | | | | |
| Mean Daily Max (°C) | 36.4 | 35.1 | 32.6 | 28.2 | 23.0 | 19.8 | 19.7 | 22.6 | 27.3 | 30.9 | 33.6 | 35.4 | 28.7 |
| Mean Daily Min (°C) | 21.5 | 20.7 | 17.5 | 12.6 | 8.2 | 5.0 | 4.0 | 6.0 | 10.3 | 14.8 | 17.9 | 20.2 | 13.2 |
| Rainfall | | | | | | | | | | | | | |
| Mean monthly (mm) | 38.5 | 43.9 | 31.8 | 17.3 | 18.7 | 13.6 | 15.4 | 9.0 | 8.4 | 21.1 | 28.7 | 36.8 | 284.0 |

### 4.1.2 Geology

The Southern Amadeus seismic survey is located within ted in the eastern, central and southern Amadeus Basin, an east-west trending structural depression extending across the southern part of the Northern Territory and into Western Australia. This basin covers an area of approximately 207,000 km$^2$ and contains up to 9100 m of late Proterozoic and Palaeozoic sediments. It is bound in the north by the Arunta complex and in the south by the Musgrave-Mann complex, both containing granite, gneiss and schists, with amphibolite and quartzite.

Geologically, rocks consist of sandstones that form resistant strike ridges and less resistant siltstones, commonly covered by superficial soils. Hydrocarbons occur in sandstones at depths ranging between 1200 and 1500 m.

### 4.1.3 Soils

The Project Area soils are dominated by tenosols soils, kandosols and rudosols asscoated with rugged rock terrain (DLRM 2013a). Smaller pockets of Calcarosols and Sodosols Soils are present in the Project Area and will be avoided by the proposed activities.

- Tenosols are weakly developed or sandy soils, commonly shallow (slightly more developed than Rudosols), although they can include the deep sand dunes of beach ridges, granitic soils and sand dunes of deserts. Tenosol soils show some degree of soil profile organisation (minor colour or soil texture changes in subsoil).
- Rudosols are very shallow soils or those with minimal soil development and includes very shallow rocky and gravely soils across rugged terrain.
- Kandosols are massive and earthy soils (formerly red, yellow and brown earths) that are widespread across the Sturt plateau regions.
- Calcarosols soils with calcium carbonate often formed on limestone are restricted to small pockets in Central Australia.
- Sodosols soils are generally high in sodium with an abrupt increase in clay content from the top soil to subsoil. They are dispersive and restricted to small occurrences in the southern region of the NT.

Within the Project Area the seismic lines will cross over the following dominate terrain:

| Land Systems | General Terrain Description | Line Km | % of Total |
|---|---|---|---|
| Desert dunefields | Dunefields with parallel linear dunes, reticulate dunes and irregular or aligned short dunes; red sands | 1,494 | 59.4 |
| Desert sandplains | Level to undulating sandplains with red sands | 234 | 9.3 |
| Sandstone plains and rises | Plateaux, plains and rises on sandstone, claystone, shale and limestone; outcrop with shallow stony soils | 226 | 9.0 |
| Sandstone hills | Stony plateaux, tablelands and hills on sandstone, quartzite, siltstone and conglomerate (deeply weathered in places); outcrop with shallow stony soils | 202 | 8.0 |
| Limestone plains and rises | Plains, rises and plateaux on dolomite, limestone, chalcedony, shale and sandstone; red clayey sands, calcareous earths and outcrop with shallow, stony soils | 193 | 7.7 |
| Salt pans | Salt pans with waterlogged saline clays and fringing dunes | 82 | 3.3 |
| Sandstone ranges | Rugged ranges on quartzite, sandstone and conglomerate; outcrop with shallow, stony sandy soils | 45 | 1.8 |
| Alluvial floodplains | River plains, swamps and alluvial fans formed on Quaternary alluvium | 24 | 0.9 |
| Lateritic plains and rises | Plains and rises on weathered sedimentary rocks; red clayey sands, red earths and texture contrast soils | 9 | 0.4 |

| Land Systems | General Terrain Description | Line Km | % of Total |
|---|---|---|---|
| Granite plains and rises | Gently undulating to undulating plains with rises and low hills on schist, gneiss and granite (deeply weathered in places); red earths, red clayey sands and texture contrast soils with outcrop and shallow stony soils on steeper areas | 5 | 0.2 |
| **Totals** | | **2,514** | **100%** |

### 4.1.4 Hydrology

All catchments within the Amadeus Basin region drain internally towards Lake Eyre (within South Australia) (Figure 4-1). All surface water including rivers, streams and drainage lines are ephemeral and subject to short flow duration and high turbidity.

The dominant basin is associated with the Finke River system and its associated tributaries and feeder rivers.

### 4.1.5 Salt Lakes

The salt lakes of Central Australia are also maintained by groundwater and support specialised flora and fauna. Salt lakes are generally formed as a result of saline ground water discharging to the surface. Such salt lakes drain groundwater from both bedrock aquifers and aquifers made up of the river sands deposited on the valley floor. The water table is generally about 300 millimetres below the lake floor, shallow enough for the water to be evaporated. These lakes occasionally fill when heavy rains occur but they are usually dry. Ground water does not generally accumulate in the salt lakes as free standing water but is all lost to evaporation. The salts in the ground water are left behind and gradually accumulate forming deposits of common salt and gypsum.

Salt lakes are a significant landform in the southern part of the Northern Territory, covering an area of some 2800 square kilometres. Within the Project Area all salt lakes will be avoided by the proposed activities.

## 4.2 Biological Environment

### 4.2.1 Bioregions, Flora and Fauna

The Arid Lands region covers 49% of the land area of the Northern Territory (658,000 sq km). It includes all of the MacDonnell Ranges and Burt Plain bioregions, the Territory sections of the Great Sandy Desert, Simpson Strzelecki Dunefields, Finke, Central Ranges, Channel Country and Stony Plains bioregions, most of the Territory section of the Tanami bioregion and parts of Sturt Plateau, Mitchell Grass Downs and Davenport Murchison Ranges bioregions.

About 55% of the Arid Lands subregion is Aboriginal freehold and about 36% pastoral leases, on which cattle are grazed. Though accounting for a small total area, horticulture is an important land use in the Arid Lands subregion. Current and proposed protected areas make up 36% of the region; the vast majority of this is as proposed Indigenous Protected Areas.

The Project Area is covered by the bioregions of the Simpson Strzelecki Dunefields Bioregion in the east and Finke Bioregion in the west (Figure 4-2).

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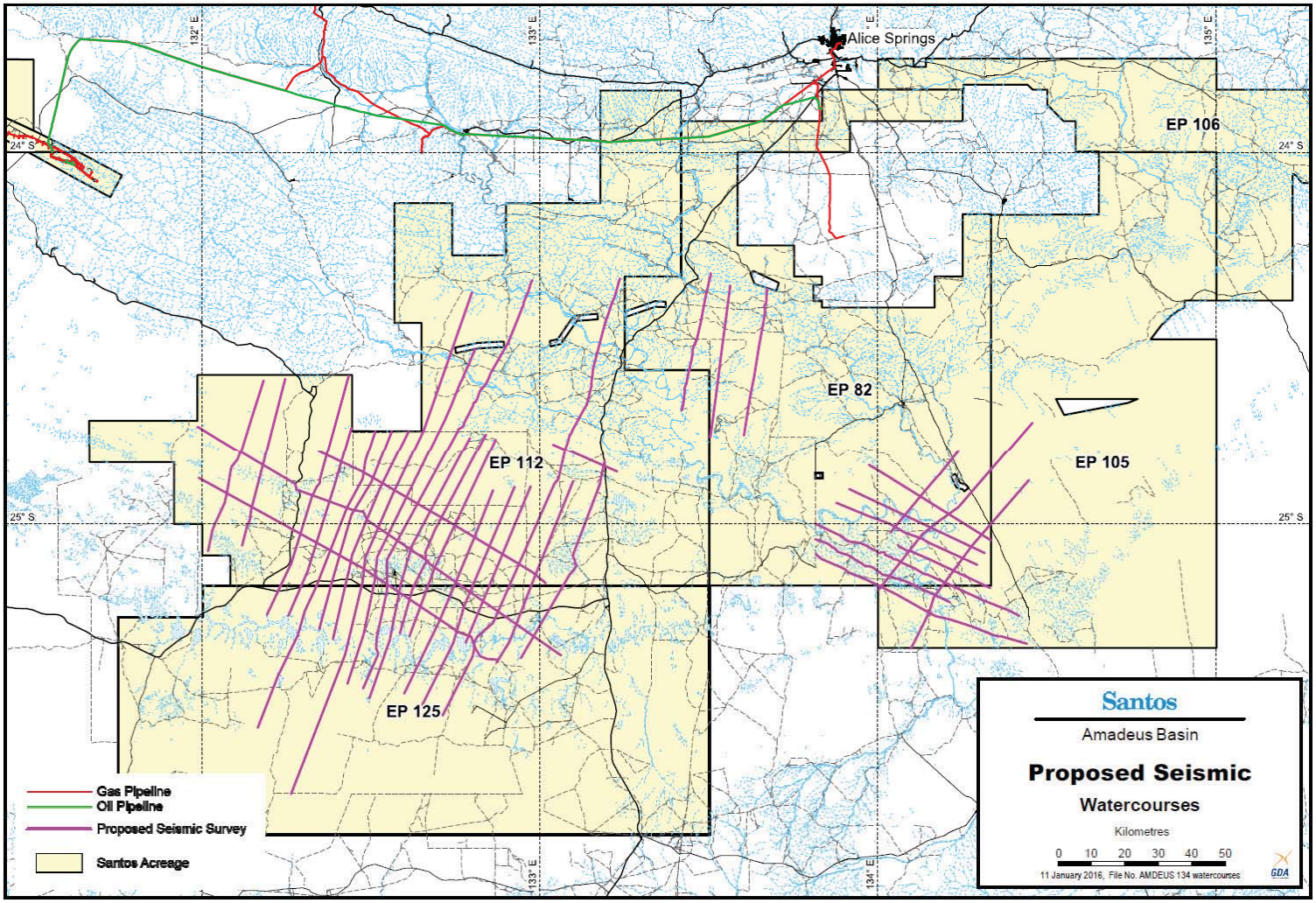


Figure 4-1: Watercourses

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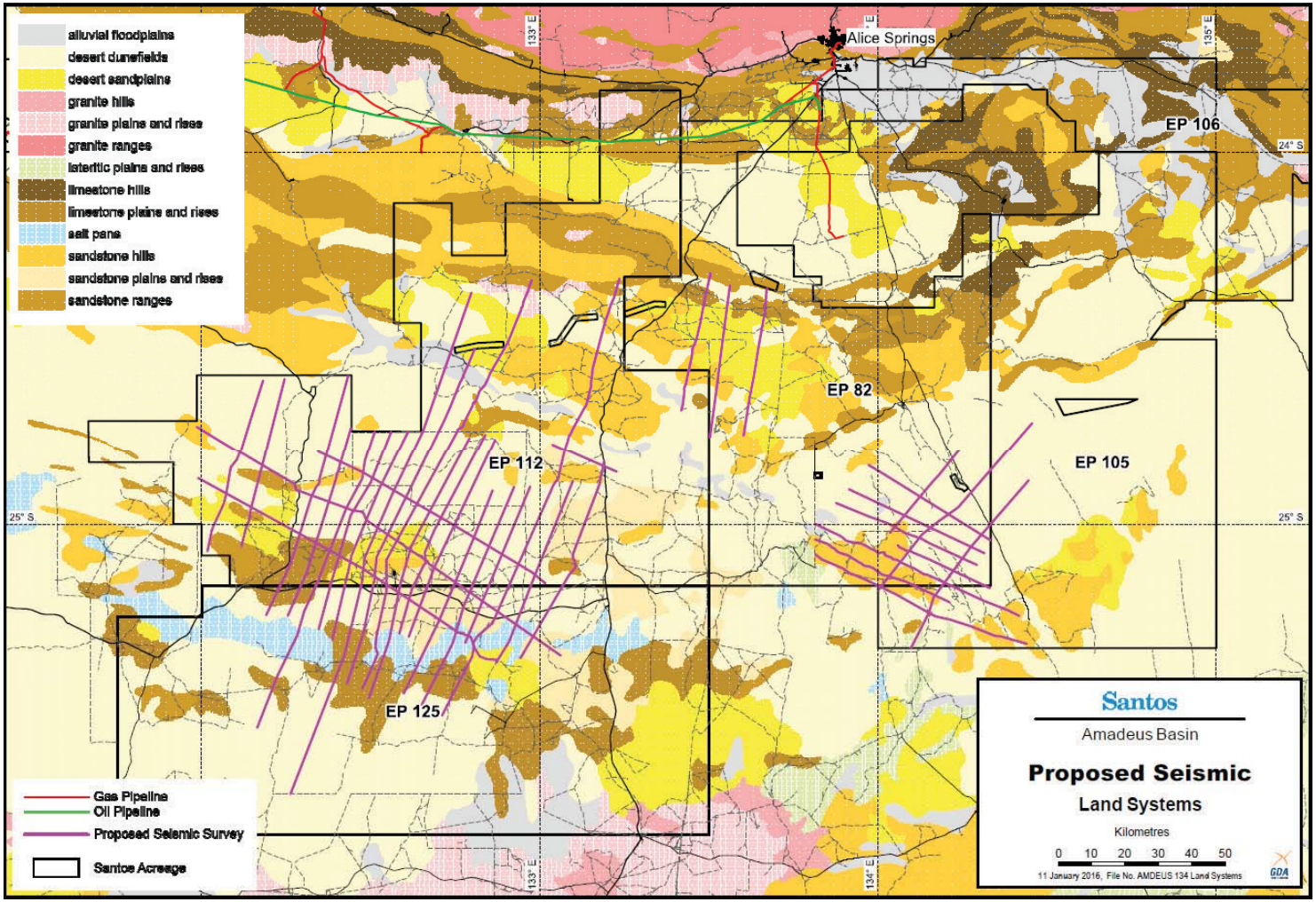


Figure 4-2: Land Systems

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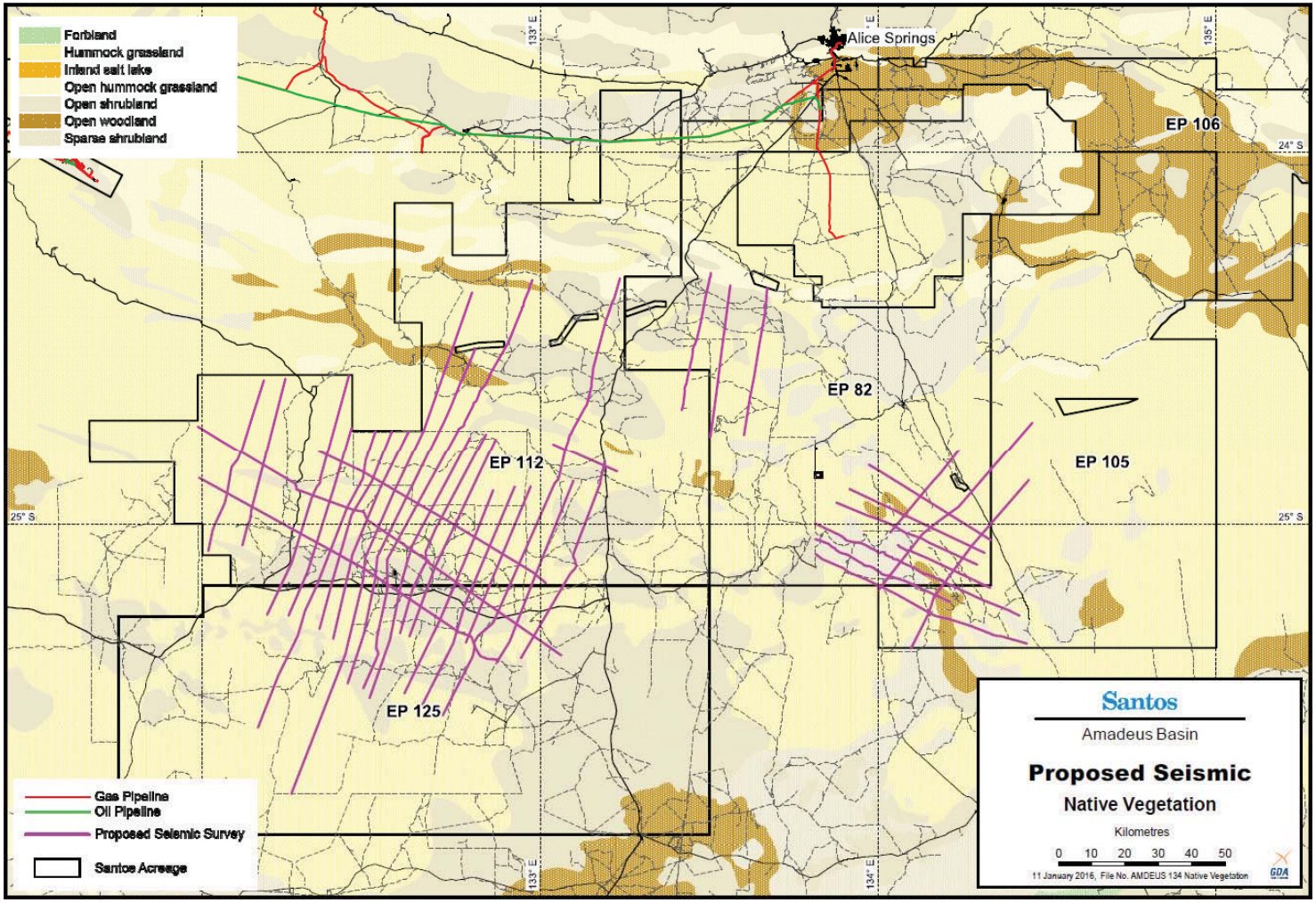


Figure 4-3: Native Vegetation

#### 4.2.1.1 Simpson Strzelecki Dunefields Bioregion

The Simpson-Strzelecki Dunefields Bioregion covers an area of 297,227 km$^2$, and extends from the southeast of the NT, through the northeast of SA, with small areas in both Qld and NSW. The bioregion is part of the Australian continental dunefields, which consist of a huge anti-clockwise whorl of linear dunes in central Australia and thus dominated by high linear dunes of red sand.

Woodland communities are dominated by *Acacia ligulata*, mulga, needlewood (*Hakea leucoptera*), whitewood (*Atalaya hemiglauca*) and beefwood (*Grevillea striata*) with an understorey shrubland consisting of species of *Cassia*, *Eremophila* and *Dodonaea*. Mitchell Grass occurs on the dunes while temporary canegrass (*Glyceria ramigera*) - lignum (*Muehlenbeckia cunninghamia*) swamp communities occurring between them.

The sand dunes and sandplains communities support sandhill wattle (*Acacia ligulata*), turpentine (*Eremophila sturtii*), scattered mulga (*Acacia anuera*), rosewood (*Heterodendrum oleifolium*), whitewood (*Atalaya hemiglauca*), canegrass (*Eragrostis australasica*), the occasional white pine (*Callitris glaucophylla*) and various cassia and eremophila species.

Lignum (*Muehlenbeckia cunninghamia*), black box (*Eucalyptus largiflorens*) and river red gum (*Eucalyptus camaldulensis*) grow along the creeks and on the margins of freshwater claypans. Many of the same species are found in the more saline clays of the Cobham land system along with prickly wattle (*Acacia victoriae*) and chenopods. Bladder saltbush (*Atriplex vesicaria*), black bluebush (*Maireana pyramidata*), Mitchell grass (*Astrebla* sp.) and scattered mulga (*Acacia anuera*) are found on the tablelands and stony downs. Bimble box (*Eucalyptus populnea*), western bloodwood (*Eucalyptus terminalis*) and ironwood (*Acacia excelsa*) are present with denser mulga on the sands.

#### 4.2.1.2 Finke Bioregion

The Finke Bioregion covers an area 73,800 km$^2$. The main land types are arid sand plains with dissected uplands and valleys, including some major rivers (Finke, Hugh and Palmer rivers). The bioregion is dominated mulga taking different forms on different soil types. The mulga is made up of various Senna, Eremophila and Acacia species (*S. nemophila, S. desolate, E. freeelingii, E. gilesii, A. kempeana, A. tetregonphylla*). The bioregion includes eucalypt low woodland with tussock and hummock grass understorey, acacia woodland, hummock grassland, and chenopod shrubland, associated with salt plains and floodouts on sand plains. The dominant chenopods are bluebush (*Maireana astroricha*) and bladder saltbush (*Atriplex vesicaria*).

Despite the lack of free-water the bioregions provide important habitat for a range of wildlife including a variety of small mammals, reptiles and birds.

Due to the mobility of animals in the arid region and the extensive habitat of the region together with the minimal impact on the habitat from the proposed activities the likely potential impact on fauna is low.

### *4.2.2 Socio-economic Environment*

The Amadeus Basin has broad indigenous cultural and European historical significance. There is a range of current land uses throughout the area including conservation, tourism, oil and gas production and pastoral activities. While the regional population has decreased with time, tourist numbers are consistent. The region remains generally undeveloped in terms of infrastructure and roads.

Tourism centres such as Alice Springs and Yulara continue to be the main destinations.

The Amadeus Basin supplies gas within the Northern Territory and oil to South Australia. Additional discoveries are necessary to maintain supply in the future. Natural gas is a comparatively lower

carbon dioxide polluting fossil fuel, and therefore, its continued use in preference to coal and oil reduces greenhouse impacts.

## 4.3 Environmental and Cultural Sensitivities

### 4.3.1 Sacred Site Protection

Binding agreements are in place to manage the key values and sensitive aspects relating to the protection of Sacred and Cultural Heritage Sites, including information provided by the NT Heritage Council and Aboriginal Areas Protection Authority.

Implementation of the Sacred Site Protection Procedure obligations, set out in the Indigenous Land Use Agreement EP No.s 82, 112, 118 and 125 and EP 105, 106 and 107, contribute to minimising the risk of damage to Sacred Sites through seismic line preparation and recording activities. Refer to Section 2.2 and Section 3.2.2.

Santos and its subcontractors will ensure that conditions of the CLC SSCC are fully complied with, and if cultural heritage sites are identified during the course of the Program they will be reported to a member of the Cultural Heritage Team who will manage discoveries in line with the relevant agreement and legislation.

Environmental and cultural heritage inductions were implemented for the seismic program in 2013 and will be updated and delivered for the 2016 Program.

For the majority of the seismic program Santos has confirmed that there will be no impacts on areas listed on the National Heritage Register (National Heritage List (DSEWPaC 2014a) or NT Heritage Register (DLPE 2014). A new work program has been submitted to the CLC in December 2015 for the additional seismic lines that are included in the 2016 program.

### 4.3.2 Protected or Conservation Areas

There are protected or conservation areas within in Project Area (DLRM 2014a and Figure 4-4). A list of sites within the Permit Areas includes:

- Chamber's pillar historical reserve
- Mac Clark (*Acacia peuce*) Conservation Reserve
- Henbury meteorites conservation reserve
- Rainbow valley conservation reserve
- Illamurta springs conservation reserve
- Ewaninga rock carvings conservation reserve
- Owen spings reserve

These protected areas will all be avoided by the Program.