13. AGRICULTURE

This chapter provides a summary of the agricultural values within and surrounding the project development area and an assessment of the potential for these values to be affected by direct and indirect impacts associated with the construction, operations and decommissioning phases of the project. The detailed findings of the project's impacts on agriculture are set out in Appendix F, Agricultural Report. Environmental protection objectives and the avoidance, mitigation and management measures to achieve these objectives have been developed. Proposed avoidance, mitigation and management measures have the potential to reduce residual impacts of the proposed development. The success of proposed trials and rehabilitation and of project planning in avoiding impacts on agricultural enterprises will determine the nature and severity of residual impacts, which primarily relate to lost or reduced productivity.

13.1 Legislative Context

The following legislation, policies and guidelines establish the planning framework that seeks to protect high-quality agricultural land and describe the statutory compensation framework for impacts arising from coal seam gas development.

Strategic Cropping Land Act 2011 **(Qld).** The Strategic Cropping Land Act was enacted on 30 January 2012. It aims to protect land that is highly suited to cropping and manage the impacts of development on the land to preserve the productive capacity of the land for future generations. The act includes trigger maps that identify potential strategic cropping land. Zonal criteria are defined in Schedule 1 of the act (DERM, 2011g). An application for development on strategic cropping land must include an assessment of whether or not the land is compliant with the zonal criteria. The zonal criteria are slope, rockiness, gilgai microrelief, soil depth, drainage, soil pH, chloride content and soil water storage. The parameters applicable for each criterion are determined by the particular zone that the subject site is in. The project development area straddles the Eastern Darling Downs and Western Cropping zones.

Sustainable Planning Act 2009 **(Qld).** This act aims to achieve ecological sustainability by managing development and ensuring the coordination of planning at the local, regional and state levels. The act also establishes planning authorities, which prepare and administer planning schemes that contain zones, overlays and policies. It controls planning and development through the administration of planning schemes and planning policy and through the processing of development applications. The level of assessment required to support a planning application is determined by the significance of potential impacts. The act is administered by the Department of Local Government and Planning. This act establishes the policy framework for the identification and protection of high-quality agricultural land, specifically through the good-quality agricultural land (GQAL) and strategic cropping land policies described below.

State Planning Policy 1/92: Development and the Conservation of Agricultural Land. This policy was gazetted on 18 December 1992 and identifies relevant land resource assessments and soils that define GQAL. Four classes of agricultural land are defined in Guideline 1 for the policy (DPI & DHLGP, 1993):

> **Class A: Crop land** – Land that is suitable for current and potential crops with limitations to production which range from none to moderate levels.

Class B: Limited crop land – Land that is marginal for current and potential crops due to severe limitations; and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered suitable for cropping.

Class C: Pasture land – Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate a short period of ground disturbance for pasture establishment.

Class D: Non-agricultural land – Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrop or poor drainage.

Class A land is defined as GQAL in all areas, Class B land is defined as GQAL in areas where agricultural land is scarce, and Class C land is defined as GQAL in areas where grazing or pastoral uses predominate.

The policy sets out the principles for the conservation of GQAL. Principles 1, 2 and 4 are relevant to the proposed development. They are:

1. Good quality agricultural land has a special importance and should not be built on unless there is an overriding need for the development in terms of public benefit and no other site is suitable for the particular purpose (Section 3).

2. The alienation of some productive agricultural land will inevitably occur as a consequence of development, but the Government will not support such alienation when equally viable alternatives exist, particularly where developments that do not have very specific locational requirements (for example, ‘rural residential') are involved (Paragraphs 4.6-4.7).

4. The preparation of strategic plans should include an evaluation of alternative forms of development, and significant weight should be given to those strategies which minimise the impacts on good quality agricultural land (Paragraph 4.2-4.3).

The policy, administered by the Department of Housing, Local Government and Planning, is supported by two guidelines. Guideline 1, Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993), is relevant to the proposed development.

Planning Guidelines: The Identification of Good Quality Agricultural Land (DPI & DHLGP, 1993). This guideline was developed by the Department of Primary Industries and the Department of Housing, Local Government and Planning. Its purpose is to assist in the identification of areas of GQAL for planning purposes. Mapping prepared by the department indicates the likely extent of GQAL. The guideline recommends detailed assessment to determine the actual extent of GQAL at the site level. Site assessment encompasses landform (including microrelief), topography, land use, groundwater depth, soil (structure, texture and pH), vegetation and substrate.

State Planning Policy 1/12: Protection of Queensland’s Strategic Cropping Land (DERM, 2012). Prepared under the auspices of the Sustainable Planning Act, the administering agency for this policy is the Department of Environment and Resource Management (DERM). This policy and associated legislation are intended to operate in parallel with and in addition to State Planning Policy 1/92. The Strategic Cropping Land Act 2011 was enacted on 30 January 2012. For the purposes of this project, GQAL and strategic cropping land are largely consistent in their extent. The aims of the policy (DERM, 2012) include:

> SCL is a finite resource that must be conserved and managed for the longer term. As a general aim, planning and approval powers should be used to protect SCL from those developments that lead to permanent impacts or diminished productivity.

The policy applies to development that will permanently alienate or temporarily diminish the productivity of strategic cropping land.

The policy framework document (DERM, 2010i) defines the types of activities that might temporarily affect strategic cropping land as 'relevant development' and defines this term as follows:

> Development that will temporarily diminish productivity of strategic cropping land or will permanently alienate the land. This includes urbanisation and mining, but excludes some agriculture and State infrastructure.
>
> There are two key types of relevant development:
>
> 1. Development that causes temporary diminished productivity—where development that impacts upon the soil resource and/or prevents cropping activity, but where the land can be fully restored following cessation of the use.
> 2. Development that will permanently alienate strategic cropping land including where:
>
> a. a development will endure for 50 years or more, and prevents cropping during that time or in the future (e.g. urban development); or
>
> b. a land use where a legal impediment prevents the land from being used for cropping for 50 years or more (e.g. permanent forest plantations with a covenant securing carbon rights); or
>
> c. a development that causes long-lasting impacts that prevents or reduces cropping capability such as subsidence, changes to the soil structure or contamination (e.g. minerals extraction); or
>
> d. a development likely to cause a land-use conflict or where reconfiguration of lots result in fragmentation and small lot sizes that would impact on the productivity of strategic cropping land. An example of development likely to cause conflict is high density urban development.

The Surat Gas Project has the potential to trigger relevant development types 1 and 2c, with wells, gathering systems and pipelines being type 1 developments and production facilities being type 2c developments. The success of project planning and implementation will be the ultimate determinant of the type of development triggered by the proposed project activities.

'Trigger maps' that identify potential strategic cropping land have been prepared by DERM. These maps indicate, at a landscape scale, the expected extent of strategic cropping land and are based on current land, soil and climate information.

The exact extent of strategic cropping land will be determined at a local scale, with site investigations forming the basis for inclusion or exclusion of this land type. The policy is supported by guidelines for applying the zonal criteria detailed in Schedule 1 to the Strategic Cropping Land Act.

Protecting Queensland's Strategic Cropping Land: Guidelines for Applying the Proposed Strategic Cropping Land Criteria (DERM, 2011h). These guidelines set out how the criteria for identifying strategic cropping land are applied at a property level, including the provision of

preliminary advice, mapping and assessment, and describing and measuring the soil and land area criteria.

Petroleum and Gas (Production and Safety) Act 2004 **(Qld).** The holder of a licence under this act is required to compensate the landholder for damage and losses arising from petroleum (coal seam gas) activities carried out on the land. The licence holder is required to compensate the landholder for:

- Temporary (or permanent) loss of rights to the land.
- Reduction in value of the land.
- Reduced ability to use the land or reduced uses that could be made through any improvements to the land.
- Severance or alienation of part of the land.
- Any cost, damage or loss arising from the exercise of petroleum activities on the land.

The landholder is also entitled to reasonable accounting, legal and valuation costs associated with negotiating a compensation agreement with the petroleum licence holder. The mandatory provisions of the Land Access Code (DEEDI, 2010b) prepared by the Queensland Government must be complied with. This act requires compensation arrangements to incorporate certain terms.

13.2 Assessment Methods

The agriculture assessment comprised a desktop study to gain an understanding of and describe the existing environment. Information was gathered from the Australian Bureau of Statistics and other government websites, together with literature reviews of related studies. The technical specialists who undertook the assessment (see Appendix F, Agricultural Report) also drew on their experience as agricultural consultants and their knowledge of farming practices in the Surat Basin. This information was then used to meet the objectives of the study, which were to:

- Identify, describe and map agricultural enterprises and activities.
- Identify and describe particular aspects of agricultural activities that contribute to their success and viability.
- Identify and describe the key potential impacts of project development on agricultural activities.
- Propose management measures that address the potential impacts with regard to the specific or particular aspects of each agricultural enterprise.

13.3 Existing Environment and Environmental Values

This section describes the climate, soils and agricultural activities in the project development area and includes information on regional agricultural development and production, as well as constraints and considerations for agricultural development. The environmental assets of the project development area are the soils, topography, flooding regime and climate. They influence the agricultural potential of the area and therefore the agricultural activities currently being conducted.

The landscape of the project development area is characterised by three physiographic regions: the Great Dividing Range highlands, the Kumbarilla Ridge uplands and the four drainage basins,

Condamine-Culgoa Basin (Condamine River and Balonne River), Fitzroy Basin (Dawson River), Border Rivers Basin (Weir and MacIntyre rivers and MacIntyre Brook) and Moonie Basin (Moonie River). The river systems are characterised by relatively gentle gradient watercourses that comprise defined, poorly defined and indistinct channels. Consequently, seasonal and storm-event flooding produces expansive overland flows that are important in replenishing soil water.

The project development area is entirely located in the Darling Downs (an Australian Bureau of Statistics statistical division) (see Figure 4.15), and this statistical division has therefore been used to describe agricultural production.

13.3.1 Climate

The project development area is temperate, with a warm to hot summer. The mean annual rainfall is 612.5 mm, with an annual evaporation of approximately 2,267 mm, indicating a water deficit. Most of the rain falls in summer. The mean monthly temperature ranges from 3.6°C in July at Miles, to 34.1°C in January at Goondiwindi. During late autumn, winter and early spring, there can be up to 30 frosts.

13.3.2 Soils

The main soil types used for agriculture in the project development area are the Vertosols and Dermosols (both black soils). Vertosols have the following properties:

- Light to heavy clays.
- High plant available moisture holding capacity (up to 200 mm per metre of soil depth).
- Self-mulching surface.
- Neutral to slightly acid topsoils (pH 6.5 to 7.5).
- Alkaline subsoils (pH greater than 7.5).
- Highly reactive shrink-swell soils.
- Brown grey or black in colour.
- Fertile in natural, undisturbed state with nutrient reserves.
- Normally base saturated with a high cation exchange capacity.

Dermosols (which are similar to the Vertosols) have the following properties:

- High clay content varying from loamy to medium to heavy clays.
- Medium to heavy clay subsoils.
- High plant available moisture holding capacity.
- Fertile.
- Prone to soil erosion.

Sandy alluvial plains with deeper, sandy Rudosols, Tenosols and Kandosols (i.e., sands, sandy loams, loams and clay loams) are also present in the project development area and are included in soils that define GQAL. Further information on soils is provided in Chapter 12, Geology, Landform and Soils.

The project development area was divided into six broad terrain units, further subdivided on the basis of geology, landform, soils, soil properties and geomorphological processes, as shown in Figure 12.4. Figure 4.10 shows the spatial distribution of GQAL within the project development area.

13.3.3 Agricultural Development and Production

Historic Development

Extensive pastoral estates dominated agriculture in the Darling Downs in the mid-1800s, with farming comprising cereal crops, such as maize and arrowroot, together with dairying, pigs and calves. A railway was constructed from Toowoomba to Ipswich during 1865 and 1866, and this allowed produce to be transported to the Brisbane markets; and by 1871, further railway networks that joined Warwick to Toowoomba were built.

Additional railway extensions occurred between 1907 and 1914 and saw the end of many large pastoral estates, as they were subdivided into smaller landholdings. Cereal cropping was promoted by improved dryland farming techniques and soldier-settlement schemes. By 1912, the sawmilling industry, established during the initial land clearing, had made way for cheese and butter making; and by the late 1930s, the dairying industry had peaked with more than 200,000 milking cows over 6,500 farms.

More recently, there has been an increase in cropping diversity in the Darling Downs, with a greater focus on higher-value crops, such as grains, legumes and cotton. Most farms are about 500 ha in size, with the majority of broadacre farms in the region being family-owned. A large number of farms are, however, owned by publicly listed and privately owned companies with a small number foreign owned.

Agricultural Production

Summer and winter crops are grown in the region. However, as there is generally higher summer rainfall in the project development area and greater economic returns are received for summer crops, summer crops are generally preferred. The winter crops rely on the summer rainfall being stored in the clay-based Vertosols and Dermosols. The soil water content, combined with lower evaporation rates in winter, allows for greater water efficiency for the crops. Stubble retention and strip cropping are carried out in flood-prone areas, and both irrigated and dryland cropping systems are used.

Grain and cotton crops are grown, with raw cotton transported to Brisbane for export. Grain is used for human consumption, in feedlots and in industrial plants, such as the ethanol plant built in Dalby. Crops, such as cotton and wheat, are grown across the Darling Downs, as are speciality pulse crops, such as adzuki beans, which are used in high-value niche exports. Several certified organic farms operate in the region.

In 2006, livestock (cattle, pigs and sheep), cereal crops and non-cereal broadacre crops were the major agricultural enterprises in the region; and the total gross value of agricultural production for the Darling Downs Statistical Division was approximately $1.7 billion. At this time, there were 958,082 beef cattle and 793,541 sheep and lambs, and cereals were grown over 733,595 ha.

The gross regional product (GRP) of the Darling Downs in 2009/10 was estimated at $12.6 billion, of which approximately 9% was from agriculture, forestry and fishing. Regional growth exceeded state and national growth (gross product) between 2006/07 and 2009/10 and was mainly attributable to increases in mining and gas exploration due to a decline in agricultural production where growth in absolute terms for that period was only 2.7%. Darling Downs GRP represented about 5.1% of Queensland gross state product and 1% of Australian gross national product in 2009/10 (see Chapter 21, Economics).

13.3.4 Existing Constraints to Agricultural Development

Water availability is a major limitation to agricultural development; however, the main soil and landscape-oriented limitations to classification as GQAL include:

- **Gilgai.** The presence of gilgai can limit crop yield, as gilgai cause localised areas of waterlogging. Even if land is levelled, the gilgai make it difficult to surface irrigate as, within a short period of time, the filled gilgai reappear.
- **Dissected Landscape.** Such features as gullies, rills and watercourses dissect the landscape and limit the size of paddocks, consequently reducing the efficiency of farming operations.
- **Shallow Groundwater.** If groundwater is shallow (i.e., less than 2 m below natural surface level), there is an increased risk of salinity, which can lead to degradation of the soil and productivity of the land. This occurs when groundwater rises to the soil surface and then evaporates, leaving salt at the surface.
- **Salinity.** Saline soils are not suitable for irrigation and can be caused by using poor-quality irrigation water or from secondary salinisation from a rising watertable.
- **Sodic Soils.** These soils are not suitable for intensive agricultural development, as subsurface drainage is impeded, leading to perched watertables and tunnel erosion in sloping sites.
- **Impermeable Subsoils.** These soils have the same limitations as sodic soils, with the impeded drainage leading to perched watertables and short-term anaerobic conditions. Consequently, there is reduced plant growth, and the soil is not suitable for irrigation.
- **Erosive Flooding.** During flood events, selective removal of the topsoil (approximately 100 mm) from cultivated soils can occur, reducing plant productivity.
- **Slope.** This affects the type of irrigation that can be carried out. For example, surface or flood irrigation can be used on slopes less than 2%, spray irrigation on slopes than 15% and localised, or crop-dependent, irrigation when slopes are less than 25%.

13.3.5 Agricultural Activities

Dryland Broadacre Farming

Dryland broadacre farming includes cereal, pulse and cotton crops. Dryland farmers typically aim to maximise water infiltration. Consequently, paddocks are often laser levelled to remove undulations and fill natural drainage paths to create uniform slopes that optimise infiltration. Tillage is minimised to reduce soil compaction and assist with infiltration. Stubble is retained to assist with moisture retention and minimise soil and water erosion. Compaction is commonly minimised by confining access to a single set of wheel ruts (often referred to as ‘tram tracking’).

Cereal Crops. These include maize, grain sorghum and sunflower in the summer and wheat, barley, canary and grain oats in the winter. Although sorghum provides a lower return compared to other crops, the stubble that remains after harvesting or when a crop fails retains moisture and can be used for grazing and to provide protection against soil erosion. Maize is generally grown by specialist growers and requires better soil types.

The fallow period for cereals varies for the summer and winter crops. For winter crops, it is between November and May; and for sorghum (a summer crop), it is from June to August. Millet is double cropped. Winter and summer planting occurs from late April to July and from late August to February respectively. Harvesting follows between October and November for winter crops and from December to February for sorghum, with maize harvested 2.5 to 6 months after planting.

Nitrogen, phosphate or zinc fertiliser may be required. Grain crops require pesticide and herbicide application during the growing cycle, with fields generally sprayed multiple times.

Pulse Crops. In the Darling Downs, chickpea, faba bean, linseed and safflower are grown in winter and sunflower, navy bean and soybean in summer. Estimated production volumes for the 2006/07 period for the Darling Downs are 26,492 t of chickpea, 2,251 t of faba bean, 1,203 t of sunflower and 250 t of soybean.

For most of the winter pulse crops, the fallow period is from November to June, planting from April to June, and then harvesting between October and January. In comparison, summer crops are planted between mid-November and February, with harvesting dependent on soil moisture content, which influences growth and access to the land. Nitrogen and phosphate fertiliser may be required.

Cotton Crops. Planting for irrigated cotton generally occurs from September to November and picking from April to May. Although the returns are high, fertiliser (such as nitrogen, phosphate, potassium, zinc and sulfur), insecticide, irrigation and picking contribute significantly to the costs. Planting for dryland cotton occurs from late September to mid-January with ground preparation from March to April for winter crops. Pesticide is applied during the growing cycle, and fields are generally sprayed multiple times, sometimes up to six times.

Irrigated Broadacre Farming

Water availability is the main limiting factor in the Darling Downs for agricultural production, with 105,683 ha irrigated in the 2000-2001 period. This accounts for approximately 20% of irrigated land in Queensland. As shown in Figure 13.1a, cotton (with 61,859 ha) was the main crop irrigated in the Darling Downs, followed by cereal (with 17,859 ha). Water sources include surface water and groundwater.

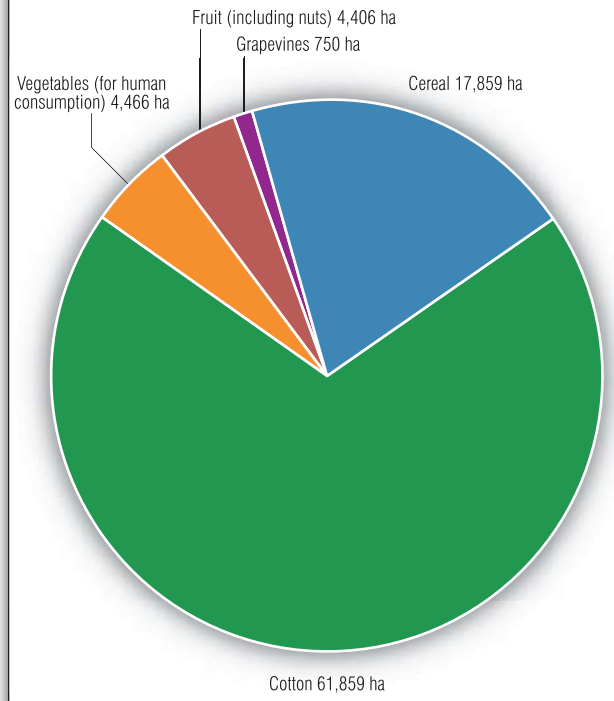
Fields are usually engineered to increase the effectiveness of irrigation and drainage. In some instances, laser levelling of fields is conducted to target specific areas of concern (i.e., ponding). The majority of farms also have water storages to store water allocations and to collect overland flow. In addition, head ditches are generally graded to particular heights to assist in delivering water at specific volumes.

The soil moisture content is measured to assist in determining the frequency and duration of irrigation required for the particular crop. This is done using such instruments as tensiometers and neutron probe moisture meters. Irrigation scheduling can then be calculated using an equation (e.g., the Penman-Monteith equation) to estimate the potential evapotranspiration, a key determinant in the frequency and duration of watering.

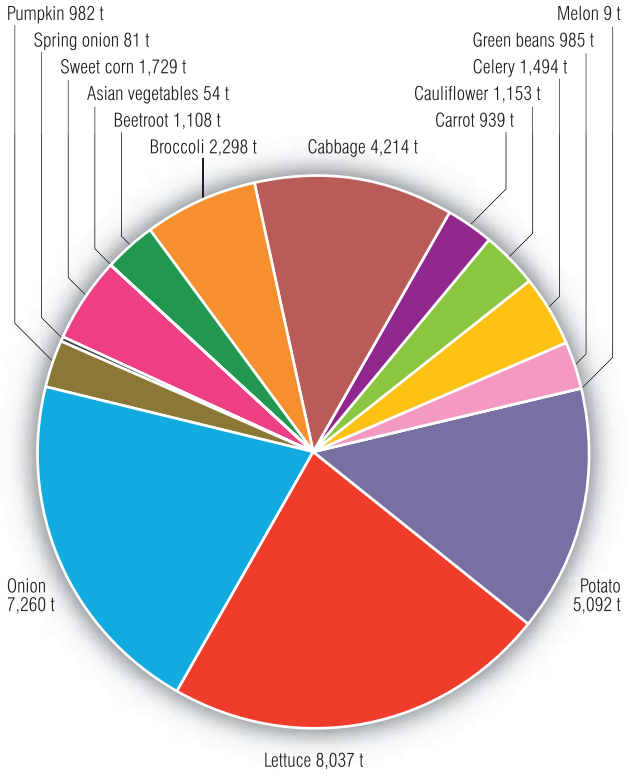
Surface (or Flood) Irrigation. There are four main types of surface irrigation: border-check, furrow, contour bay and contour channel. All are based on the principle of using a drainage (head) ditch to transport water to the upper slope of a field. Polyethylene pipe is usually used to siphon the water from the ditch to the planted rows. Different surface irrigation methods are used depending on the type of crop. However, furrow irrigation, where a furrow is dug between individual rows of plants parallel to the slope, is the most common.

Spray Irrigation. These systems include sprinkler, centre pivot, low-pressure boom (lateral move) or high-pressure ‘big gun’ and can be portable, semi-permanent or permanent. Spray irrigation is the most common irrigation method for broadacre cropping.

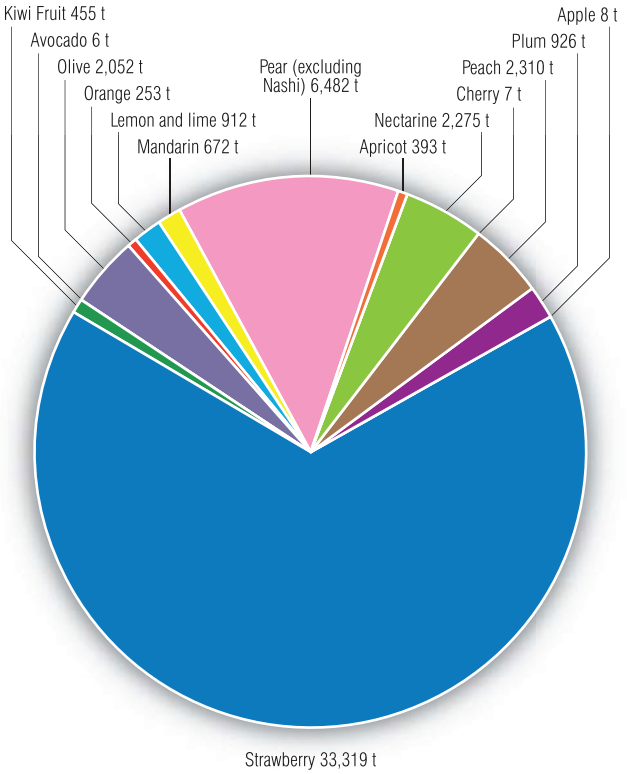
a) Irrigated area in the Darling Downs for 2000/2001



b) Production levels of key vegetables grown in the Darling Downs for 2005/2006



c) Production volume of fruit crops in the Darling Downs for 2006/2007



Source: Gilbert and Sutherland Pty Ltd.

coffey environments

Job No: 7040

File Name: 7040_04_F13.01_JO

Arrow Energy

Surat Gas Project

arrow energy go further

Selected agricultural statistics for the Darling Downs

Figure No: 13.1

Localised Irrigation. A spray or low-pressure drip directed at a plant's base or root system. As this type of system is labour intensive to install and removing plants can damage the irrigation lines, it is used for perennial crops, e.g., drips associated with vine trellises in vineyards.

Horticulture

For 2005/06, the key vegetable crops grown in the Darling Downs were lettuce (8,037 t), onions (7,260 t), potato (5,092 t), cabbage (4,214 t) and broccoli (2,298 t) (Figure 13.1b). Watermelon, rockmelon and honeydew are grown near Chinchilla. Water availability for irrigation and the number of frosts during winter tend to be the main limiting factors to horticultural development. The fallow period for crops in the area varies from May to August for beetroot, Chinese cabbage, carrots and celery and from November to March for onions. Carrots and celery are planted from July to April, with onions planted from August to March.

Fruit

Figure F13.1c shows the fruit crops grown in the Darling Downs for 2006/07, with strawberries being the largest crop at 33,319 t and avocados the smallest at 6 t. The picking period for fruits varies from February to March for apples and pears to September to October for stone fruit. The fruit crops usually require fertilising with nitrogen, phosphate and potassium. An olive processing plant has been established to accommodate the olives grown in the Millmerran region, which cover approximately 3,000 ha. For the 2006/07 period, 2,052 t of olives were produced in the Darling Downs Statistical Division.

Vineyards

For the 2006/07 period, 1.9 t of grapes were grown in the Darling Downs Statistical Division, with large wine grape producers near Jimbour and Maclagan and table grape producers near Chinchilla. Approximately 721 ha of vineyards are in the Darling Downs area. Localised (drip) irrigation is generally used in preference to spray irrigation to limit foliage wetting, which can lead to disease.

Intensive Livestock Industries

Intensive livestock industries include piggeries, poultry, beef feedlots, and horse agistment and breeding. Laying chickens (3,183,158 birds), meat cattle (1,310,310 head), meat chickens (267,816 birds) and milk cattle (excluding house cows) (37,247 head) were the largest animal products of the Darling Downs region in 2006/07.

Pigs. There are between 300 and 500 pork production units in the Darling Downs, largely attributed to the region's grain production. Piggeries are heavily dependant on a reliable water supply of a sufficient quality. Piggeries are designed to minimise disturbance to the pigs, as they are sensitive to disruption, which can affect breeding, which occurs year-round.

Eggs. Laying chickens rather than meat chickens are more common in the region and tend to be family-owned operations. Anecdotal evidence suggests there are a higher number of free-range egg operations than laying sheds. Egg production can be affected by noise and vibration as chickens are sensitive to such disturbance. Disease is also a threat and is controlled through shed hygiene.

Feedlots. Since the establishment of feedlots in the Darling Downs in the early 1960s, the area has become the most intensively developed region in Australia. Feedlots operate year-round and comprise pens, feeding stations, water supplies and support infrastructure, such as feed mills, manure stockpiles or effluent ponds, and silage pits. Some are attached to grain operations. Adequate space and a reliable water supply are the two key requirements for feedlots.

Dairies. Dairy infrastructure generally includes sheds, effluent areas or ponds, feed pads, silage pits and manure pits, as well as pastures or crops that can be consumed by milk-producing cows between milking. There are extensive dairy operations in the Darling Downs. The distance between the dairy sheds (where the milking takes place) and feeding stations has a large impact on efficiency.

Rangeland Grazing

The main livestock enterprises in the Darling Downs are beef cattle grazing and sheep grazing, with herd sizes generally comprising 300 to 400 animals. They are usually farmed in conjunction with grain production. Meatworks are located at Oakey and Toowoomba, and cattle sales are conducted at Dalby, Millmerran, Oakey and Toowoomba. Beef cattle tend to calve in August and September, and lamb fattening occurs from September to December.

Rangeland grazing infrastructure typically includes yards, loading facilities, shearing sheds, and watering and feeding points. Additional infrastructure, such as facilities for feed storage and production and for effluent, manure and litter disposal, is also generally required. Maintaining fences and gates of holding pens and paddocks and the infrastructure associated with watering systems, such as bores, holding tanks, supply pipes and troughs, are important rangeland grazing management activities.

Timber Production

Large quantities of timber, including cypress pine, spotted gum and ironbark, are harvested from forests on freehold, leasehold and Crown land in the project development area. This timber is mainly used for fencing, landscaping and firewood. Specialty craftwood timbers, such as brigalow, budgeroo, hairy oak and red ash, are becoming more common as a boutique timber industry establishes itself.

In the Darling Downs, there are approximately 120,000 ha of privately owned forestry plantations. In 2001, 65,146 trees were planted for timber and wood pulp. Farm forestry is still in the early stages of development in the area.

Thinning is carried out in plantations to remove non-target species and those that show substandard or suboptimal growth.

13.3.6 Environmental Values

The environmental values of agriculture are embodied in the soil profile (i.e., depth and composition of the soil horizons), soil properties (i.e., organic matter, biochemistry and soil water content), topography, flooding regime and climate. They influence the agricultural potential of the project development area and therefore the agricultural activities being and able to be conducted.

13.4 Issues and Potential Impacts

Potential impacts on the identified environmental values are disturbance of the soil profile and its function, disruption to machinery operations, impediments to farm workability, increased or new management overheads (including integration with farm plans) and loss of amenity.

13.4.1 Soil Profile

Vertosols have complex structures and are therefore more susceptible to disturbance than Dermosols and the sandy, clay loam Rudosols, Tenosols and Kandosols. Small and large pore connections between the soil layers in Vertosols are important for maintaining water flow through the soil profile. Potential impacts to Vertosols and soils in general relate to:

- Compaction from traffic.
- Inversion from mixing of soil horizons during excavation and preparatory works.
- Reduced organic matter from disturbance.
- Disrupted soil structure due to changes in soil constituents (organic matter) and plastic deformation.
- Crust formation.
- Biological degradation from stockpiling of the soil reducing organism vigour and seed stores.
- Impeded infiltration and drainage.
- Increased soil runoff during rain events.
- Reduction in plant available water.
- Reduced soil air, which may induce anaerobic soil conditions.
- Reduced fallow efficiency.
- Reduced fertility due to lowered organic matter, soil water or denitrification.

13.4.2 Machinery Operations

Mechanised farming is sensitive to:

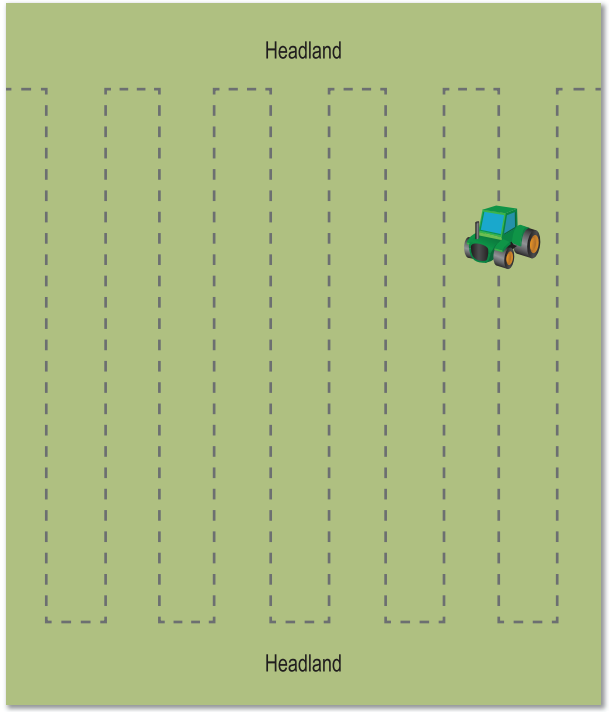
- Soil compaction, especially at headlands, leading to reduced crop yields.
- Irregular paddock shapes requiring double passes of machinery, leading to soil compaction and increased machinery operating costs.
- Uneven planting rates.
- Tillage gaps and unplanted areas leading to reduced crop yields.
- Tillage gaps and weed banks causing increased weed control costs.

Headlands are where machinery turns to start the next run down the paddock and are formed at the end of each tillage or planter run. The headland is subject to greater compaction due to the repeated turns of machinery. Figure 13.2a shows a typical tillage pattern in a rectangular, unobstructed paddock, with the headlands located at each end of the paddock. Inappropriately placed wells and tracks can obstruct tillage operations through the creation of more headlands, leading to a reduction in productivity as shown in Figure 13.2b. Figure 13.2c shows an example of how headlands can be reduced by locating infrastructure adjacent to the edges of paddocks or by aligning tracks and wells with the direction of tillage.

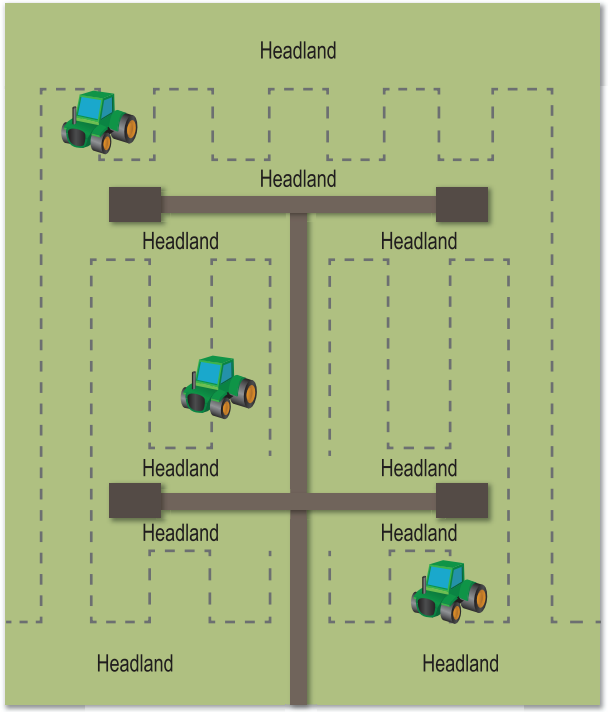
13.4.3 Farm Workability

Changes to the layout of farming properties caused by the introduction of coal seam gas infrastructure can disrupt operations, leading to increased capital and operating costs.

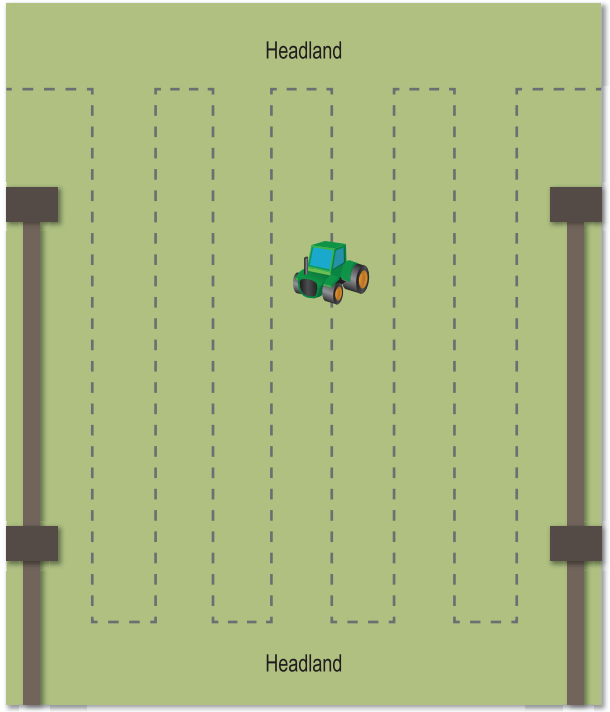
This is particularly evident in surface irrigation where modifications to irrigation channels, head ditches and tail drains can reduce the efficiency of delivery and distribution of water throughout the farm. Similarly, shortening of lateral booms and centre-pivot irrigators may require additional irrigators (e.g., big gun sprays) to irrigate the land inaccessible by the booms or centre pivots.



a) Typical unobstructed pattern of machinery movement



b) Example pattern of machinery movement resulting from multiple wells with track network



c) Example pattern of machinery movement resulting from relocation of wells and tracks to edges of paddock or in line with tillage direction

LEGEND

- Machinery movement
- Road
- Well

Source: Gilbert and Sutherland Pty Ltd.

coffey environments

Job No: 7040

File Name: 7040_04_F13.02_FT

Arrow Energy

Surat Gas Project

arrow energy go further

Example patterns of machinery movement

Figure No: 13.2

Increased headlands may require smaller tractors and planters to negotiate the introduced corners leading to increased capital and operating costs.

Development of coal seam gas infrastructure may also limit the ability of farmers to change farm plans to incorporate proposed capital improvements to the property and to account for new technologies and farming techniques.

13.4.4 Management Overheads

Irrigated and dryland broadacre cropping properties in the project development area typically have farm plans that extend over four to eight years. The plans set out the cropping and fallow cycles of each paddock and the rotation of crops to ensure soil organic matter is maintained and optimised, and they detail future development. They include information on the cultivation, planting, spraying and harvesting requirements for each crop. They may incorporate development plans that include the extension or augmentation of irrigation systems and associated infrastructure. Integration of project construction and operations activities with farm operations may introduce a management overhead that does not currently exist.

13.4.5 Loss of Amenity

Changes to the rural landscape as a result of the introduction of coal seam gas infrastructure and access to properties by Arrow staff and contractors will affect the amenity currently enjoyed by the farmers and their families. The extent and configuration of coal seam gas infrastructure on each property and the frequency and duration of visits by authorised personnel, along with the lifestyle of the farmers and their families, will determine the degree to which amenity is affected.

The effect of coal seam gas development on land value is considered to be variable based on a range of factors. Factors that will influence land value include the quality of the soils, access to water, farm productivity before and after coal seam gas development, and the nature of compensation agreements. Arrow aims to integrate its activities with agricultural enterprises in a way that does not adversely affect their viability or the agricultural potential of the land.

13.4.6 Potential Impacts of Project Activities

Project activities with the potential to cause adverse impacts on agricultural enterprises during the construction, operations and decommissioning phases of the project are described below:

- Loss of productive land (temporarily and potentially permanently) from development of production facilities.
- Temporary or permanent disturbance and potential diminished productivity as a result of the development of wells, gathering systems, pipelines and access tracks.
- Reduced crop yield from unsuccessful rehabilitation.
- Disruption to farm operations, such as tillage, planting, irrigation, weed control and harvesting, from inappropriate placement of wells, gathering systems, pipelines and access tracks.
- Disruption to intensive farming operations, including piggeries, poultry operations, feedlots and dairy farms, from inappropriate placement of production facilities, wells, gathering systems, pipelines and access tracks.
- Soil degradation from disturbance of the soil structure from all project activities, resulting in impacts to fertility and biologic function and crop yield.

- Changes to surface irrigation infrastructure, including head ditches, bays and tail drains, from inappropriate placement of wells, gathering systems, pipelines and access tracks.
- Diversion of flows and changes to the hydrology of the landscape from poorly sited or constructed access tracks.
- Farm hygiene issues relating to weeds and disease management from construction and operations vehicles, plant and equipment.
- Site contamination from all project activities.

13.4.7 Extent of Disturbance to Good-quality Agricultural Land and Potential Strategic Cropping Land

GQAL covers approximately 59% of the project development area, with the balance comprising other agricultural land, Crown land, state forest, and urban and industrial areas. Potential strategic cropping land is generally coincident with GQAL and covers 49% of the project development area.

It is not yet possible to assess the impact of project development on GQAL, strategic cropping land and specific agricultural enterprises, as locations of proposed infrastructure are not known. However, Arrow's experience indicates that construction of a typical production well, together with associated gas and water gathering infrastructure, will disturb 2% to 3% of land associated with a typical 160-acre (65-ha) production spacing. As gas field development is based on a series of production spaces, the estimate provides an indication of the overall area of disturbance to each property. Rehabilitation of gathering systems and temporary workspaces around wells will reduce this area with, the extent of the reduction depending on the success of rehabilitation.

There is also potential for medium-pressure pipelines and field compression facilities to be developed on GQAL and strategic cropping land. It is Arrow's intention to avoid locating the larger central gas processing facilities and integrated processing facilities on GQAL and strategic cropping land. The land requirements for this infrastructure are:

- Production well. Up to 0.5 ha for drilling and the installation of wellhead infrastructure, reducing to 10 m by 10 m (0.01 ha) during operation. A workover, which is required every 2 to 4 years, will require a similar area to that required to establish the well. Approximately 7,500 wells are proposed over the life of the project.
- Medium-pressure pipelines. Between 15 and 25 km in length, with a construction right of way up to 25 m wide.
- Production facilities. Eighteen production facilities are required: six field compression facilities (typically 0.5 ha in size), six central gas processing facilities (each 15 ha) and six integrated processing facilities (each up to 220 ha).

13.4.8 Summary of Potential Impacts

Potential impacts to the environmental or agricultural values of the project development area can be summarised as follows:

Reduced Productivity and Increased Costs. Caused by changes in farm configuration (e.g., creation of more headlands), disruption to farming practices (e.g., changes to irrigation infrastructure, interference with overland flow), unsuccessful rehabilitation and temporary loss of arable land.

Crop Losses or Disturbance to Stock. Caused by drilling or construction occurring during inopportune times that disrupts cropping or breeding (depending on the proximity to breeding animals and the nature and intensity of the disturbance) and unsuccessful rehabilitation.

Soil Disturbance. Caused by compaction from traffic, mixing and inversion of soil horizons, settling of pipeline trenches or soil loss from erosion caused by construction activities.

Increased Costs of Farm Management. Caused by increased operating overheads from management of coal seam gas activities and coordination of activities (e.g., spraying and withholding periods) and integration with farm plans. Increased costs may also result from limitations on the capability of farms to incorporate new technologies and farming techniques.

Loss of Amenity. Caused by contractors and employees entering and working on properties, disruption to lifestyle, increased levels of noise and dust, and the visual impact of project infrastructure.

13.5 Environmental Protection Objectives

The environmental protection objectives for agriculture are:

- To avoid or reduce adverse impacts to agricultural infrastructure.
- To reduce adverse impacts to agricultural production (cropping and breeding).
- To reduce adverse impacts to farming practices (i.e., day-to-day agricultural activities).
- To maintain or restore soils to support the intended land use.

13.6 Avoidance, Mitigation and Management Measures

Each agricultural enterprise is unique and has developed particular practices to maximise the productivity of the land. The planning, design and development of project infrastructure and undertaking of project activities will need to address the specific issues raised by each property. This is particularly relevant to intensively farmed land.

Intensively farmed land is a term developed by Arrow to reflect agricultural areas on sensitive soils (i.e., black soils) that are currently intensively farmed (i.e., irrigated, cropped), where relatively minor changes to the landform and farming activities can have a disproportionate impact on the productivity of the land.

Arrow believes that, through appropriate consultation with landholders and the broader community together with coal seam gas development planning, intensively farmed land and coal seam gas developments can coexist without causing permanent alienation of, or diminished productivity from intensively farmed land. Siting of wells in consultation with landholders in locations which minimise impacts on productive areas and provide the best opportunity for rehabilitation, as well as locating of production facilities in less productive land are key strategies for reducing the potential for permanent alienation of intensively farmed land.

Arrow understands that its development activities will have an impact on landholders and recognises that its development plans need to consider the location of infrastructure, the timing and duration of site access, and how drilling and construction activities are conducted in light of the needs of the landowner and landholders. Arrow is actively engaging with the community on the issues associated with development of intensively farmed land through a range of forums, including:

- **Arrow Surat Community Reference Group.** A consultative forum that consists of spokespeople from the Basin Sustainability Alliance, Future Food Queensland, Cotton

Australia, Central Downs Irrigators Limited, Australian Petroleum Production and Exploration Association, DERM, the Department of Employment, Economic Development and Innovation, regional councils, the University of Southern Queensland and Arrow. The forum is an opportunity for Arrow to provide project updates and to hear and work through community issues and concerns.

- **Arrow Intensively Farmed Land Committee.** Comprised of representatives from Arrow and various landholders representing different agricultural enterprises on intensively farmed land, the committee provides an opportunity for feedback from the farming representatives on Arrow's proposed approach to development on intensively farmed land, including the establishment and reporting of case studies and trials.
- **Community Consultation.** Since June 2010, Arrow has consulted with more that 1,200 landholders and community members in the Surat Basin via various forums, including community information sessions; call-in centres; and meetings with representative bodies, state and local government agencies, and individual community members. Community consultation has included static displays and coal seam gas water management workshops at which independent experts provided advice on groundwater systems, their behaviour and modelling.
- **Irrigator Groups.** Arrow is currently working with Central Downs Irrigators Limited, the Basin Sustainability Alliance and Future Foods Queensland to investigate the best means of implementing Arrow's coal seam gas water management strategy.
- **CSG Engagement Group.** This group provides a forum for landholders; state government directors-general and local government mayors; and representatives from Queensland Water Commission, the coal seam gas industry, Agforce Queensland, Cotton Australia, the Basin Sustainability Alliance, the Australian Petroleum Production and Exploration Association and the Queensland Resources Council to identify and resolve concerns relating to the coal seam gas industry. Arrow is also represented on two subcommittees, the water and land access working groups.

The primary mitigation for reducing potential impacts on agricultural land and agricultural enterprises is siting of infrastructure. The secondary mitigation is the design and development of construction and operations methods that enable project activities to integrate with farm activities. The tertiary mitigation is the application of environmental management controls, i.e., proven methods and techniques for protecting the environment.

Primary and secondary mitigation is to be achieved through the implementation of 12 performance-based objectives that provide an opportunity for the proponent to work with the landowner to develop appropriate methods for the development of coal seam gas infrastructure on the property, having regard to the property-specific values and farming practices. The proposed performance objectives are:

1. **Integrate Development Activities.** Integrate development activities (and infrastructure) with farming operations, recognising and understanding the particular farming practices and property-specific development and farming plans. Consult landowners on the location of infrastructure and on construction methods to reduce overall impacts to the farming operation, including capital and operating costs and productivity.
2. **Intensive Farming Operations.** Avoid infrastructure and associated farm management areas of intensive farming operations, including piggeries, feedlots, vineyards, orchards, horticultural enterprises, poultry farms and small-lot plantations. Maintain a minimum

separation (nominally 200 m) between animal enclosures and production wells and facilities to ensure biosecurity or animal health, as agreed with landowners or landholders.

3. **Production Facility Site Selection.** Site production facilities, electricity substations and associated access tracks to avoid or reduce loss of cultivation areas and irrigation infrastructure. Arrow has committed to ensuring dams for coal seam gas water and brine are not constructed on intensively farmed land as per commitment C092.
4. **Medium-pressure Pipelines.** Route medium-pressure pipelines along boundary fences, parallel to the direction of cultivation or soil conservation structures, or in the lowest quality soils to reduce impacts on cultivation and irrigation systems.
5. **Cultivation Paddocks.** Minimise the introduction of additional headlands in cultivation paddocks.
6. **Controlled Traffic Operations.** Minimise the loss of productive land in controlled traffic paddocks.
7. **Soil Conservation Structures.** Maintain the operation and effectiveness of soil conservation structures.
8. **Spray Irrigation.** Locate wells, gathering lines and associated access tracks in a manner that does not significantly interfere with swept paths (effective coverage) of centre-pivot and lateral and low-pressure boom irrigators.
9. **Surface Irrigation.** Maintain the integrity and efficiency of surface irrigation systems.
10. **Cropping Cycles.** Maximise the opportunity to schedule development and routine maintenance activities, particularly drilling and construction with the cropping cycle (i.e., with fallow periods).
11. **Access Track Design.** Develop construction methods and design access tracks in cultivation paddocks to maintain the existing hydrologic and hydraulic regime of the site. Evaluate the material used in construction of the access tracks for potential impacts to the farming operations (e.g., gravel above a certain size can cause damage to machinery).
12. **Wellpad Design.** Minimise disturbance and temporary loss of productive land associated with drilling wells, particularly from workspace creep, by agreeing on the layout of the drill pad and associated work areas with the landowner subject to any safety requirements.

These objectives have underpinned the development of the avoidance, mitigation and management measures and are embodied in them; they are the primary tools for ensuring an effective response to the issues. The measures fulfil the nominated environmental protection objectives. All personnel and contractors will be inducted and trained in the implementation of the avoidance, mitigation and management measures. Groundwater and surface water are also integral to agriculture, and the management of these aspects is addressed in Chapter 14, Groundwater, and Chapter 15, Surface Water, respectively.

The effectiveness of the proposed environmental management controls in addressing the identified impacts is being investigated through trials and case studies that are currently focused on rehabilitation of black soils (Vertosols and Dermosols) and construction methods for work on those soils. Trials and case studies currently in progress include:

- A trial on an Arrow-owned farm to demonstrate the effectiveness of the procedures developed for exploration chip and core drilling on black soils.

- Three separate case studies on different properties with different farming practices in intensively farmed land areas, involving working directly with landowners to design coal seam gas developments on their land in a manner that minimises the impact on their land and farming activities.
- Drilling and development trials of techniques to reduce impacts on intensively farmed land, including:
  - Using surface tanks to manage drilling muds during the drilling process to eliminate the need to excavate pits in intensively farmed land areas.
  - Constructing and reinstating a pipeline ROW in black soils to demonstrate how existing surface profiles can be maintained and rehabilitated, thereby reducing impacts on farming enterprises.

The case studies are being developed in consultation with the Intensively Farmed Land Committee and with the cooperation of its members. The results of the case studies and trials will be presented to the committee.

The management measures set out below have been grouped according to the potential impact that they address. General measures are followed by measures that specifically address the identified impact.

The avoidance, mitigation and management measures outlined below will avoid adverse impacts to or reduce the severity of potential impacts on agricultural values.

13.6.1 General Measures

The following general avoidance, mitigation and management measures will be implemented for all activities:

- Comply with the provisions of the *Petroleum and Gas (Production and Safety) Act 2004* and the Land Access Code (DEEDI, 2010b) prior to accessing private land. All appropriate agreements (with accompanying maps of the area of interest and detail on infrastructure development) will be in place prior to entry onto the land. Arrow will ensure all appropriate landowners are notified prior to access being required to allow stock to be moved and access routes to be cleared of machinery or materials. [C075]
- Consult and agree with landowners on the appropriate location for infrastructure and access routes (to well sites and to and along pipelines). Clearly identify the outcome of the discussions on scaled plans of the property and clearly indicate agreed access routes using signs, temporary fencing, barricade tape or traffic control measures. [C084]
- Investigate the opportunity to increase well spacing from 160 acres (65 ha) to 320 acres (129 ha) or greater to reduce the footprint on strategic cropping land. [C083]
- Ensure an Arrow representative is in attendance at the time of first entry to check contractors have the appropriate environmental management procedures and property-specific information. [C094]
- Maintain the grievance process (complaint management system) for the community to register complaints, issues, comments and suggestions. [C077]
- Ensure construction activities do not extend beyond the work site boundaries. [C091]

- Cap or fit wellhead equipment to wells at the completion of drilling to ensure no uncontrolled release of gas or water. [C113]
- Ensure dams for coal seam gas water and brine are not constructed on intensively farmed land. [C092]
- Remove salt from the landscape as part of decommissioning works and dispose of in an approved and regulated landfill. [C114]

13.6.2 Reduced Productivity and Increased Costs

The following avoidance, mitigation and management measures have been developed to address the potential impact of reduced productivity and increased costs due to changes in farm configuration or to disruption to farming practices:

- Develop and implement a compensation framework to 'add value' rather than just compensating for impacts. [C081]
- Consult with landowners on the most appropriate method to minimise disruption to cultivation paddocks (including the introduction of additional headlands) and loss of productive land in controlled-traffic paddocks. The following measures will be considered in reaching agreement: [C088]
  - Locate infrastructure (in order of preference) outside of cultivation areas, in headlands or at the corners of cultivated areas, adjacent to boundary fences or in areas of a paddock with the lowest-quality soil.
  - Locate access tracks in headlands or adjacent to boundary fences.
  - Utilise existing access tracks and trafficked areas.
  - Align gathering lines and new access tracks parallel to the direction of cultivation, soil conservation structures and controlled traffic runs and avoid perpendicular or lateral connections.
  - Lay out drill pads in accordance with landowner requirements, subject to safety requirements, to reduce the overall impact on cultivation, where practicable.
- Maintain the integrity and efficiency of surface irrigation systems by adopting the following measures: [C095]
  - Locate infrastructure at or adjacent to the end of head ditches or tail drains and in a manner that does not significantly interfere with swept paths of boom irrigators to avoid severance or fragmentation of water delivery systems.
  - Locate wells, gathering lines and access tracks adjacent to boundary fences, where practicable.
  - Align gathering lines and access tracks perpendicular to the direction of head ditches and tail drains (i.e., parallel to the direction of surface flows and cultivation).
- Investigate alternative drilling technologies, such as using directional drilling to access coal measures, reducing gathering system pipe diameters and drilling multiple wells from one drill pad to potentially reduce the footprint on strategic cropping land. [C087]
- Use surface tanks (not pits) to manage drilling muds on black soils when drilling production wells. [C096]

- Remove sediment fencing prior to cultivation and dispose of in accordance with landowner requirements or in accordance with the waste management plan of the Arrow HSEMS. [C112]
- Ensure coal seam gas water used for dust suppression on roads or for construction and operation activities is treated if required. [C497]
- Ensure that the quality of coal seam gas water used for dust suppression meets the prescribed limits. [C540]

13.6.3 Crop Losses or Disturbance to Stock

The following avoidance, mitigation and management measures have been developed to address the potential impact of crop losses or disturbance to stock resulting from disruption to cropping or breeding:

- Fence the exclusion zone of production well sites (i.e., 10 m by 10 m) to exclude unauthorised personnel, stock and wildlife from that area. [C097]
- Inspect work sites and access routes for notifiable weeds and pest plants and animals prior to accessing the site; and if detected, manage in accordance with the Petroleum Industry – Minimising Pest Spread Advisory Guidelines, Queensland Department of Primary Industries and Fisheries, June 2008 (Biosecurity Queensland, 2008). [C098]
- Wash down vehicles and equipment that have potentially been in contact with weeds before entering new work sites. [C099]
- When operating on black soils, collect, contain and store drilling fluids and waste (solid and liquid) on site in appropriate storage tanks until recycled, treated (if necessary) or disposed of off site. [C100]
- Stockpile drilling cuttings adjacent to the well or in containers and dispose of appropriately in consultation with the landowner. [C101]
- Store onsite materials in suitable containment systems constructed to industry standards and Australian standards (AS 1940-2004, The Storage and Handling of Flammable and Combustible Liquids (Standards Australia, 2004a), and AS 3780, The Storage and Handling of Corrosive Substances (Standards Australia, 2008b) at a minimum). Maintain quality control and quality assurance procedures to monitor volumes and quantities. Bund aboveground storage areas to contain spills. [C102]
- Manage soil contaminated by oil, fuel and grease in accordance with the hydrocarbon management plan (prepared as part of the Arrow HSEMS), which includes procedures for the excavation and removal to a licensed landfill or remediation at site. Where contamination has occurred, investigate and remediate in accordance with Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland, Department of Environment, 1998 (DE, 1998). [C103]
- Develop or facilitate the development of a method for assessing impacts on productivity (crop yields) that incorporates statistical analysis and appropriate control and sampling sites. [C086]
- Regrade work sites to original surface contours following reinstatement of soil. [C116]
- Maintain a minimum separation, as agreed with the landowner, between animal enclosures and production wells and facilities. [C104]

- Develop construction methods and design access tracks in cultivation paddocks to maintain the existing hydrologic and hydraulic regime of the site and in a way that does not cause erosion. [C089]

13.6.4 Soil Disturbance

Avoidance, mitigation and management measures developed to address the potential impact of soil disturbance from soil compaction, mixing and inversion of soil horizons, or soil loss from erosion:

- Maintain the operation and effectiveness of soil conservation structures by adopting the following measures: [C111]
  - Avoid breaching, diversion or disturbance of contour banks, waterways and dams.
  - Avoid earthworks that affect waterway function.
  - Locate wells, access tracks and gathering lines downhill and parallel to soil conservation structures and avoid perpendicular or lateral connections.
  - Utilise existing access tracks and trafficked areas.
- Stockpile cleared or mulched vegetation along the inside edge of the work sites (separate from soil stockpiles), to aid the control of runoff and ensure stockpiled vegetation does not pose a bushfire hazard. [C106]
- Prevent subsurface water flows and erosion along the backfilled trench by appropriate means, such as trench blocks and compaction of backfilled soils. [C503]
- Mulch vegetation and reuse in site rehabilitation. [C117]
- Strip, salvage and stockpile topsoil near the work site separately to subsoils (in consultation with landowners). Ensure topsoil stockpiles have a maximum height of 2 m, where the future use is intended for rehabilitation, and are protected from erosion. [C062]
- Stockpile imported fill for bedding of pipes adjacent to the trench and away from vegetation, topsoil and subsoil stockpiles. [C109]
- Develop an erosion and sediment control plan and install and maintain appropriate site-specific controls. [C034]
- Clean and reinstate (if necessary) erosion and sediment control structures prior to and following storm events and periodically during long periods of rain. [C122]
- Construct batters and embankments of drill pads and production facility benches at appropriate slopes and protect from erosion. [C108]
- Suspend works when rainfall or storm events produce onsite conditions that, if trafficked or worked, would compromise the effectiveness of erosion and sediment control structures, or would lead to rutting and compaction of soils or mixing or inversion of soil horizons. [C105]
- Backfill soils in the reverse order of removal, and undertake backfilling progressively and regularly during pipeline construction. [C090]
- Compact padding material and subsoils used to backfill pipeline trenches to reduce settling. Limit compaction to no deeper than 0.5 m below natural surface level. [C119]

- Backfill and rehabilitate excavations, particularly pipeline trenches and drilling sumps. Conduct backfilling in a manner that will promote successful rehabilitation, including capping of exposed subsoil with topsoil and replacement of the land surface to preconstruction levels to reduce trench subsidence and concentration of flow. Mounding of soils to allow for settling may be required in some areas. However, in laser-levelled paddocks, this may not be practicable, and backfilling should be carried out in consultation with the landowner. [C071]
- Remove excess imported fill and residual subsoil from the work site, and reuse or dispose of in accordance with landowner requirements. [C110]
- Retain and regularly inspect erosion and sediment control structures until reinstated soils have been stabilised and sown. [C078]
- Deep rip and cross rip all construction areas and temporary access tracks to a depth of at least 0.4 m. Repeat following topsoil reinstatement to promote infiltration and assist the re-establishment of connections between soil horizons. [C118]
- Rehabilitate clean water diversions, down-gradient soil erosion control works and temporary sediment dams to preconstruction site levels, and rip prior to sowing with crops or pasture grasses. [C121]
- Visually inspect rehabilitated work sites for flow diversions and evidence of erosion associated with trench settling or incomplete reinstatement of surface contours. [C123]
- Study methods to reduce impacts and maintain the soil profile during gathering system pipeline construction by understanding the soil type, reducing pipe diameters, plowing (instead of trenching) and potentially burying deeper than the minimum standard. [C085]

13.6.5 Increased Costs of Farm Management

The following avoidance measures have been developed, in addition to the measures described in Section 13.6.2 above, to address the potential impact of increased costs of farm management due to greater operating overheads:

- Avoid infrastructure and associated farm management areas of intensive farming operations, including piggeries, feedlots, vineyards, orchards, horticultural enterprises, poultry farms and small-lot plantations. [C076]
- Develop coal seam gas development property plans to address key issues raised by landowners relating to potential impacts on intensively farmed land. [C082]
- Plan and integrate construction and operations activities with harvesting, spraying and withholding periods. [C080]

13.6.6 Loss of Amenity

Avoidance, mitigation and management measures developed to address the potential impact of loss of amenity due to contractors and employees entering and working on properties, disruption to lifestyle, increased levels of noise and dust, and the visual impact of project infrastructure are:

- Clear areas progressively and implement rehabilitation as soon as practicable following construction and decommissioning activities. [C015]
- Install gates in fences of an appropriate standard to restrict access to authorised personnel, vehicles, plant and equipment. [C093]

- Replace or rehabilitate all disturbed infrastructure to predisturbance condition. [C115]

13.7 Residual Impacts

Potential impacts can be successfully managed through gas field planning, modifying work practices and rehabilitation, however it is acknowledged there is the potential for residual impacts depending on the ability to rehabilitate disturbed land to its former use. The success of rehabilitation will determine whether there are any residual impacts and their severity.

The primary factors that will influence the success of rehabilitation include:

- The hydrologic regime and drainage patterns of the disturbed land and surrounding area; i.e., can the predisturbance drainage patterns be reinstated or replicated to ensure a stable landform that does not alter overland flow behaviour or cause erosion?
- The type and properties of the disturbed soils; i.e., can the soil profile, small and large pore connections, soil organic matter, soil chemistry and biological function be reinstated?
- The predisturbance land use and productivity; i.e., can the former land use and productivity be reinstated?

The type and location of coal seam gas infrastructure – production wells, gathering systems, pipelines, or production facilities – will determine the techniques, effort and investment required to achieve successful rehabilitation and reinstatement of former land use and productivity.

Land that cannot be rehabilitated to its former use may lead to a residual permanent change in land use. For example, production facility sites may not be suitable for cropping once rehabilitated but might be suitable for grazing. Site selection is the most effective way to manage this potential residual impact. Arrow will ensure that site selection considers low value agricultural land in preference to high value agricultural land to minimise potential residual impacts to land use.

Residual impacts will be identified through inspection and monitoring proposed in the following section. They will be remediated or addressed through appropriate compensation.

13.8 Inspection and Monitoring

Inspection and monitoring of construction, operations and decommissioning activities will be undertaken to ensure the proper implementation of standard operating procedures that incorporate the proposed environmental management controls. Monitoring of rehabilitation will also be undertaken to ensure the performance objectives have been met. Where the outcomes are not achieved, remedial measures will be implemented to achieve the desired outcomes.

Inspections proposed to ensure the conservation of soils are:

- Inspect erosion and sediment control measures following significant rainfall events to ensure effectiveness of measures is maintained. [C505]
- Inspect pipeline ROWs routinely until ground stabilisation and natural revegetation or pasture grasses or crops are established. [C506]

Monitoring programs to be developed include:

- Monitor crop productivity or pasture health periodically to measure productivity on disturbed areas. [C519]

- Review landowner grievances regularly, including status of project actions and close-outs. [C520]