Well Design and Abandonment - NGP

Michael Zed

Project Lead, Drilling and Completions

Santos

Well Design

Santos has been a leader in the Australian oil and gas industry for more than 50 years

Santos

High Standards in Well Design and Abandonment

Santos

Santos standards meet or exceed the Australian regulatory requirements, governed by each state

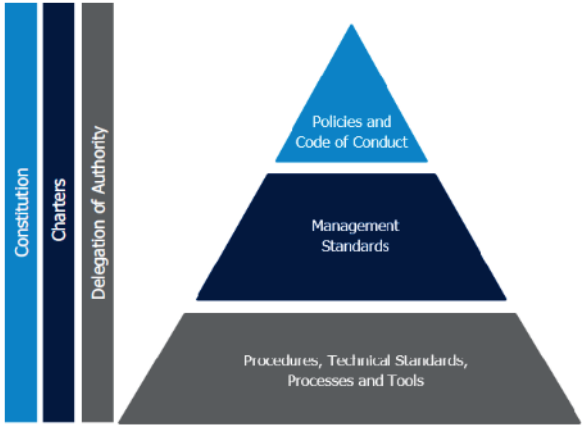
+ NSW Codes of Practice are the strictest regulations in Australia
+ D&C designs are submitted to the state government regulators in the form of a programme and approved before commencing any activity
+ We comply with industry standards and best practices including the American Petroleum Institute (API) standards
  - Those standards include clear specifications for well design, construction and abandonment
+ The CSG well conditions (low pressure / temperature and shallow depth) may be less complex to conventional O&G operations, however Santos design and operating standards remain high
+ The same well design principles applied to offshore operations are used across the company, specific to the well type and conditions

Regulatory Assurance

Santos

NSW has a world class regulatory process ensuring strict controls are put in place prior to any CSG activities occurring

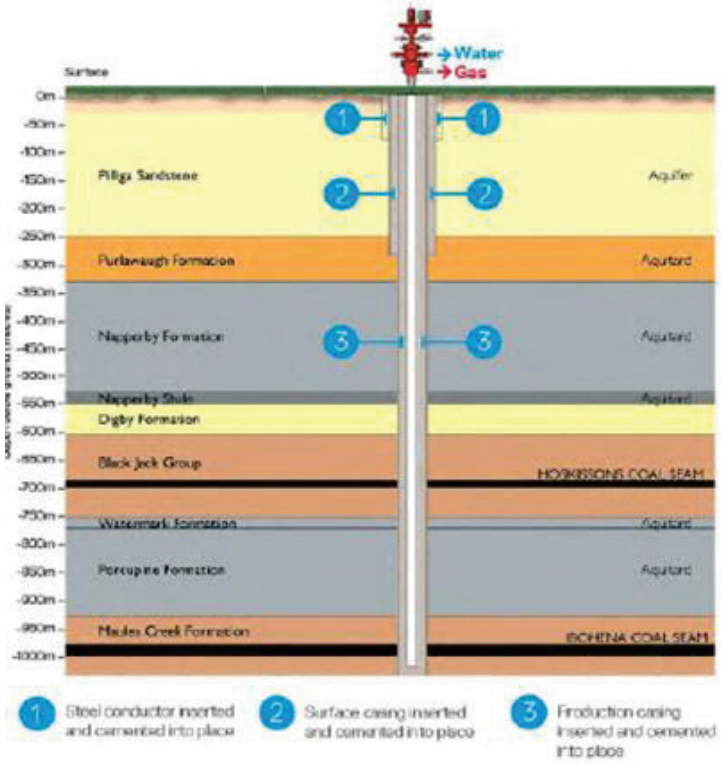
+ Coal Seam Gas industry in NSW is regulated by state agencies with multiple approvals required prior to beginning any drilling and completion operations
  - Environment Protection Authority (EPA)
  - Department of Primary Industries (DPI) - Crown Lands and Water
  - Department of Planning and Environment (DPE) – Resource Regulator
+ NSW Petroleum (Onshore) Act (1991), NSW Petroleum (Onshore) Regulation (2007)
+ NSW Work Health and Safety (Mines and Petroleum Sites) Act 2014
+ NSW Code of Practice for Coal Seam Gas , Well Integrity
+ The Code stipulates mandatory practices for well design and construction to ensure CSG activities are environmentally safe and groundwater resources are protected



Drilling with Care

Santos

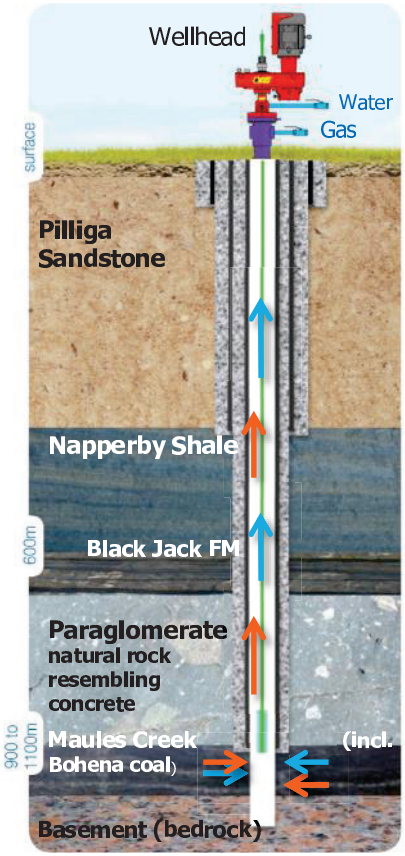
Local geology and Santos' high standards ensure natural gas is produced safely and groundwater is protected



+ To produce gas, water is extracted from the coal seam, reducing the pressure and allowing the gas to flow
+ Pilliga sandstone contains aquifers used for agriculture and community
+ Coal seams in the Project area are generally between 500 – 1,000 m below the surface
+ Impermeable rock layers form a barrier between shallow aquifers and coal seams
+ Layers of steel and cement isolate the aquifers and ensure well integrity
+ Well design and construction codified within the NSW Code of Practice for CSG Well Integrity

How We Extract the Natural Gas

Santos



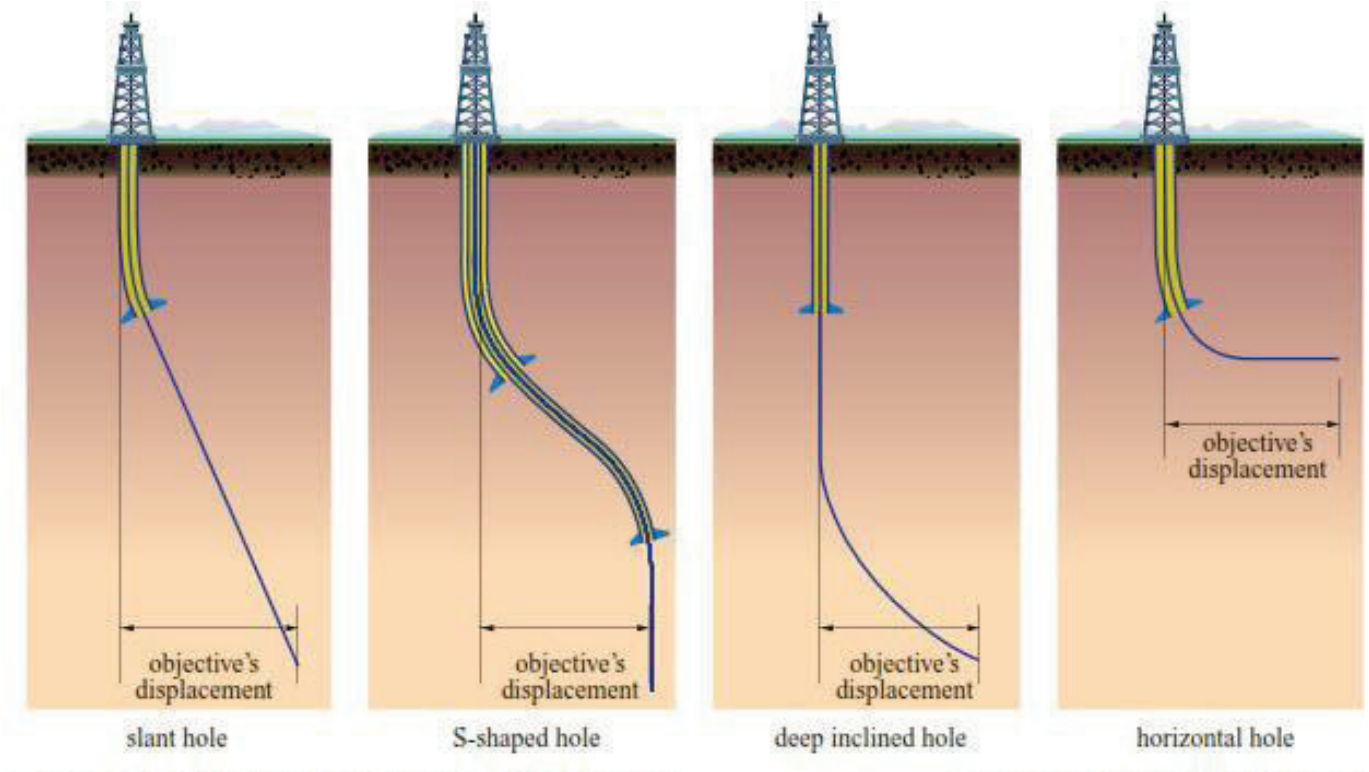
Wellbore design, construction and operations are heavily regulated in Australia

+ A conductor is cemented in place to give ground stability
+ Surface casing is run inside the conductor and down through and beyond the aquifers. It is cemented into place (back to surface) to protect the aquifers
+ Production casing is then run inside the surface casing from the surface to below the coal seam and is cemented in place
+ A pump is run in the well to pump water to the surface. It is driven by an electric motor at surface

Typical Well Types

Santos

Depending on the objective there are many different well types that can be used to develop a project



Well Design Considerations

Santos

Wells are designed for anticipated pressure regimes present across the life of the well

+ Consider drilling risks in design
+ Casing depths, sizes and numbers of strings decided accordingly
+ Total depth (TD) based on target coal horizon depths and requirements for well completion / production

Wellbore Integrity

Santos

Why is cement necessary?

+ The purpose of placing cement in the annular space (gap between casing and formation) is primarily to support the casing and to provide zonal isolation
    - The cement sheath creates an engineered and tested barrier in the wellbore, which provides zonal isolation and prevents migration and communication of gas and water
    - The cement sheath maintains well integrity; cemented casing provides the structural integrity necessary to perform further operations
    - Once pumped the cement does not degrade as a function of time
    - Testing of mechanical properties for life of the well integrity, such as compressive strength, tensile strength, expansion, as well as elasticity is done to ensure the required zonal isolation requirements are included in the engineered cement blend

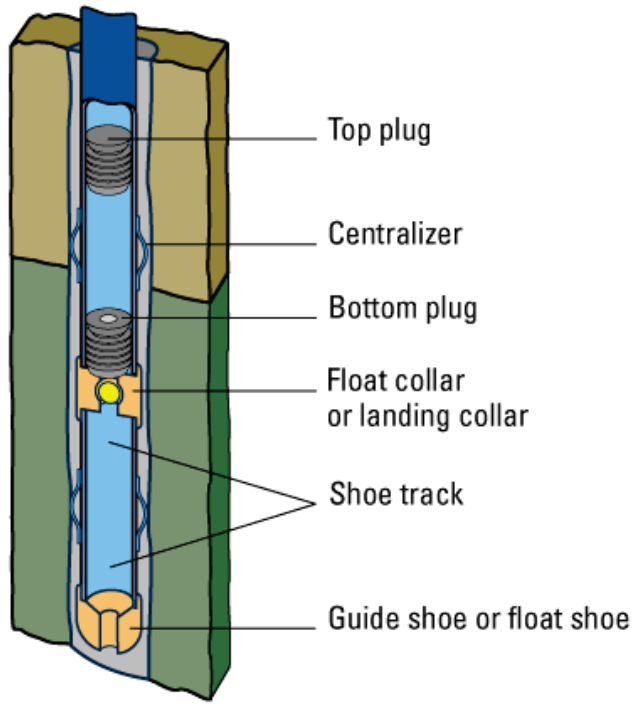
Cementing Casing Strings

Santos

Cement is engineered to specific parameters to ensure consistent performance and zonal isolation without cement degradation

+ Pressure cemented (ie casing annulus cemented from the bottom upwards) with float valve (s) in the casing strings
+ Engineered cement slurries
+ Simulations used to determine placement and frequency of centralisers attached to the casing string to achieve quality cement sheath
+ Pressure test casing and shoe cementing prior to drilling ahead (casing pressure test and shoe FIT)
+ Representative samples are taken during blending and mixing in the field for quality assurance

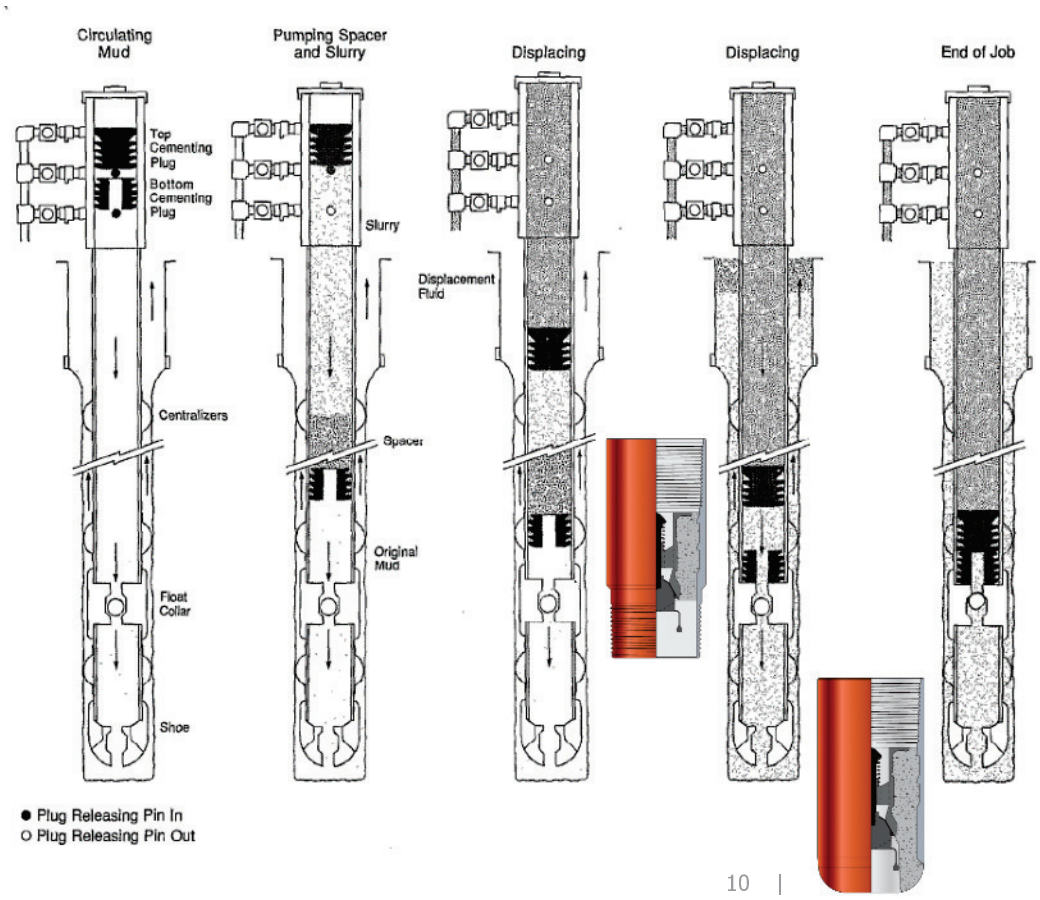
Cement shoe and float



Cementing Equipment and Technique

Santos

- **Cement head** – holds the cementing plug(s)
- **Float collar** with non-return valve
- **Float shoe** with non-return valve
- **Casing centralisers** attached to the outside of the casing run into the hole



Well Monitoring

Santos

All wells are included in a field monitoring program which includes inspections of the lease and wellhead equipment in addition to telemetry.

+ Dedicated Well Integrity Group
+ Monitoring program for wells post drilling
+ Regular integrity and maintenance inspections
+ Santos currently monitors all wells in the existing Narrabri Project area
+ Asset Integrity Management System **(AIMS)**

Plug and Abandonment (P&A)

Santos will understand and manage the impact of our operations on the environment

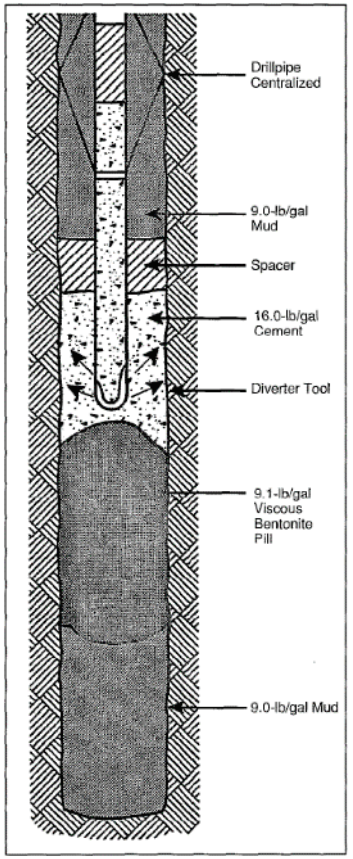
Santos

Cement Plugs for Abandonment

Santos

Cement is engineered to specific parameters to ensure consistent performance and zonal isolation without cement degradation

+ Pressure cemented (ie casing cemented from the bottom upwards)
+ Engineered cement slurries
+ Simulations used to determine cement placement to achieve zonal isolation
+ Representative samples are taken during blending and mixing in the field for quality assurance
+ During plug and abandonment operations, cement plugs are set throughout the entire well to surface
+ Pressure tested and wireline logging operations are undertaken

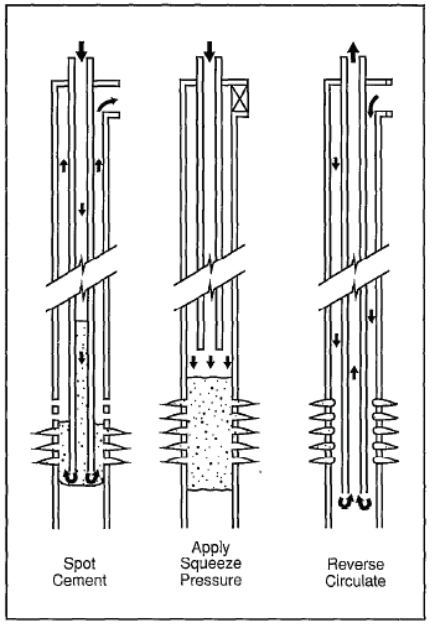


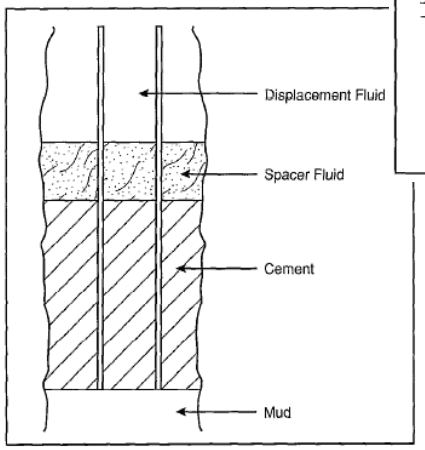
Cementing Equipment and Techniques

Santos

How do you pump a cement plug?

- Pipe is run into the well, to the desired depth for the bottom of the plug
- A calculated volume of spacer is pumped ahead and behind the slurry to avoid any detrimental contamination of the cement by the mud
- Under displacement of the cement plug occurs to avoid mud flowback after pumping the cement plug
- Once the plug is balanced, the pipe is slowly pulled out of the cement to a depth above the plug and excess cement is reversed out



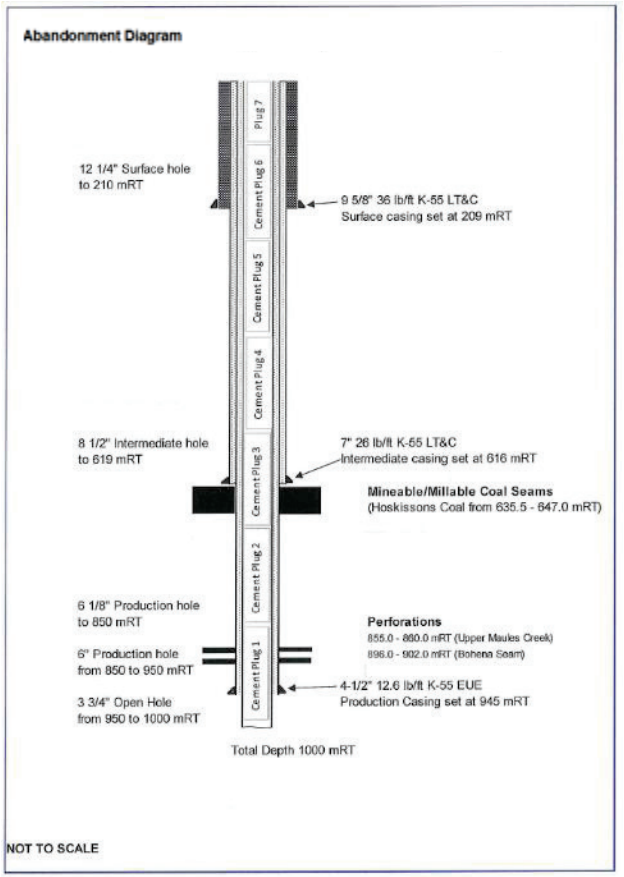


Plugging and Abandoning a Well

Santos

P&A plans are submitted to the Resource Regulator and approved before commencing any activity

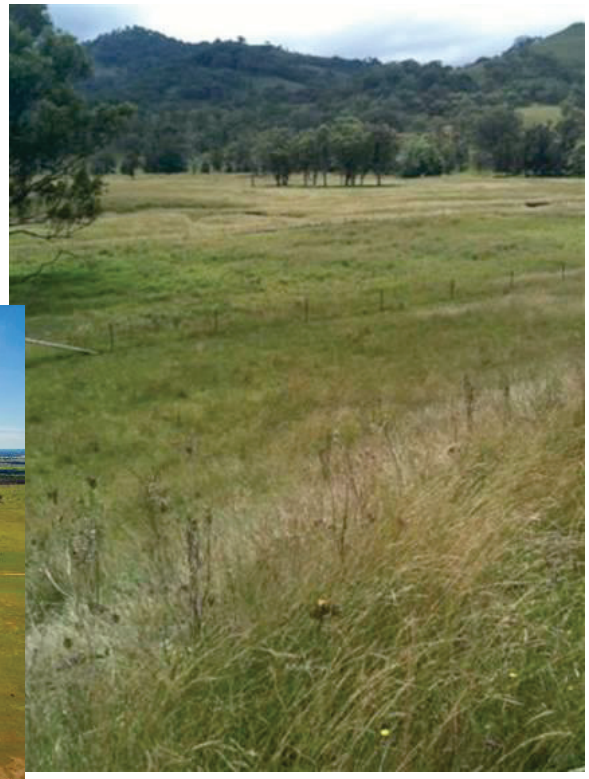
- Abandonment involves filling the entire wellbore from bottom to surface with cement in 'plug' stages
- Individual cement plugs are limited to 200 m in length
- All open hole 'plugs' are left to set and tagged to confirm placement before the next cement plug is pumped
- Once a cement 'plug' top is inside casing, it is left to set, tagged to confirm placement and pressure tested to confirm isolation
- Cement 'plugs' are then pumped one by one to surface



Rehabilitating the Site

Santos will work pro-actively and collaboratively with our stakeholders and the communities in which we operate

- After the plug and abandonment process has been completed, the wellhead is cut off below ground level
- An abandonment marker is welded to the casing and all the infrastructure is removed from site
- The site is rehabilitated back to its original use
- The regulator signs off on rehabilitate site



Questions

Santos