

**BROWSE BASIN GAS TECHNICAL REPORT
DEVELOPMENT OPTIONS STUDY**

**ADDENDUM TO REPORT 1 of 3
LNG PLANT SITE SELECTION VALIDATION**

**Prepared for
THE NORTHERN DEVELOPMENT TASKFORCE**

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TABLE OF CONTENTS

	Page No.
INTRODUCTION	1
CONCLUSIONS	3
1. STUDY METHODOLOGY.....	4
2. DISCUSSION	6
2.1 Sites Evaluation and Likely Technical Issues for an LNG Hub	6
2.1.1 North Kimberley: Anjo Peninsula	6
2.1.2 North Kimberley: Cape Voltaire	8
2.1.3 South Kimberley: Gourdon Bay / Saddle Hill.....	10
 TABLES	
1. Summary of Site Suitability For LNG and Gas Processing Hub	5
2. Anjo Peninsula LNG Site Comparative Technical Evaluation... ..	6
3. Cape Voltaire LNG Site Comparative Technical Evaluation	8
4. Gourdon Bay / Saddle Hill LNG Site Comparative Technical Evaluation	10
 FIGURE	
1. Additional Potential Kimberley Sites for Browse Basin LNG Facilities.....	2
 APPENDIX	
I. Glossary	

INTRODUCTION

The Browse Basin, offshore of north-west Western Australia, holds substantial resources of natural gas. At the date of this report, there is no hydrocarbons production from the Basin and there are no hydrocarbons based projects that are either under construction or approved for construction. However, two of the Basin joint ventures, one operated by Woodside Energy Limited (Woodside), and the other by INPEX Browse Ltd (INPEX)¹, are planning to use their known gas resources for “greenfield” land based Liquefied Natural Gas (LNG) projects².

The two projects are based on total gas resources of approximately 27 Trillion cubic feet (Tcf). While some of these resources were discovered over thirty years ago, the basin is “gas prone” and has been relatively lightly explored. The level of exploration activity has increased in recent years and it is likely that other companies currently active in the area will eventually propose LNG projects using Browse Basin gas.

From a technical perspective, the “logical” sites for a land based LNG plants to receive, process and export Browse Basin gas are on the Northern and Southern Kimberley coast or on one of the islands off the coast. The North Kimberley area is totally undeveloped, has no infrastructure and is an eco-tourist destination. The South Kimberley has some development (Broome and Derby), has minimal infrastructure and has several tourist destinations.

At the time of this report, both the Woodside and INPEX operated Joint Ventures have conceptualised their respective projects on a “stand alone” basis and have evaluated potential LNG processing sites on the basis of the individual requirements of those projects. Woodside has prepared a shortlist of several potential sites and the Maret Islands are INPEX’s preferred site. Forecast total LNG production from the two projects is in the order of 20 to 25 MMtpa.

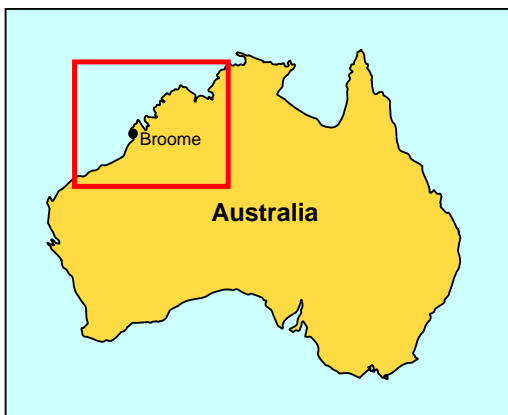
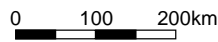
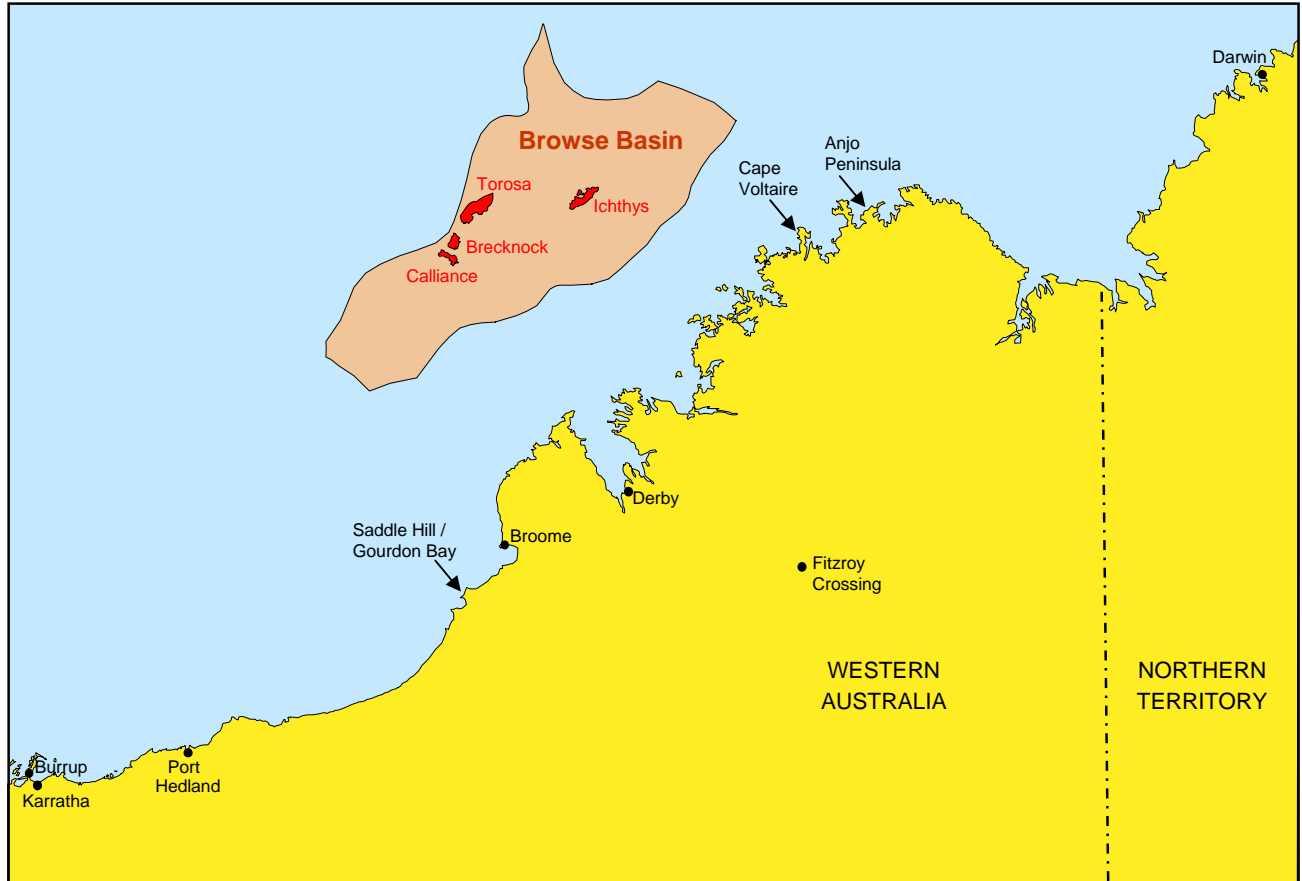
The Kimberley Northern Development Taskforce (Taskforce) is an inter-departmental body formed by the Government of Western Australia. The Project Manager is Mr. Gary Simmons from DoIR. The taskforce has been engaged to set the framework by which the State will protect and manage the important heritage, environment and tourism values of the Kimberley area while facilitating structured industrial development. The West Kimberley Subdivision of the Taskforce was established to manage across-government planning processes and stakeholder consultation in regard to selection and development of a suitable location or locations for the processing of Browse Basin gas reserves.

The Taskforce, through DoIR, has retained Gaffney, Cline & Associates (GCA) to provide independent advice on technical issues associated with the selection and development of onshore and offshore locations, for the processing of the Browse Basin gas. This advice is to be in the form of a report titled “Browse Basin Development Options Study” (The Study).

The objective of the first section of this Study is to review the technical issues surrounding the processing of natural gas resources at an LNG hub. In this context, GCA has provided commentary on the technical suitability of fourteen potential sites in May 2008 (Report 1) based on the information made available by DoIR, Woodside and INPEX. GCA has since been asked to evaluate three additional sites, Anjo Peninsula, Cape Voltaire and Gourdon Bay / Saddle Hill, using the same methodology as for the May 2008 report. This analysis follows and forms the “Addendum to Report 1”.

¹ “Woodside” is used throughout this report to refer to the Woodside led Joint Venture (JV) and likewise for INPEX.

² During the course of the study Shell Development (Australia), (Shell) announced that it plans to develop the Prelude field, in the Browse Basin, using a floating LNG facility (FLNG) with no onshore processing facilities.



Additional Potential Kimberley Sites for Browse Basin LNG Facilities

Proj. K1177.10 July08 | Checked: *mdf* | Fig. 1

CONCLUSIONS

The scope of work provided for this study by DoIR lists a number of very specific points to be addressed. This has been done in detail in the pages that follow. GCA's "high level" conclusions are summarised as follows:-

1. The three additional locations considered could accommodate a Gas Processing Hub. They each provide 950 hectares of technically suitable land and a manageable marine environment. The sites are:
 - i. **Northern Kimberley**:- Anjo Peninsula, Cape Voltaire.
 - ii. **Southern Kimberley**:- Gourdon Bay / Saddle Hill.
2. The Anjo Peninsula has particularly favourable marine conditions, whereas Gourdon Bay / Saddle Hill's marine conditions are very challenging.
3. Site preparation requirements are likely to be minimal for Gourdon Bay / Saddle Hill, acceptable for the Anjo Peninsula and very substantial for Cape Voltaire.
4. Overall, and taking only these three sites into consideration, the most appropriate location, from a technical perspective for LNG and gas processing facilities, is the Anjo Peninsula.
5. Further "pooling" of available information held by individual stakeholders supplemented by additional "on site" topographical, marine and geotechnical evaluation would confirm these conclusions.
6. The evaluation of the costs associated with a development at each of the proposed locations would provide additional differentiating factors supporting objective site ranking. In particular, pipeline length, marine and geotechnical work have a significant impact on project costs and their quantification would complement the technical analysis in this report.

It is noted that GCA's scope of work covered only the technical aspects of the hub site selection. The conclusions above have not taken into account any of the socio-economic aspects of a hub selection including those arising from land ownership and environmental considerations.

1. STUDY METHODOLOGY

The evaluations conducted in this report are based on the expertise of the Team Members involved, leveraging public information and tools (including SRTM maps incorporated in the Google Earth® software), as well as the information provided by Browse basin tenement holders. Thompson Clarke Shipping (TCS) were retained by GCA to provide advice on the marine aspects of the study.

GCA has adopted the same methodology as for the previous sites studied. No site visits were undertaken and all estimation work has been done at a very high level, mostly by analogy.

The specific site evaluation criteria and LNG Hub concepts are detailed in the previous report, entitled “REPORT 1 of 3 - LNG PLANT SITE SELECTION VALIDATION” and delivered to DoIR in May 2008.

DoIR has recently requested GCA to technically evaluate three additional potential hub sites against the specific technical criteria. This additional work, together with that from the original May study, is summarized in **Table 1**:-

TABLE 1

SUMMARY OF SITE SUITABILITY FOR LNG AND GAS PROCESSING HUB

	Port Availability and Navigation	Land Availability and Suitability		
		Single Op. (1)	Multi Op. (2)	Gas Proc. (3)
North Kimberley				
Anjo Peninsula	Y	Y	Y	Y
Cape Voltaire	Y	Y	Y	Y
Maret Islands	Y	Y	N	N
Bigge Island	Y	Y	Y	Y
Champagne Island East	Y	Y	N	N
Wilson Point	Y	Y	Y	Y
Koolan Island	Y	Y	N	N
Cockatoo Island	Y	N	N	N
South Kimberley				
Cape Leveque	Y	Y	Y	Y
Lombadina (Packer Island)	Y	Y	Y	Y
North/ Perpendicular Head	Y	Y	Y	Y
Quondong Point	Y	Y	Y	Y
Fisherman's Bend	Y	Y	Y	Y
Gourdon Bay / Saddle Hill	Y	Y	Y	Y
Offshore Kimberley				
Scott Reef (4)	?	n.a.	n.a.	n.a.
Echuca Shoals (4)	?	n.a.	n.a.	n.a.
Existing LNG Site				
Burrup (NWS & Pluto)	Y	Y(5)	N	N

Notes:-

1. An LNG Hub with a single LNG plant and up to 5 LNG trains that could be accommodated on a site of 360 hectares.
2. An LNG Hub with multiple LNG plants and up to 10 LNG trains that could be accommodated on a site of 660 hectares.
3. A Gas Processing Hub which provides for a multiple LNG plants and several large scale Gas to Liquids (GTL) plants. This will require a minimum of 950 hectares.
4. These sites are partially submerged and would be developed as "offshore" facilities.
5. There is insufficient land available in the Burrup area for a new Single Operator LNG Hub. GCA has assumed production would be integrated into existing gas processing hubs.

It is emphasised that the above sites have been evaluated on technical grounds only. Environmental, Land access and other community based issues have not been considered.

2. DISCUSSION

2.1 Sites Evaluation and Likely Technical Issues for an LNG Hub

2.1.1 North Kimberley: Anjo Peninsula

TABLE 2

ANJO PENINSULA LNG SITE COMPARATIVE TECHNICAL EVALUATION

	Navigable water for LNG carriers	Port suitability	Land area requirements	Site elevation and gradient	Proximity to gas fields	Proximity of plant site to coastline	Pipeline approach	Geotechnical conditions	Proximity to existing infrastructure
Single Operator LNG Hub	Y	Y	Y	Y	Y	Y	Y	Y	N
Multi Operator LNG Hub			Y						
Gas Processing Hub			Y						

Navigable Water for LNG Carriers & Port Suitability

The Anjo Peninsula has a suitable marine environment to support LNG operations, with particularly favourable conditions on its East coast. Deep water is present close to the coast and the approach is sheltered from wind and swell.

Marine works are likely to require the construction of a ~2 kilometre jetty and the dredging of a ~5 kilometre channel. A breakwater would not be necessary. Maintenance dredging needs is not expected.

Land Area Requirements

The Anjo Peninsula is a coastal location with over 950 hectares of available land, which would be sufficient for the development of multiple LNG plants and gas processing facilities.

Site Elevation and Gradient

The Anjo Peninsula lies in irregular terrain with gentle slopes and elevations ranging from sea level to ~70 meters.

Several locations, with relatively flat sections of land within an elevation range of 30 to 40 meters, provide sufficient area for an LNG development and gas processing facilities.

Mountains are present further inland, reaching over 200 meters above sea level.

Proximity to Gas Fields

The Anjo Peninsula is located within ~350 kilometres from the INPEX operated Ichthys field and ~500 kilometres from the Woodside operated Browse (Scott Reef) fields. This distance does not present any specific issues in terms of pipeline construction.

For the purposes of this study, the distances between the gas fields and the potential sites are taken as the most direct offshore line between these points. This is likely to differ from the actual pipeline trajectory, which will be constrained by bathymetry and offshore geotechnical features.

Proximity of Plant Site to Coastline

The plant site could be within one kilometre from the coastline, which is technically suitable.

Pipeline Approach

There are several sandy beaches with gentle slopes on the Anjo Peninsula. These could be appropriate locations for pipeline crossings.

There are a number of tidal areas appearing to be covered in mangrove. Even though these may be suitable from a technical perspective, pipeline beach crossings in mangrove will require careful environmental assessment.

Geotechnical Conditions

The Anjo Peninsula displays signs of erosion along its coasts. The dominant soils are likely to be a combination of deep sands and stony soils. There are relatively flat sufficiently elevated areas for the installation of LNG facilities and no major earthworks are foreseen.

Proximity to Existing Infrastructure

The Anjo Peninsula is isolated with limited infrastructure in the vicinity.

Truscott Airbase, on the Anjo Peninsula, has a sealed airstrip (1,800m x 30m) with the capacity for a 70 seat jet to land. It has two helicopter hangars, full maintenance facilities and fuel capacity of 1 million litres. Three Briscoe helicopters currently operate out of there, servicing the gas fields to the north. The base is gearing up for five helicopters. There is accommodation for 60 people and modern mess. This base is on a lease between Wunambal Gaambera Aboriginal Corporation and the Aboriginal Lands Trust.

The Kalumburu Aboriginal Community, with a population of over 400 people, is ~50 kilometres to the South East. The closest formed road is over ~200 kilometres to the South. The closest port is Wyndham, ~240 kilometres to the South East.

Summary Evaluation

The Anjo Peninsula has sufficient land and suitable marine conditions, in particular on its eastern coast, to support multiple LNG plants and gas processing facilities. Several adequate locations can be considered for pipeline beach crossings. Extensive geotechnical work is not expected. The existing airstrip could be leveraged; however the creation of a port is likely to be required to handle facilities construction, due to the remote location of this site relative to existing ports and formed roads.

The Anjo Peninsula is a technically suitable site for LNG developments.

2.1.2 North Kimberley: Cape Voltaire

TABLE 3

CAPE VOLTAIRE LNG SITE COMPARATIVE TECHNICAL EVALUATION

	Navigable water for LNG carriers	Port suitability	Land area requirements	Site elevation and gradient	Proximity to gas fields	Proximity of plant site to coastline	Pipeline approach	Geotechnical conditions	Proximity to existing infrastructure
Single Operator LNG Hub	Y	Y	Y	Y	Y	Y	Y	Y	N
Multi Operator LNG Hub			Y						
Gas Processing Hub			Y						

Note: "Cape Voltaire" is used to identify the whole peninsula between Montague Sound and Walmesly Bay, extending to Voltaire Passage on its North Coast.

Navigable Water for LNG Carriers & Port Suitability

The West side of Cape Voltaire is very exposed and, despite the presence of deep water close to shore, would not provide suitable marine conditions to support an LNG development.

The East side of Cape Voltaire, though partially surveyed, is likely to provide an adequate marine environment. Navigational access to the eastern side of the Voltaire peninsula can be satisfactorily obtained from the north passing Troughton Island, then passing to the east of Long Reef and Tancred Bank, and then entering Admiralty Gulf.

Land Area Requirements

Cape Voltaire is a coastal location, where available land is constrained by the steep slope of the terrain, in particular in the North. There is sufficient land available to construct any of the types of hubs considered.

Site Elevation and Gradient

Site elevation ranges from sea level to ~130 meters, with steep sections along the West coast. However, there is over ~950 hectares of relatively flat ground to the South East of Cape Voltaire, with elevation comprised between ~15 and ~30 meters and limited gradient. This site would be acceptable for the construction of LNG facilities.

Proximity to Gas Fields

Cape Voltaire is located within ~260 kilometres from the INPEX operated Ichthys field and ~410 kilometres from the Woodside operated Browse (Scott Reef) fields. This distance does not present any specific issues in terms of pipeline construction.

Proximity of Plant Site to Coastline

The plant site could be within one kilometre from the coastline, which is technically suitable.

Pipeline Approach

There are few sandy beaches in Cape Voltaire, with a majority of small hills facing the sea front. Adequate pipeline land fall sites can be identified but may require significant earthworks.

Tidal areas and mangrove are present to the East of the Cape, which may constitute an environmental constraint impacting pipeline beach crossing.

Geotechnical Conditions

Cape Voltaire appears to have signs of erosion with uneven and deeply fissured rocky land. The dominant soils are likely to be a combination of stony soils and loamy earth.

There are sufficient elevated areas for the installation of LNG facilities. However, site preparation is likely to require substantial earthworks.

Proximity to Existing Infrastructure

Cape Voltaire is isolated with limited accessible infrastructure. The closest formed road is over ~250 kilometres to the South. The closest port is Wyndham, ~300 kilometres to the South East. The Mitchell Plateau unsealed airstrip is ~50 kilometres South.

Summary Evaluation

Cape Voltaire has sufficient area for the installation of LNG and gas processing facilities. Substantial earthwork is likely to be required to level the peninsula's rocky and weathered terrain. The East side of Cape Voltaire could provide suitable marine conditions for LNG related maritime traffic.

Cape Voltaire could be a technically suitable site. However, further land and marine studies would be required to evaluate site preparation needs and confirm the suitability of its partially surveyed the East coast.

2.1.3 South Kimberley: Gourdon Bay / Saddle Hill

TABLE 4

GOURDON BAY / SADDLE HILL LNG SITE COMPARATIVE TECHNICAL EVALUATION

	Navigable water for LNG carriers	Port suitability	Land area requirements	Site elevation and gradient	Proximity to gas fields	Proximity of plant site to coastline	Pipeline approach	Geotechnical conditions	Proximity to existing infrastructure
Single Operator LNG Hub	Y	Y	Y	Y	Y	Y	Y	Y	Y
Multi Operator LNG Hub			Y						
Gas Processing Hub			Y						

Navigable Water for LNG Carriers & Port Suitability

Gourdon Bay / Saddle Hill is wholly exposed to the weather and swell. Significant initial and maintenance dredging, including the preparation of a ~15 kilometre channel, will be required. A significant breakwater will be required to enclose the berth. This site will require a long jetty.

The marine conditions of Gourdon Bay / Saddle Hill are not favourable to support an LNG development. However, with very substantial investment in marine infrastructure, this site could be made suitable.

Land Area Requirements

Gourdon Bay / Saddle Hill is a coastal location with over 950 hectares of available land. This could constitute sufficient area for the development of a gas processing Hub.

Site Elevation and Gradient

The site is flat with elevations ranging from sea level to ~30 meters. Saddle Hill is surrounded by low lying areas, but has sufficient suitable land within elevations of ~15 meters to ~30 meters.

Proximity to Gas Fields

Gourdon Bay / Saddle Hill is located within ~530 kilometres from the INPEX operated Ichthys field and ~490 kilometres from the Woodside operated Browse (Scott Reef) fields. This distance does not present any specific issues in terms of pipeline construction.

Proximity of Plant Site to Coastline

Suitably elevated land, over 15 meters above sea level, is within one kilometer of the North coastline and ~5 kilometers to the West. The gas processing facilities could be located within a technically acceptable distance from the coastline.

Pipeline Approach

The West and South West of Saddle Hill appear to be tidal areas covered with mangrove. The North of this site would provide appropriate beach landing areas with gentle slopes and few visible signs of erosion.

Geotechnical Conditions

The dominant soils of Saddle Hill / Gourdon Bay are likely to be a combination of deep sands and sandy earth. This site is relatively level, with few visible irregularities. Extensive earthworks are not anticipated.

Proximity to Existing Infrastructure

There are some habitations and an unsealed airstrip on Saddle Hill / Gourdon Bay. The Bidyadanga Aboriginal Community is ~20 kilometres to the South West. The closest formed road is less than 20 kilometres to the East. The closest port and sealed airstrips are located in Broome, ~90 kilometres to the North West.

Summary Evaluation

Saddle Hill / Gourdon Bay has adequate land to support LNG and gas processing facilities. Site topography is favourable and extensive earthworks are not expected. Proximity to existing infrastructure could facilitate the construction and operation of LNG facilities. Saddle Hill / Gourdon Bay is marginal from a marine standpoint. It is fully exposed and likely to require regular dredging.

Further marine studies would be required to quantify and optimize the jetty, breakwater and dredging configuration. The North coast of this site is more suitable than the West coast, especially from a marine and pipeline approach perspective.

APPENDIX I

GLOSSARY

GLOSSARY

bar	The bar (symbol bar), decibar (symbol dbar) and the millibar (symbol mbar, also mb) are units of pressure. The bar is still widely used in descriptions of pressure because it is about the same as atmospheric pressure.
Btu	The British thermal unit (BTU or Btu) is a unit of energy used in the power, steam generation, and heating and air conditioning industries. One BTU is approximately 1,054—1,060 kJ (kilojoules).
CGR	Condensate to Gas Ratio
DWT	DWT, for deadweight tones, is the displacement at any loaded condition minus the lightship weight. It includes the crew, passengers, cargo, fuel, water, and stores. Like Displacement, it is often expressed in long tons or in metric tons.
GCA	Gaffney, Cline & Associates
ha	A hectare (symbol ha) is a unit of area equal to 10,000 square meters, or one square hectometer, and commonly used for measuring land area. A 100 m square is one ha.
km	Kilometre(s)
LNG	LNG is natural gas that has been converted to liquid form for ease of storage or transport. Liquefied natural gas takes up about 1/600th the volume of natural gas at a stove burner tip. It is odorless, colorless, non-corrosive, and non-toxic. The liquefaction process involves removal of certain components, such as dust, helium, water, and heavy hydrocarbons, which could cause difficulty downstream, and then condensation into a liquid at close to atmospheric pressure (Maximum Transport Pressure set around 25 kPa (3.6psi)) by cooling it to approximately -163 °C (-260 °F).
LOA	Length Over All, commonly used to indicate maximum hull length of a vessel. LOA is the most commonly-used way of expressing the size of a boat.
LPG	Liquefied petroleum gas (also called LPG, LP Gas, or autogas) is a mixture of hydrocarbon gases used as a fuel in heating appliances and vehicles, as well as as an aerosol propellant and a refrigerant. Varieties of LPG bought and sold include mixes that are primarily propane, mixes that are primarily butane, and the more common, mixes including both propane (60%) and butane (40%).
MMtpa	Million tones per annum
PPP	Public-Private Partnership, the operation of a service in the partnership of government and the private sector. In some types of PPP, the government uses tax revenue to provide capital for investment, with operations run jointly with the private sector or under contract (see contracting out). In other types (notably the Private Finance Initiative), capital investment is made by the private sector on the strength of a contract with government to provide agreed services. Government contributions to a PPP may also be in kind (notably the transfer of existing assets).
psi	The pound per square inch or, more accurately, pound-force per square inch (symbol: psi or lbf/in ² or lbf/in ²) is a unit of pressure or of stress. It is the pressure resulting from a force of one pound-force applied to an area of one square inch: 1 psi (6.894757 kPa) : Pascal (Pa) is the SI unit of pressure

SPM	Single Point Mooring are loading Buoys anchored offshore, which serve as a mooring point for tankers to (off)load gas or fluid products. They are the link between the geostatic subsea manifold connections and the weathervaning tanker. The main purpose of the buoy is to transfer fluids between onshore or offshore facilities and the moored tanker.
SRTM	The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth. SRTM consisted of a specially modified radar system that flew onboard the Space Shuttle Endeavour during an 11-day mission in February of 2000. SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency (NGA) and the National Aeronautics and Space Administration (NASA).
Tcf	Trillion cubic feet
TCS	Thompson Clarke Shipping
WEL	Woodside Energy Limited