ACQUISITION REPORT

PGS Geophysical

Origin Energy

RAMFORM STERLING

Bellerive 3D, Block T30P, Offshore Tasmania, Bass Strait, Australia

2010184

08th February 2011
to
22nd February 2011

version 1

Petroleum-Geo Services , 111 Somerset Road, Singapore

AUTHORISATION

Leif-Inge Iversen — Singapore

Operations Manager — 23rd March 2011

DISTRIBUTION

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REVISED VERSIONS

NUMBER	CHANGES	AUTHOR	DATE

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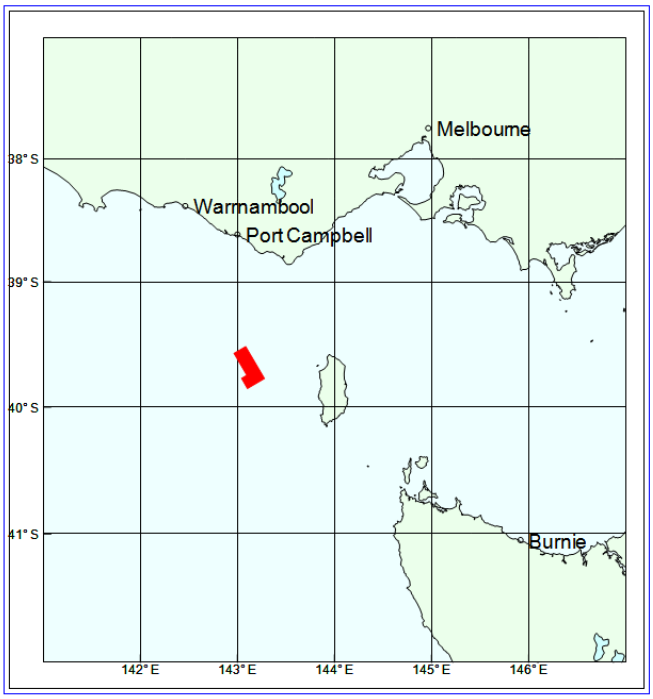
1 Introduction

1.1 Summary

PGS was contracted by Origin Energy to carry out a 3D seismic survey offshore Australia. The PGS vessel MV RAMFORM STERLING was contracted to acquire the survey.

The Bellerive 3D survey was located in Block T30P to the north west of Tasmania in the Otway Basin. The survey vessel was accompanied by the support vessel: 'M/V OCEAN DYNASTY'.

A start-up meeting was held onboard MV RAMFORM STERLING on Thursday, 20th January in Sydney, discussing all three Origin Energy surveys. The vessel transited from the Origin Energy, Chappel survey (2010185) to the East of King Island inside the Bass Strait to the Bellerive survey area. The transit was performed with full gear deployed and guns were recovered for general maintenance. The transit took 12hrs although the start was delayed by 22hrs due to weather.



The support vessel 'MV OCEAN DYNASTY' joined the MV RAMFORM STERLING on 8th February 2011 from Melbourne after a brief port call for resupplies and pick up two Marine Mammal Observers (MMO's) for the Otway Basin contracts. During the transit, two Origin Energy employees (Project Manager Neil Millar and HSEQ HSE advisor Robert Meagher) and one additional MMO for the MV RAMFORM STERLING arrived by helicopter.

The first line commenced at 11:35 UTC on the 9th February 2011 after a period of inclement weather.

The two MMO's on the 'MV OCEAN DYNASTY' later transferred to the MV RAMFORM STERLING on 12th February 2011 due to regulations for the Otway surveys, a total of four MMO's on the MV RAMFORM STERLING, Origin Energy Project Manager Neil Millar departed on the 'MV OCEAN DYNASTY' to Port Portland the same day. The 'MV OCEAN DYNASTY' later picked up two more MMO's from Port Portland on 17th February 2011.

Good production continued until survey completion on 13th February. The port super wide broke close to the ships side. The vessel turned head into the seas to recover and resplice the port superwide, a total of 22.65hrs downtime.

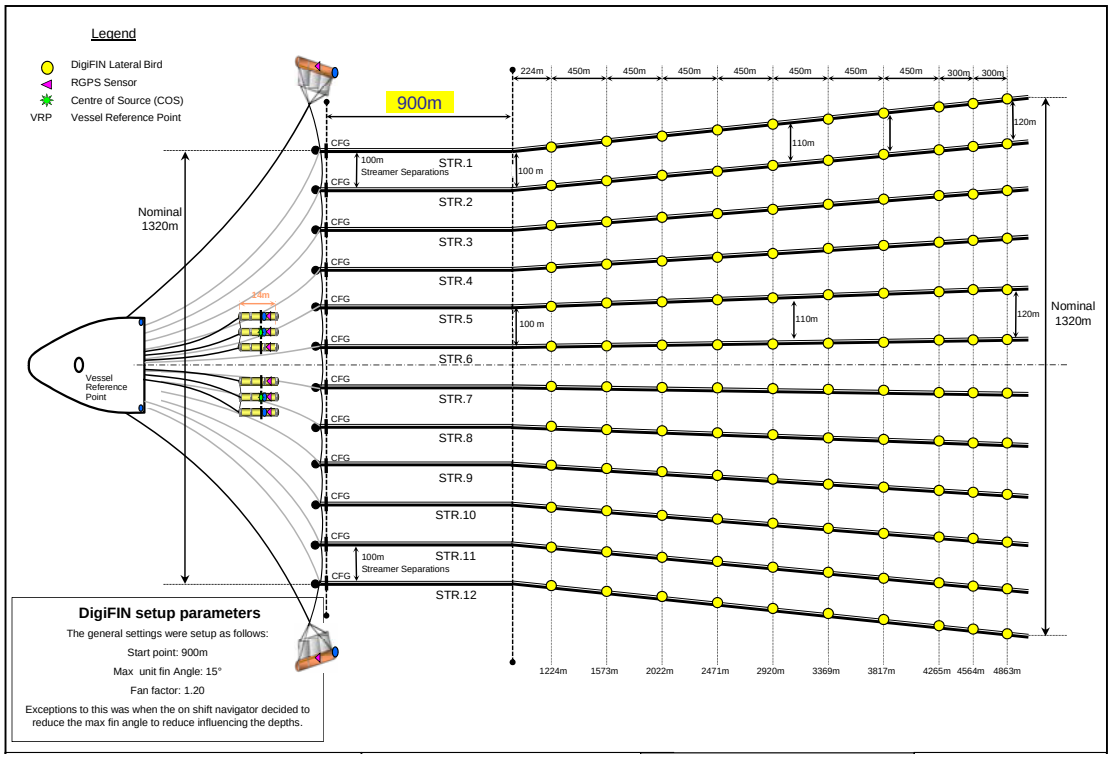
Two periods of high sea conditions were experienced: The first around 11/12th February 2011 (Sequences 8-11) and the second at the end of the survey 17-18 February 2011 (Sequences 27-28). During the last days of production, Infill was being acquired and any additional prime lines were shot using "reverse shooting" or "herring bone" so that all areas contained continuous coverage. The survey was cut short on 18th February when a storm front passed into the area. The vessel headed for shelter to the East of King Island and waited for suitable weather to retrieve the seismic equipment. Late 21st February the weather improved and all equipment was recovered and onboard by noon 22nd February. The vessel then head for Port Portland to demobilise the Orign Energy clients and conduct crew change.

1.2 Special techniques

1.2.1 Fan mode

Using Digicourse's Lateral controller software and DigiFIN units, Fan mode was used to increase the tail streamer width and maintain a tapered separation through the streamer length. The system involved installing 10 DigiFIN units on each streamer separated by 450m inline. These units provided lateral forces to help steer the streamer and maintain a separation. The setting used for this survey was based on a starting point of 900m and a factor of 1.2 (20%). The fanning mode aided the tail coverage by providing extra 1-2 columns of data either side of the nominal setup.

Fan mode setup



1.3 Key parameters

Source	:	2 x 3090 in^3
Source depth	:	7 m
Streamers	:	12 X 5100 m
Streamer spacing	:	100 m
Streamer depth	:	8 m
Near trace offset	:	130 m (see details on offset diagram sect 6.2)

1.4 Systems

Source type	:	Bolt LLXT 1900 guns
Streamer type	:	RDH-Solid
Recording system	:	PGS gAS system, NTRS
Navigation	:	SkyFix.XP Orbit & Clock Corrected GPS
	:	StarFix.HP High Performance DGPS
Float positioning	:	Seatrack RGPS
Acoustic ranging	:	DigiCOURSE DigiRANGE DRII

1.5 Production

	Sail line km	CDP km	Sq km
Prime chargeable	680.51	16,332.30	408.31
Prime run out	56.10	1,346.40	33.66
Infill	123.19	2,956.50	73.91
Infill percentage	7.65	183.60	4.59
Total	867.45	20,818.80	520.47

1.6 Survey timing

	Hours		Hours	% of total
Production	**174.95**	Production Prime	75.57	22.49
		Prime Run Out	6.22	1.85
		Production Infill	14.37	4.28
		Infill Run Out	0.88	0.26
		Line Change	65.92	19.26
		Line Change Infill	12.00	3.57
Standby	**112.35**	Weather	80.65	24.00
		Local Transit / prospect change	19.58	5.83
		Extended L/C d/t survey shape	6.27	1.87
		Cetaceans	3.27	0.97
		Extended L/C for Infill	2.77	0.82
Downtime	**30.02**	Superwide rope break	22.65	6.74
		Module failure gun arrays	7.37	2.19
Demob	**18.50**	Demob	18.50	5.51
Total	**336.00**			

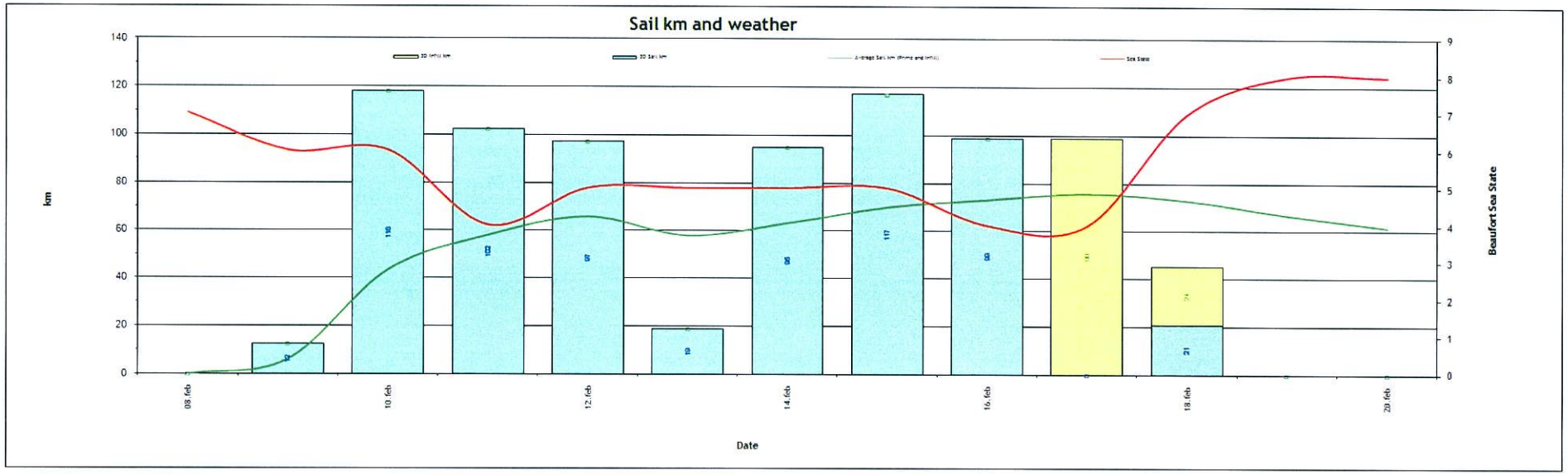
2 Sequence of events

2.1 Daily log

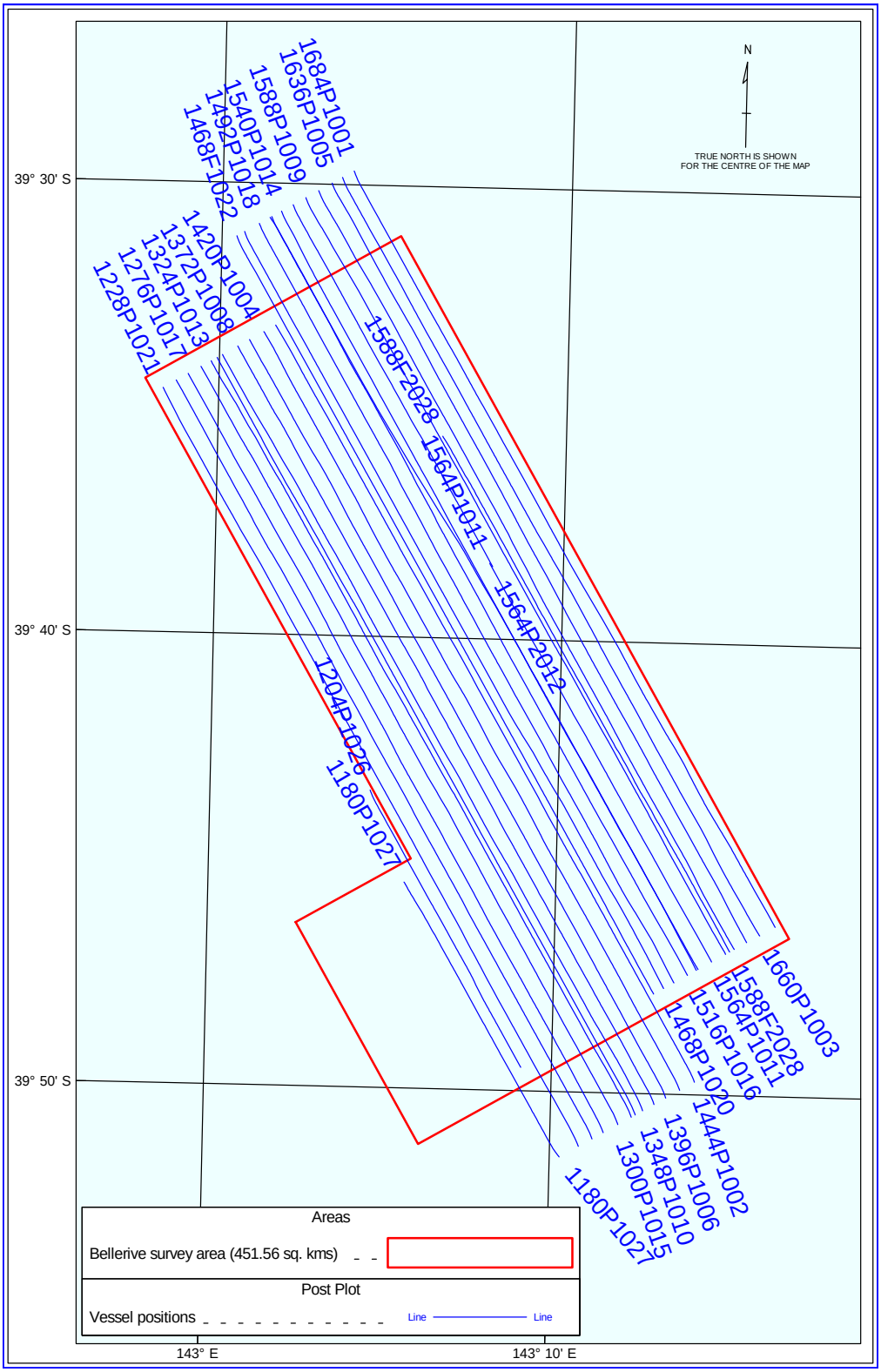
Date	Total Km	wind f'ce	sea state	comments
08/02/2011	0.000000	6	High	END OF PROJECT 2010185 Chappell 3D. START of PROJECT 2010184 Bellerive 3D. TRANSIT to the OTWAY BASIN PROJECTS halted due to poor weather west of King Island, vessel standing-by in lee of King Island until weather improves. Down for weather. Safety: Helicopter operation, personnel change, crew numbers updated. HFO:4238 MGO:332
09/02/2011	12.300000	4	Very Rough	Vessel stood-by in lee of King Island due to poor weather conditions in Otway Basin, by mid morning conditions improved, vessel continued transit to Bellerive 3D project. Vessel arrived in project area late afternoon, MMO pre-watch conducted during daylight, production started late evening. Safety: WB operation to transfer provisions and shipments from support vessel. HFO:4204 MGO:332
10/02/2011	125.831250	3	Very Rough	In production, weather conditions marginal (large swell) data quality acceptable. HFO:4167 MGO:332
11/02/2011	112.387500	4	Moderate	In production, weather conditions good for most of day, conditions deteriorated late evening, all data acquired today acceptable. HFO:4122 MGO:332
12/02/2011	104.831250	4	Rough	In production, poor weather until mid-day, conditions improving through the afternoon, all data acquired today acceptable. WB operation to transfer 1 Origin Energy Client to support vessel and 2 MMO to the Sterling. Support vessel Ocean Dynasty departed for Portland for personnel transfers, ETA 08:00 13th Feb. HFO:4076 MGO:332
13/02/2011	18.750000	4	Rough	Port super wide broke during production. Vessel head into the seas, port side front ends partially recovered and parted super wide connected to line from vessel using work boat, hauled onboard and respliced. Vessel remained head into the seas for the operation, long journey back to prospect once repaired. Ocean Dynasty in Portland to drop off one personnel, arrived 08:00, departed 17:00, ETA prospect 04:00 14th Feb. Western Light on station. HFO:4029 MGO:332
14/02/2011	102.637500	4	Rough	In production. HFO:3994 MGO:332
15/02/2011	126.262500	4	Rough	In production. HFO:3949 MGO:332
16/02/2011	107.662500	3	Moderate	In production. EDIT: Whale sighting requiring a powerdown leaving 340 shot hole. Lifeboat drill. Ocean Dynasty departed for Portland to pick-up two MMO and stores. HFO:3902 MGO:332
17/02/2011	106.593750	4	Moderate	In production, acquired infill all day. Ocean Dynasty in Portland tp pick-up personnel, Two MMO and One pax for trwansfer to Sterling, crew numbers updated. HFO:3856 MGO:332

Date	Total Km	wind f'ce	sea state	comments
18/02/2011	50.193750	7	High	In production until early evening, weather conditions deteriorated, vessel turned East into the seas. Origin Energy instructed survey now considered complete. Vessel heading towards King Island waiting for weather to improve before retrieving in-water gear. Western Light departed shortly after lunch for Port Fairy. Ocean Dynasty back on location this morning, One Maritime pax transferred to Sterling, crew numbers updated. HFO:3810 MGO:332
19/02/2011	0.000000	7	Very Rough	Vessel headed into the seas, East of King Island, waiting for suitable weather to retrieve the gear. Guns retrieved this morning. Weather very poor for the day, Force 9, Wind 45kts, reducing slightly late evening. HFO:3766 MGO:332
20/02/2011	0.000000	8	Very Rough	Weather conditions improved by very early morning, started recovering front ends, had to abort full recovery as weather deteriorated again, retrieved centre two streamers only. Weather very poor for later in the day, Force 8, Wind 40kts. Forecast predicts good weather by tomorrow (21st) afternoon. Ocean Dynasty on station 2nm ahead. HFO:3731 MGO:332
21/02/2011	0.000000	5	Moderate	Weather conditions improved by early evening, started recovering streamers. Ocean Dynasty on station 2nm ahead. HFO:3697 MGO:332
22/02/2011	0.000000	5	Moderate	Completed recovering streamers, tangle on Port side streamers required some assistance from the work boat to remove units. All onboard @13:00, Vessel in transit to Port Portland for crew change. Ocean Dynasty released for port call Portland @09:20 HFO:3663 MGO:332.

2.2 Daily production and sea state



2.3 Post plotted vessel positions



3 Key personnel

	SHIFT B 08th February 2011 to 18th February 2011
Party Chief	Neil Jackson
Chief observer	Jørn Helmen
Chief navigator	Steve White
Chief mechanic	Tate Asbridge
Chief geophysicist	Murray Brown
Captain	Robert Heggdal
Client representative onboard	Drew Murray
	Ray Doughty
Client Contact Onshore	Neil Millar
Origin Energy QHSA Advisor	Bob Meagher
Principal MMO	Fiona Macknight

4 HSE

4.1 Statistics

Exposure hours	Marine crew	9840
	Seismic crew	10080
	Third party crew	2784
	Chase boat crew	2712
	Total	25416

Workboat operations	20
Workboat exposure hours	77.85

Safety meetings	2
Safety training meetings	4
Toolbox meetings	20
Audits	1
Drills	1
SAFE cards	43

4.2 Incidents

Report no.	Date	Action by	Classification	Comments
2199/11	13/02/11	PC	Equipment	Port Super Wide Broke

5 Survey operations review

5.1 Survey area information

Oilfield installations

There were no oil field installations in the vicinity of the survey area.

Oilfield activity

There was no oil field activity in the vicinity of the survey area.

Shipping Activity

There was no commercial traffic in the survey area.

The M/V RAMFORM STERLING was assisted by the support vessel 'M/V OCEAN DYNASTY' and fishing liason vessel 'MV WESTERN LIGHT'.

Sea Conditions, Tides and Currents

During the survey the acquisition was continuously affected by long periods of swell coming from the south-west and the occasional increase in wave heigh due to wind. The lines were orientated in such a way that the swell was approximately 90° to the swell which reduced the noise effect. The currents were predominantly line orientated although there was a higher feather range than on the previous surveys resulting in infill being required.

In Sea Dangers

There were no shallows or obstructions in the full fold survey area, water depths ranged from 100m to 1000m.

Time sharing

There was no time sharing on this survey. The Western-Geco seismic survey vessel 'MV WESTERN PATRIOT' was scheduled to commence a survey approximately 85nm to the south of Bellerive for the oil company Perenco**.** However**,** the project was complete before the 'Western Patriot' started production.

Fishing Activity

The fishing liason vessel 'MV WESTERN LIGHT' had cleared the area ahead of the vessel's arrival in the area, they also informed the local fishing communities of our intentions and there was subsequently no fishing activity noted in the vicinity of the survey area.

The 'MV WESTERN LIGHT' scouted a corridor from the Chappell 3D survey to the Bellerive 3D area to ensure that when the vessel transitted between the two locations, no fishing activity was interrupted.

Weather

Winds in the area were ever present reducing the ability to deploy the workboat on numerours occasions. At times when the wind dropped below 10kts there was an increase of drifting fog banks.

The increased periods of wind, on top of the long swell, created a confused sea state.

No sequences were scratched or edited as a result of swell noise.

Cetaceans

Four Marine Mammal Officers (MMO's) were situated on the vessel conducting daylight watches. A number of sightings were made during the transit to the survey area and throughout the duration of the survey although they did not impact the survey. One sighting on 12th February 2011, resulted in the MV RAMFORM STERLING aborting the run into line. The whale was approx 11Km from the survey area and moving away. It was decided to circle back and start the line later, giving the whale time to pass further away from the survey area.

On 16th February pilot whales were spotted inside the 3km zone requiring a powerdown affecting Sequence 21. The resultant hole was not reacquired before the survey was terminated.

Airbourn surveys were conducted on a frequent basis as part of the Origin Energy permit to explore this region. The surveys were conducted over the Astrolabe and Bellerive survey areas to determine the presence of marine species and most notably the Blue Whale, being **listed as** an endangered species.

Naval Activity

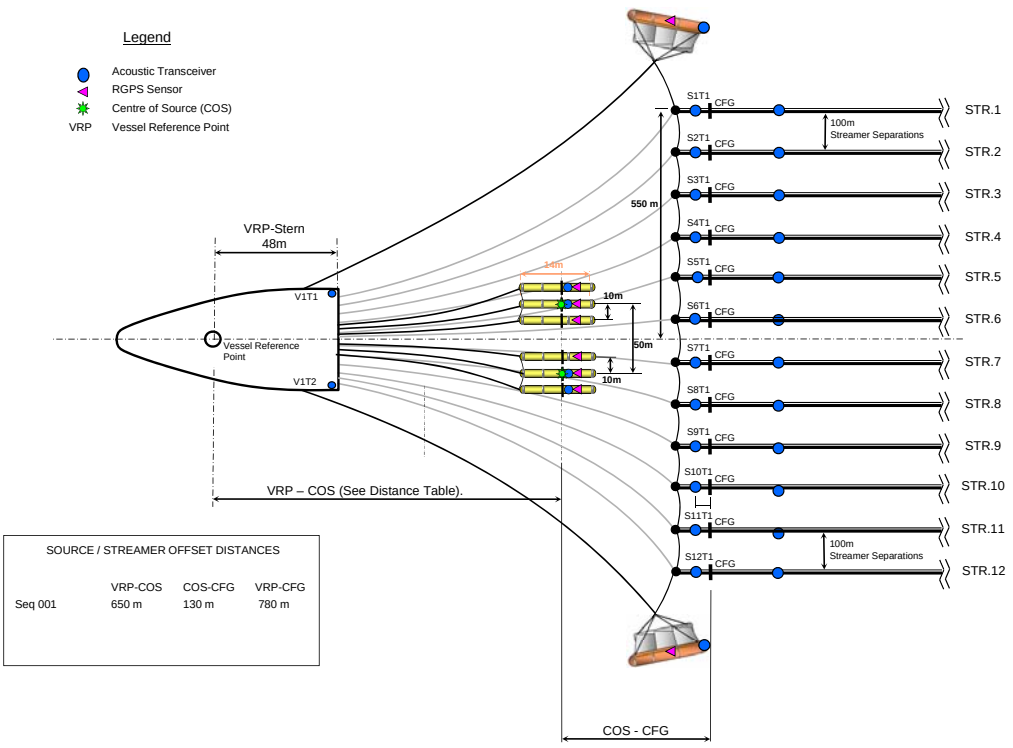
There was no Naval activity.

6 Seismic energy source

6.1 Source details

Source type	:	Bolt LLXT air guns
Air pressure	:	2000 psi
Volume	:	3090 in^3
Number of sources	:	Dual Source -3090
Number of sub-arrays	:	3
Source separation	:	50m
Sub-array separation	:	10.0 m
Source length	:	14 m
Gun synchronisation	:	± 1.5 ms
Drop-out specification	:	10%
Shot interval	:	18.75 m
Depth	:	7 m
Depth control	:	Fixed depth ropes
Depth monitoring	:	Syntron depth transducers, DigiShot
Spacing control	:	Spread-ropes on sliding collars. Steerable sub-arrays.
Near field signatures	:	7 phones per subarray
Compressors	:	LMF
Source controller	:	Digishot
Modelled source signature	:	See Appendix section 12.2

6.2 Offset diagram

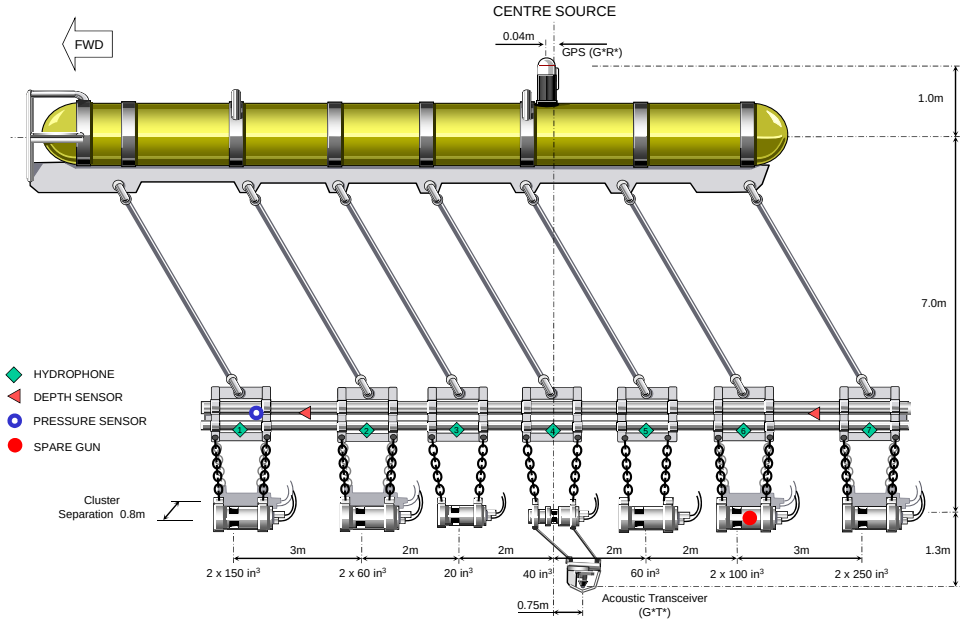


SOURCE / STREAMER OFFSET DISTANCES

	VRP-COS	COS-CFG	VRP-CFG
Seq 001	650 m	130 m	780 m

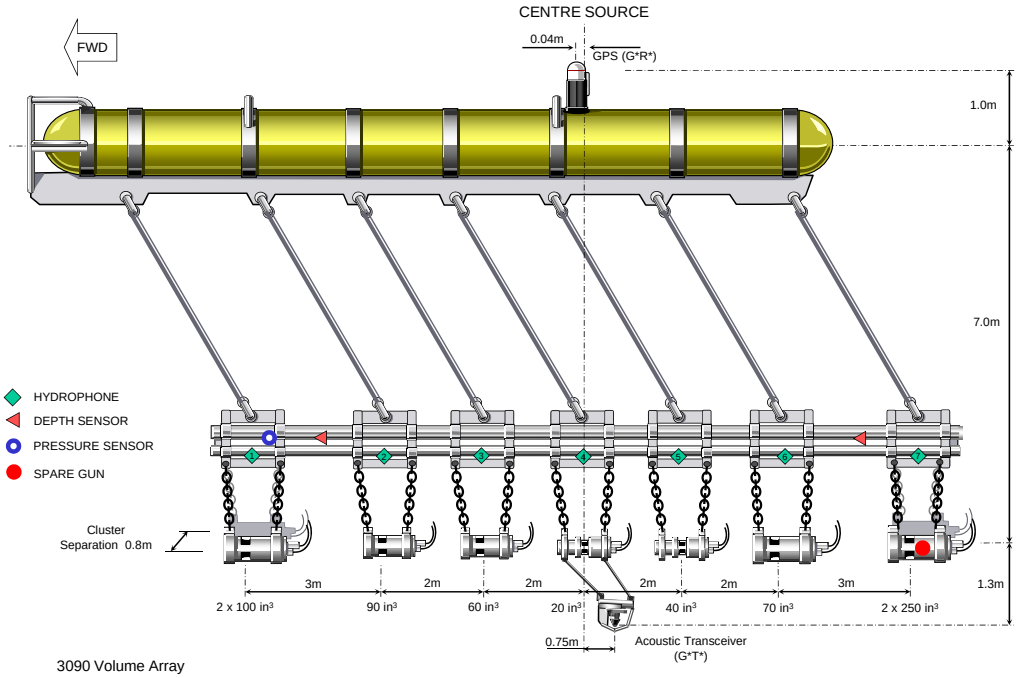
6.3 Gun array layout

Arrays 1 and 4



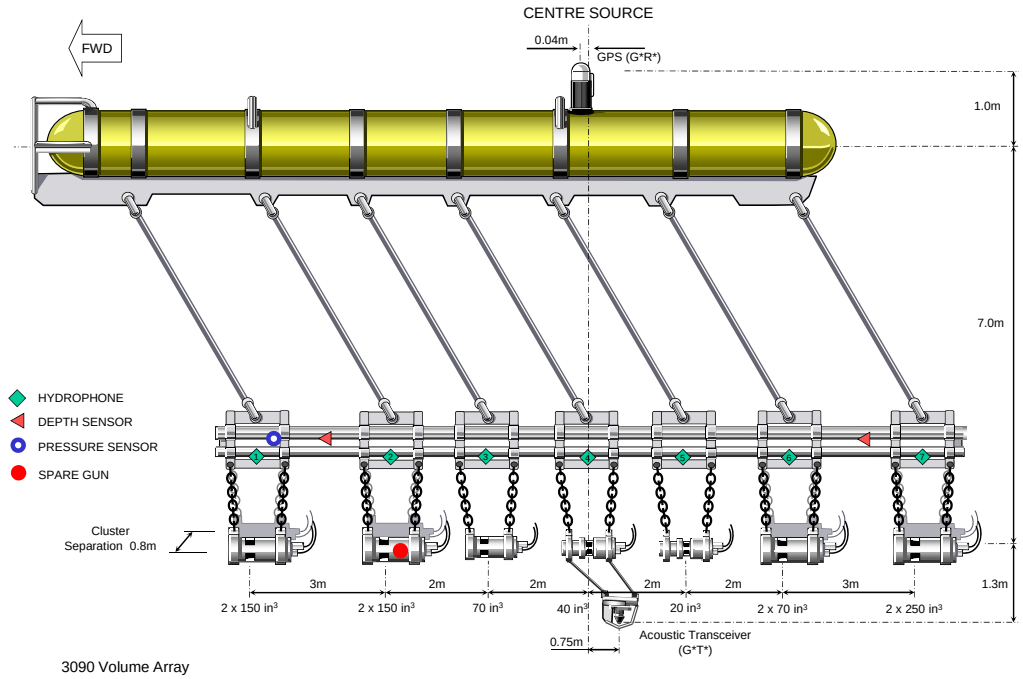
3090 Volume Array

Arrays 2 and 5



3090 Volume Array

Arrays 3 and 6



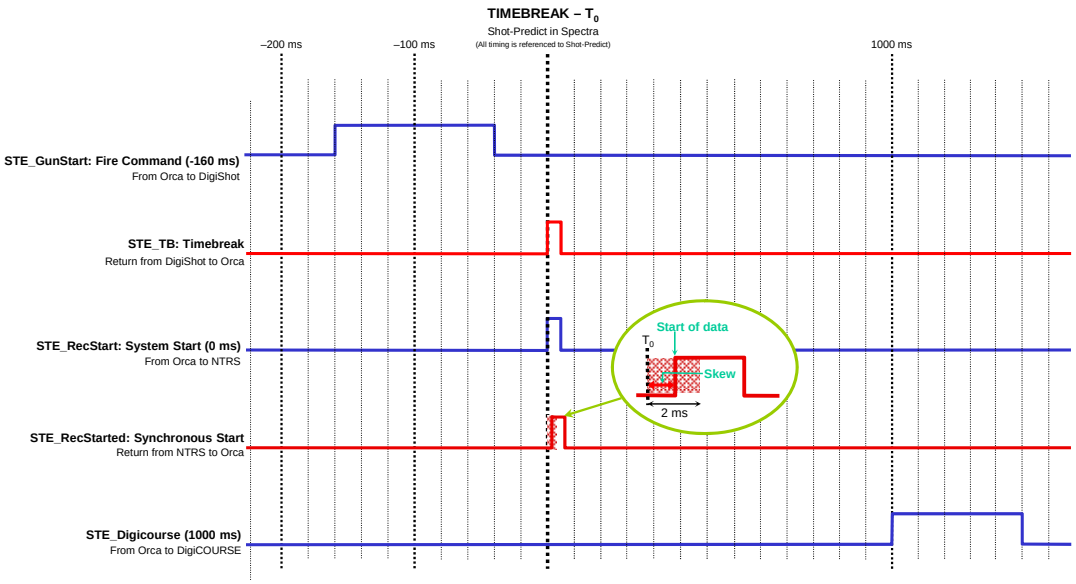
3090 Volume Array

7 Seismic acquisition system

7.1 System details

Recording System	:	gAS / SeaTrak NTRS 2™
Software Version	:	Ver. 5.0-0 with patch 5.0-2.
Amplitude resolution	:	24 bit
Data Channels	:	12 x 408
Auxiliary Channels	:	48
Tape Transports	:	4 x IBM 3592 cartridge drives
Tape Format	:	SEG D 8036 Rev. 2.1
Recording Media	:	IBM 3592.
Record Length	:	6144 ms
Deep water delay	:	Not used
Sample Rate	:	2 ms
High Cut Filter	:	206 Hz / 276 dB/octave
Low Cut Filter	:	4.6 Hz / 6 dB/octave
Gain Setting	:	12 dB
Amplifier	:	Voltage Mode Differential Input
Input Range	:	Peak Voltage 1.125 V
A/D Converter	:	Delta Sigma 24 bit
Distortion	:	< 0.003 % (- 100 dB)
Cross-Feed Isolation	:	> 95 dB
Power Consumption	:	6.5 W per module
Polarity Convention	:	SEG, positive pressure gives negative number
SEG-D header description	:	See Appendix section 12.3

7.2 System timing



Notes:

- Pulse widths – FC: 120 ms; SS: 10 ms; DigiCOURSE: 100 ms
- NTRS Record Length: 6144 ms
- The first seismic data sample is at 58 ms, due to module A/D delays.

7.3 Streamers

7.3.1 Streamer details

Type of streamer	:	RDH solid
Number of streamers	:	12
Streamer sensitivity	:	20 V/bar
Streamer length	:	5100m
Number of groups	:	408
Group interval	:	12.5 m
Group length	:	12.5 m
Hydrophone type	:	T-2BX
Streamer depth control	:	DigiBIRD 5011
Streamer depth	:	8m
Number of compass-birds	:	20 on streamers 1,3,6,7,10,12.
	:	12 on streamers 2,4,5,8,9,11.

Some streamers (with 12 compass birds) have compass positions replaced with acoustic birds. This created a full acoustic network improving the overall positioning of the streamers. Additional birds were installed on streamer 1 and 12 to help improve depth stability of the streamers affected by the diverter wake, 6 birds were installed on active sections 15, 19, 23, 27, 31 and 35. See chapter 7.5 streamer layout.

7.3.2 Trace Numbering

STREAMER	TRACE		TRACE
Streamer 1	1	to	408
Streamer 2	409	to	816
Streamer 3	817	to	1224
Streamer 4	1225	to	1632
Streamer 5	1633	to	2040
Streamer 6	2041	to	2448
Streamer 7	2449	to	2856
Streamer 8	2857	to	3264
Streamer 9	3265	to	3672
Streamer 10	3673	to	4080
Streamer 11	4181	to	4488
Streamer 12	4489	to	4896
Auxiliaries as streamer 13	48		

7.3.3 Component dimensions

	NUMBER per STREAMER	NOMINAL LENGTH (m)
Lead-in	1	1100 or 1250
FO Boot	1	2.7
Boot Section	1	2.7
Head Stretch Sections	1	5
Dead Section	1	15
SeaTrak Module	34	0.354
Live Sections	68	74.54
Tail dead Sections	1	50

7.4 Recording System

Geophysical Acquisition System (gAS)

The SeaTrak NTRS 2™ is the digital seismic recording instrument with 24-bit in sea data acquisition modules. The SeaMUX New Technology Recording System2 with QUAD Array Interface (NTRS2 QAI) is able to acquire and record large quantities of data in real-time.

The SeaMUX NTRS2 QAI collects data from the seismic streamers. The NTRS2 QAI supports data collection via a QUAD Array Interface (QAI) to a PCI bus. Received data is sent directly (DMA) to one of many dynamically allocated buffers in memory. Over 2000 channels (per array) of seismic data can be collected at a sample rate of 2ms. The NTRS2 supports sample rates of ½, 1, 2, and 4ms and can also perform adjacent channel summing. Once the data has been collected and stored in one of the buffers, it is passed on for collection by the gAS recording system.

The gAS provides the user with a common interface in which to interface to the SeatRAK NTRS2®. The large recording capacity of gAS has been reaffirmed numerous times. Increased data rates easily handled within gAS are written primarily to a RAID disk and from there written to the recording media of choice, (gAS supports a wide variety of tape technologies). The seismic data were written to 3592 tape cartridges.

gAS online QC has an intuitive and simple set-up. Automated tools scan both the seismic/auxiliary data and information from a number of ancillary systems (e.g. bird and gun controllers) for anomalies or errors. This is an important task in modern seismic acquisition in order to reduce the immense amounts of data produced by onboard systems into an easily digestible format.

The automatic detection of errors, coupled with an integrated logging system, rolling data displays and diagnostics, enable quick and accurate evaluations.

Automated routines with added human input produce a machine readable data log for further use in Viper and subsequent processing. The log forms a complete history and audit trail of the data production process, from recording through to QC to production of a SEGY product in Viper.

Detection of a variety of instrumentation and external noise issues are accomplished with a combination of purpose designed routines, and with the aid of noise attenuation routines from within the Viper Package.

Continuous rolling data displays employ a variety of graphical display techniques in order to give the operator access to a large amount of diagnostic information. These displays aid investigation of the automated errors identified by the system, and provide an invaluable overview of environmental factors and system performance.

The gAS system makes the entire dataset available to Viper in real-time for further geophysical analysis.

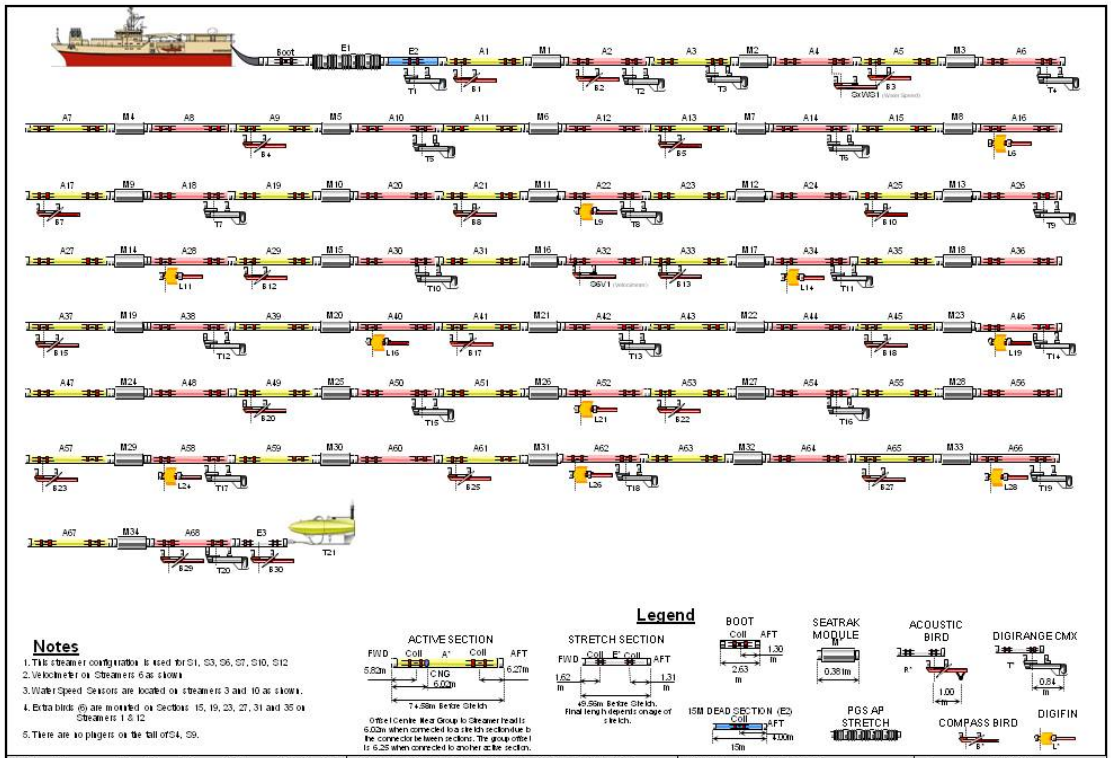
Recording System	:	gAS Ver. 5.0-0 with patch 5.0-2 / NTRS2 version A.88q+
gAS Configuration	:	Configured to match the SeaTrak NTRS 2 system
gAS Equipment	:	5 x IBM Node xSeries 3650 Type 7979
gAS Equipment Configuration	:	1 X Collector
	:	1 X Master QC
	:	2 X Slave QC
	:	1 X Tape server/Offline recording system
	:	3 X Raid recording system
Tape Transport for Recorders	:	4 X IBM 3592 cartridge drives, E05 density.

7.4.1 Recording System performance

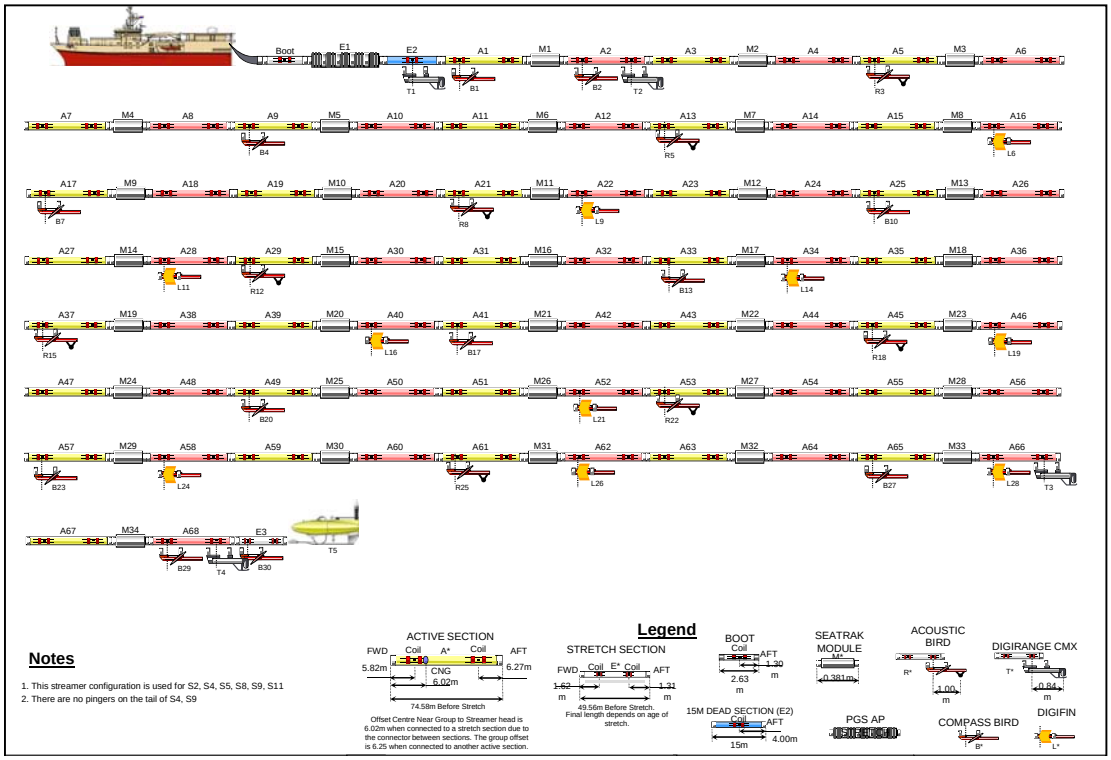
Recording systems performed well with no problems.

7.5 Streamer layout

"A" Streamers 1, 3, 6, 7, 10 and 12



"B" Streamers 2, 4, 5, 8, 9 and 11



Notes

1. This streamer configuration is used for S2, S4, S5, S8, S9, S11
2. There are no pingers on the tail of S4, S9

8 Navigation and Positioning

8.1 Geodetic reference

8.1.1 Survey Datum

Survey datum	:	GDA94
Ellipsoid	:	GRS 80
Semi Major Axis	:	*6 378 137 m*
1/Flattening	:	*298.257223563*
GPS Datum	*:*	*WGS84*
Ellipsoid	*:*	*WGS84*
Semi Major Axis	*:*	*6 378 137 m*
1/Flattening	*:*	*298.257223563*

8.2 Datum shift from GDA94 to WGS84

X translation	:	-0.0504 m
Y translation	:	0.0619 m
Z translation	:	0.1557 m
X-axis Rotation*	:	0.02066”
Y-axis Rotation*	:	0.01708”
Z-axis Rotation*	:	0.02127”
Scale Factor*	:	-0.001748 ppm

**Bursa-Wolf sign convention*

Datum shift parameters are based on the GEOSCIENCE AUSTRALIA document ‘International Terrestrial Reference Frame (ITRF) to GDA94 Coordinate Transformation’ by John Dawson and Jim Steed. The numbers have been calculated to year 2011.5 using the initial value and /year tabulated values from Table A1.

The WGS84 coordinate of a point in Australia changes each year by about 7cm due mainly to tectonic motion of the Australian landmass. The consequence is that WGS84 coordinates must always be accompanied by the collection date to be meaningful at the sub-metre level."

Test Point

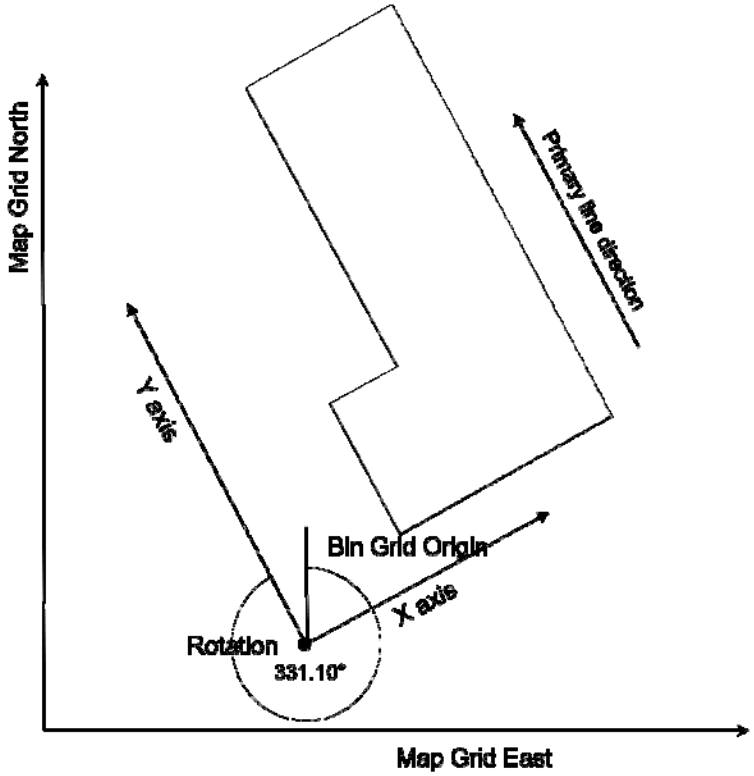
Datum	Latitude	Longitude	Height
GDA94	40° 00’ 00.0313” S	144° 59’ 59.9856” E	0.06 m
WGS84	40° 00’ 00.0000” S	145° 00’ 00.0000” E	0.00 m

Geoid height : -5.00m (min -5.79m, max -4.20m)

8.2.1 Map projection

Projection	:	Transver Mercator
Projection System	:	UTM
Zone	:	54
Central Meridian	:	141° East
Scale Factor on Central Meridian	:	0.9996
Latitude of Origin	:	0°
False Northing	:	10000000m
False Easting	:	500000m

8.2.2 Binning grid



Origin Easting (m)	:	683054.75
Origin Northing (m)	:	5576608.17
Rotation (deg)	:	331.1°

	X	Y
Origin bin number	921	467
Bin number increment	25.0	6.25
Area size (m)	21552.0	52912.00
Bin interval (m)	1.0	.33333
Bin size (m) at 130 m offset	50.0	6.25
Bin size (m) at 1405 m offset	62.5	6.25
Bin size (m) at 2680 m offset	75.0	6.25
Bin size (m) at 3955 m offset	87.5	6.25
Bin size (m) at 5230 m offset	125.0	6.25

It was requested that the survey lines were acquired so that the front near coverage butted up to existing coverage and leaving one column free on the nears. No steering was to be made for the remaining groups. During Seq 4 Origin Energy requested we do not leave the empty column as it was seen the feather was not consistent between lines.

8.3 Surface positioning

8.3.1 System I

Type	:	SkyFix.XP DGPS
Differential Corrections via	:	SPOT OCSAT / NTRIP POR (internet) / Inmarsat POR
Reference stations	:	N/A global orbit and clock corrections
Software	:	Multifix6, version 1.01
Sub-Contractor	:	Fugro Survey AS

8.3.2 System II

Type	:	StarFix.HP DGPS
Differential Corrections via	:	SPOT OCSAT / NTRIP POR (internet)
Reference stations	:	Melbourne 250 km distant Bathhurst 900 km distant Ceduna 1200 km distant Brisban 1625 km distant
Software	:	Starpack SPM 07.02.03
Sub-Contractor	:	Fugro Survey AS

8.3.3 Float positioning

Relative GPS	:	Seatex Seatrack 220 / 230
GPS receiver	:	Trimble DSM
UHF communication	:	UHF 450MHz range
Software version	:	StarFix.RGPS

8.3.4 Heading reference

GPS Heading / Attitude system	:	Seapath 200
Gyro	:	2x SG Brown Meridian Surveyor

8.3.5 Delivered P1/90 and P2/94

Two copies of the following were produced for delivery from the vessel, with each set of data tapes:

- Processed data (Final P1/90)	:	3592
- Raw data (Final P2/94)	:	3592

The following were to be produced for delivery from the office:

- Shotpoint loc. map, vessel positions	:	CD ROM
- Vessel position tape	:	CD ROM
- Bathymetry tape	:	P1/90, draft, tide and velocity corrected
- Bathymetry data and map	:	CD ROM
- Bathymetry map (Contour)	:	In .pdf format on CD ROM

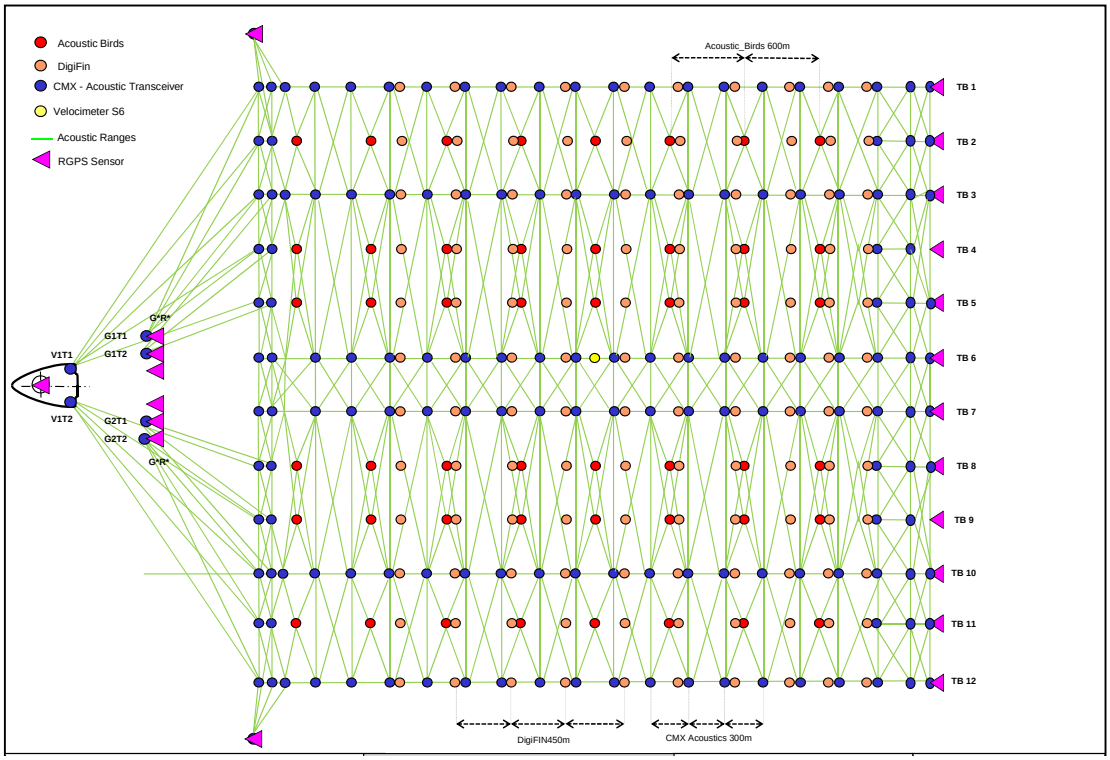
8.4 Underwater Positioning

8.4.1 Acoustic ranging system

System name	:	Digicourse System3
Software version	:	6.14
Frequency	:	50-110 kHz

The Acoustic ranging system developed communication problems on sequences 006 for 22 shots and seq 019 for 17 shots. During these short periods there was limited movement of the cables and the a valid processed solution was provided.

8.4.2 Acoustic network



8.4.3 Magnetic compasses

Bird Compasses	:	Digicourse 5011 Compass bird
Software version	:	System3, version 6.14
Magnetic variation	:	11.36 (IGRF11) 31th january 2011

As the weather increased throught the duration of the survey the compasses became noisy. This was reported in the NRT EOL reports. Due to the full acoustic network the positioning of the cables was not effected due to this additional noise.

Higher rotation values were seen on seq 008-010 and 27-28 and these were attributed to the higher sea state.

8.4.4 Echosounder

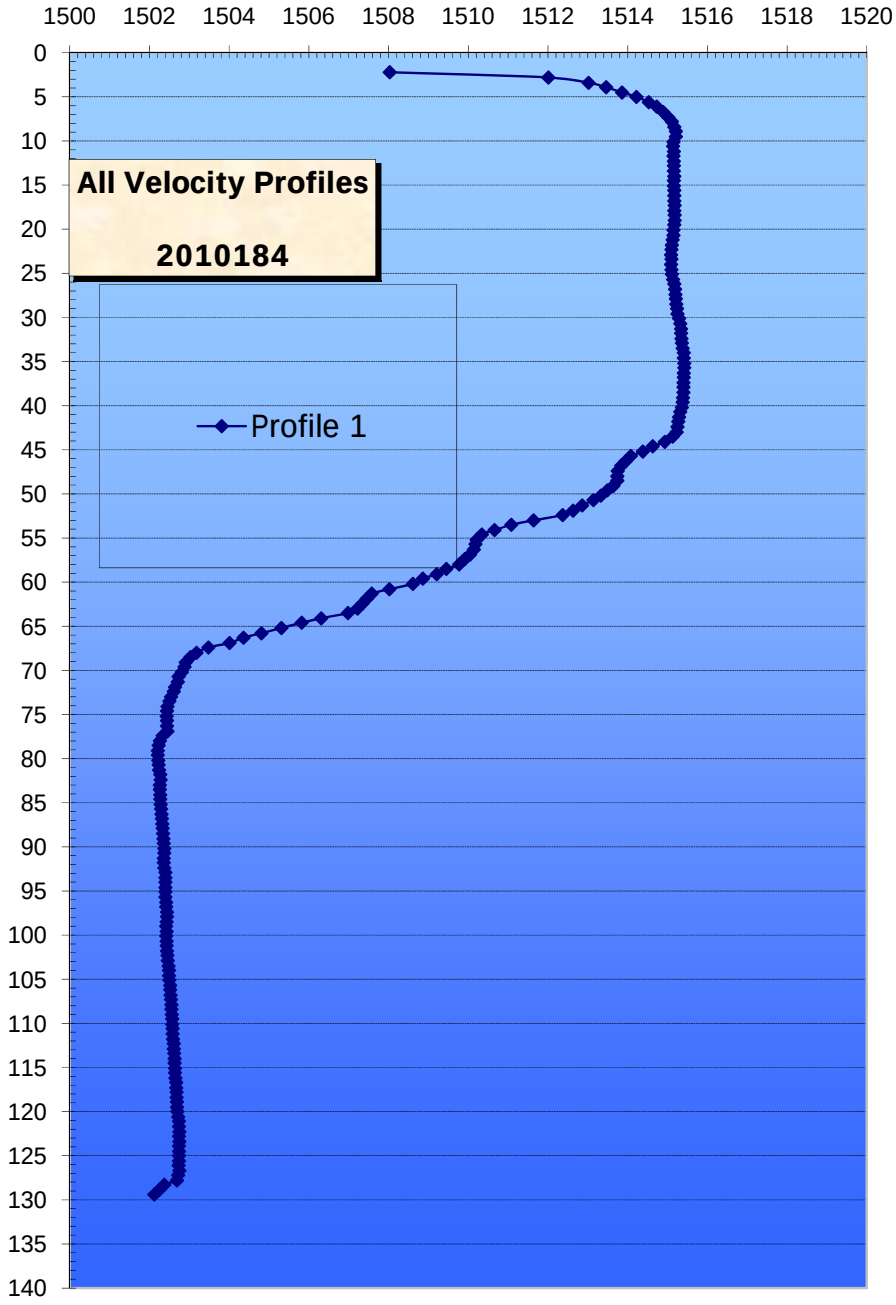
Type and model	:	Simrad EA600
Transceiver frequency	:	12, 36 (Master), 200 kHz
Heave compensated	:	Yes, via Kongsberg MRU5

Due to the rapid variation of the seabed caused by the continental shelf dropping off from 100 to over 600m the 38KHz transducer used for the final P190 was occasionally refiltered or swapped to the 12KHz.

8.4.5 Sound velocity

Velocity probe	:	Sippican Mk21 with XBT probe
Real time sensors	:	Digicourse Model 700 Velocimeter Strm

Below is a summary of the one profile collected during the first and last survey line of the survey. Only one profile was collected due to the rapid end of the survey and increased sea state at the end. The comparison between the sippican and the velocimeter data at streamer depth showed a good comparison and was steady through out the surveyat 1515m/s.



8.6 Navigation and binning systems

8.6.1 Integrated navigation system

Type	:	ORCA
Supplier	:	Concept Systems Ltd.
Software version	:	1.8.1
Real Time Interface	:	PowerRTNU
Machine type	:	IBM Blade servers
X-terminals	:	IBM workstation Blades
Tape storage	:	IBM 3592

8.6.2 Binning system

Type	:	Reflex
Supplier	:	Concept Systems Ltd.
Software Version	:	1.11.4
Machine type	:	IBM Blade server
Tape storage	:	IBM 3952

9 Navigation processing

9.1 Introduction

A Final P1/90 file was generated using either the Near Real Time (NRT) module within ORCA or with the SPRINT processing system. NRT is an automated system that puts out a solution with a qualifier a few minutes after EOL. Sprint is the off-line processing system used to produce a solution through manual assessment and editing of the individual observations. The two systems are interfaced, so the manual editing needed in Sprint can be limited to the problems encountered by NRT.

NRT gives the solution one of four quality indicator flags:

- OPTIMAL – the data will not benefit from manual processing. All tests were passed without problems.
- CAVEATS – the data will not benefit from manual processing. However some data are highlighted for further QC analysis.
- REPROCESS – the data may benefit from manual processing. The Sprint database generated by NRT can be used to process the flagged data. Manual processing required.
- REPROCESS P2 - manual processing required. The Sprint database generated by NRT may not be complete, so import of the raw data into Sprint is required.

The decision of whether to use the NRT solution or to process with Sprint is based on these flags and line specific QC reports produced by Orca/NRT. After processing was complete, the solution was used by ORCA to produce the final P1/90 file.

9.2 NRT

The way NRT calculates the positions can be broken down into the following steps:

- **NCN calculated positions**
  NRT uses the real time positions calculated by Orca as the basis for further processing of the raw observations.
- **Outlier rejection**
  Based on the Orca real time calculated positions, outliers in the raw sensor data are rejected. Note that this does not apply to compass observations, as these generally have low redundancy.
- **40 shots filter buffer**
  Raw observations are filtered to remove noise. Future data (40 shots) is used to improve the quality of filtering. Secondary spike rejection – based on time series – is applied to remove remaining spikes. This is particularly useful for compass observations.
- **Compass drift detection**
  Temporary biases (drifts) in compasses are removed based on deviations from the smoothness of the streamers.
- **Least squares adjustment**
  All filtered observations are used to update the positions in the network in a least squares adjustment. The weights of these observations are proportional to the quality of the data and vary in time.
- **QC end of line report**
  A QC report is created, containing the outcome of from the main qualifier checks.

NRT replay is an Orca node that essentially runs the NRT calculation over again on a line for which the initial NRT solution was not satisfactory. After editing of the flagged problem data, the new solution goes through the same assessment as the original solution and a new quality flag is produced.

9.3 Sprint

Sprint processing consists of

- Editing of the raw observations in the *preprocess* module
- Calculation of positions through least-squares adjustment in the *netadjust* module

This is an iterative process as *preprocess* is typically revisited as required by the statistics produced in the *netadjust* module. It is also possible to use only the *preprocess* module of Sprint and let NRT do the adjustment of the edited data.

In *preprocess*, a configurable collection of gates, filters and parameters for interpolation is applied to the raw observations. Each observation can be visually inspected and manually edited. The weights assigned to each observation for use in the least squares adjustment can also be set here. The resulting processed observations are used in the *netadjust* calculation or by NRT replay.

In Netadjust, the positions of the network are computed by using the processed observations from Preprocess in a least-squares adjustment. This module is used mostly if the NRT replay cannot produce a good solution after editing of data in Preprocess. The solution is exported to Orca where the P1/90 is generated.

9.4 Data quality control procedures

Orca and NRT produce line specific reports with plots of key parameters. These reports were examined after each line to detect possible problems at an early stage. Special attention was paid to the stretch- and rotation-values, separations between guns and streamers, and the development of such parameters from line to line.

For the first line of the survey and for the first line following each crew change, data was sent in to the PGS office for a QC check. The P2/94 file, the ORCA/NRT generated P1/90 file and a P1/90 file produced onboard using SPRINT were checked for errors, omissions and inconsistencies.

Periodically during the survey NRT P1/90 positions were checked by comparison with P1/90 data produced by post processing with Sprint.

Comparison Sequence	Maximum Position Differences Across/Along (m)			
	Vessels	Sources	Tail buoys	Receivers
001	-0.7/0.5	-1.3/1.5	-2.1/3.7	-4.0/3.9
006	0.7/-0.5	-1.1/-0.8	-1.9/3.1	6.6/-4.6
016	-0.7/0.5	-0.9/1.4	-2.2/2.9	4.3/3.4
026	2.0/2.0	2.2/1.9	2.5/3.7	4.6/4.3

Sequence 006: Reprocessed in Sprint due to the Acoustic system losing communications for 22 shots, after analysis of the produced NRT P190 it was decided to use a Sprint processed P190, this was due to a single shot instability in the NRT solution.

Sequence 027: Orca did not produce a NRT solution due to database issues. Sprint was used to provide the final solution.

The type of processing the lines went through, is summarized in the table below.

NRT Statistics			Final P1/90's		
Optimal Lines	7	25.0%	Sprint Lines	2	7.1%
Caveats Lines	12	42.9%	NRT Lines	20	71.4%
Reprocess Lines	7	25.0%	NRT Replay Lines	5	17.9%
Reprocess P2 Lines	1	3.6%	NTBP Lines	1	3.6%
NTBP Lines	1	3.6%	Total lines	28	100.0%
Total lines	28	100.0%			

Sequence 006: Reprocessed in Sprint due to the Acoustic system losing communications for 22 shots, after analysis of the produced NRT P190 it was decided to use a Sprint processed P190, this was due to a single shot instability in the NRT solution (approx 6.6m).

Sequence 025: NTBP due to gun array communication problems.

Sequence 027: Orca did not produce a NRT solution due to database issues. Sprint was used to provide the final solution.

Common reason for the use of NRT Replay was due to noisy compasses. The NRT rejected data and reported missing compass data. The data was analysed using sprint and re-filtered if necessary before running back through NRT Replay.

Each P1/90 and P2/94 was finalized using the PGS program FinalQC. The program checks that the files comply with format and PGS standards and list key parameters of the file. The program writes the final files to tape and uses a checksum facility to ensure that files on tape and hard drive are identical.

Tape labels are created from the final tapes by use of Final QC.

10 Seismic data quality

The PGS Marine Acquisition quality control system includes a set of standard products for online QC, general seismic data QC processing, investigations, and data archiving.

The geophysical Acquisition System (gAS) and Viper systems were developed by PGS for onboard recording, quality control (QC), and SEGY production, and are the standard on all PGS seismic vessels. The gAS system has a massive data recording capacity, and also performs automated online QC and logging. The system places a particular emphasis on the display and the detection of any online anomalies or errors due to instrumentation or external factors. Viper is used for subsequent geophysical analysis in order that the root cause of the anomalies can be determined and the potential impact on survey objectives qualified and quantified.

Instances of rig noise, ship noise and seismic interference did not pose data acceptability issues at any point during the acquisition program. There were no instances of a line being terminated due to excessive levels of external noise, although 2 lines discussed below were considered marginal.

All incidences of external noise are documented thoroughly in the Line Logs.

It is not practical to discuss every single individual instance of externally generated noise in the end of job report

Sequences deemed 'Not To Be Processed' were:

Sequence 025: NTBP due to a power failure on gun array 5.

Some miscellaneous comments on incomplete lines:

Sequence 011 Line incomplete. Line aborted due to port superwide rope breaking. LGSP 2000.

Sequence 021 Edit. NDR SP 2475-2129 due to pilot whale sighting.

Sequence 023 Edit. NDR SP 2663-2653; SP 2644-2620 due to NTRS system reboot and a gAS recording system crash.

10.1 Seismic interference

No SI recorded during this survey

10.2 Swell noise

A note regarding the standard Viper noise attenuation tool:

SINK (Seismic Interference Noise Killer) is the PGS proprietary threshold limited noise attenuation software. Commonly applied pre-stack, it can be run in a number of passes to target both swell noise and seismic interference noise. Additionally, SINK attenuation operators can be designed using limited bandwidths for more robust interference/signal separation.

The strongest levels of swell noise were recorded on sequences 008 and 009, affecting 30-50% of data traces. The levels of swell noise seen required the application of SINK filtering to the data. Although the swell noise showed up on the brute stacks to shallow times, after the application of SINK filtering, the swell noise on the stack data was considerably reduced, and not visible above 3.0s TWT where the zones of interest are located. The direction of sea swell was from the side, and so the actual recorded levels of swell noise were lower (13-15 uB) than they might have been had the survey been oriented in the other direction. Indeed whilst turning into the seas on a line change, the RMS values recorded when heading directly into the seas showed 20-25uB with the cables at 12m depths.

10.3 Ship noise

Ship noise was not a problem during this survey.

10.4 Bad channels

Noise can be generated by the in-sea equipment (birds, pingers, modules, streamer sections, and tail buoys) either by device malfunctions or by noise induced at the streamer section caused by the act of towing the equipment.

Channels failing daily instrument tests were flagged as edits. Equipment that was noted as malfunctioning was subsequently changed out during the next available line change (subject to favourable sea conditions and daylight hours), so as not to affect the acquisition production rate.

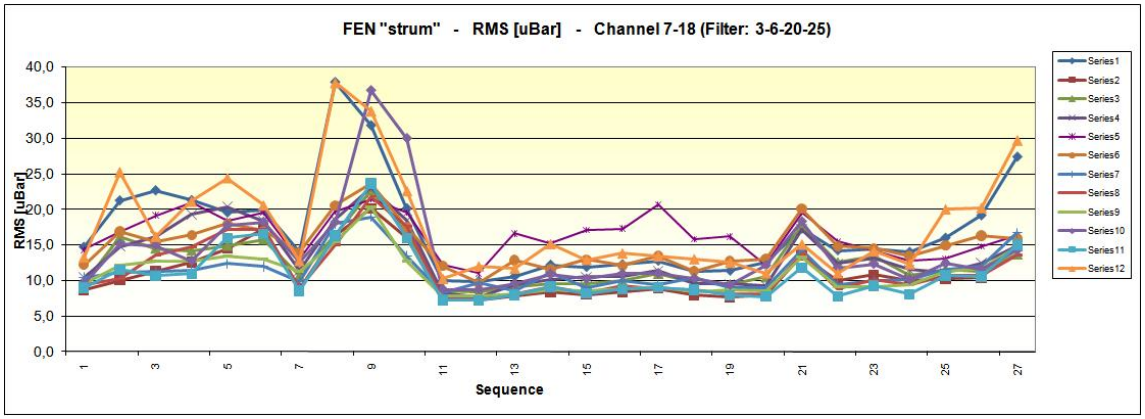
There were very few bad or noisy channels in the spread at any time during the survey.

10.5 RMS and noise analysis

At the start and end of each line, 10 noise records were recorded and displayed in real time, both as shot records and RMS values. These were used to assess ambient background noise levels and identify any noisy traces for further examination.

Front end and tail end noise statistics were monitored throughout the duration of the survey at the start and end of every sequence. Both sources of noise were comfortably within acceptable levels at all times.

Front end noise values were calculated using the near traces 7-18 on each cable, and filtered to 3-6-20-25Hz. The noise levels remained steady for all streamers throughout the majority of the survey around 10-12 µbar, with higher levels of front end tug noise (35µB) prevalent on sequences 008 and 009 shot in marginal conditions, and on the last sequence 028 before the vessel went down for weather. The graph shown below represents the front end noise statistics for all sequences.



Tail end noise values also remained steady throughout the survey, in the order of 5-8 ubar.

10.6 First break / P1 offset check

The P1/90 data, as created onboard by the navigation department, were merged with the seismic data. QC consisted of calculating the first break time from the coordinates of shot and receiver (FB_NAV = offset / speed of sound in water), and plotting this as a header overlay on top of the seismic traces. Simply by sorting the data by cable and gun mask, it was possible to see accurately the header values lining up along the direct arrivals for the near trace of each cable and thus spot any deviations from the norm accordingly. Any mismatches between the direct arrival time and the navigation derived pick were referred back to the navigation department.

10.7 Common offset cube

The main QC step for navigation merged data is a common offset cube to check for anomalies and time shifts between sail lines on cross-line sections and time slices.

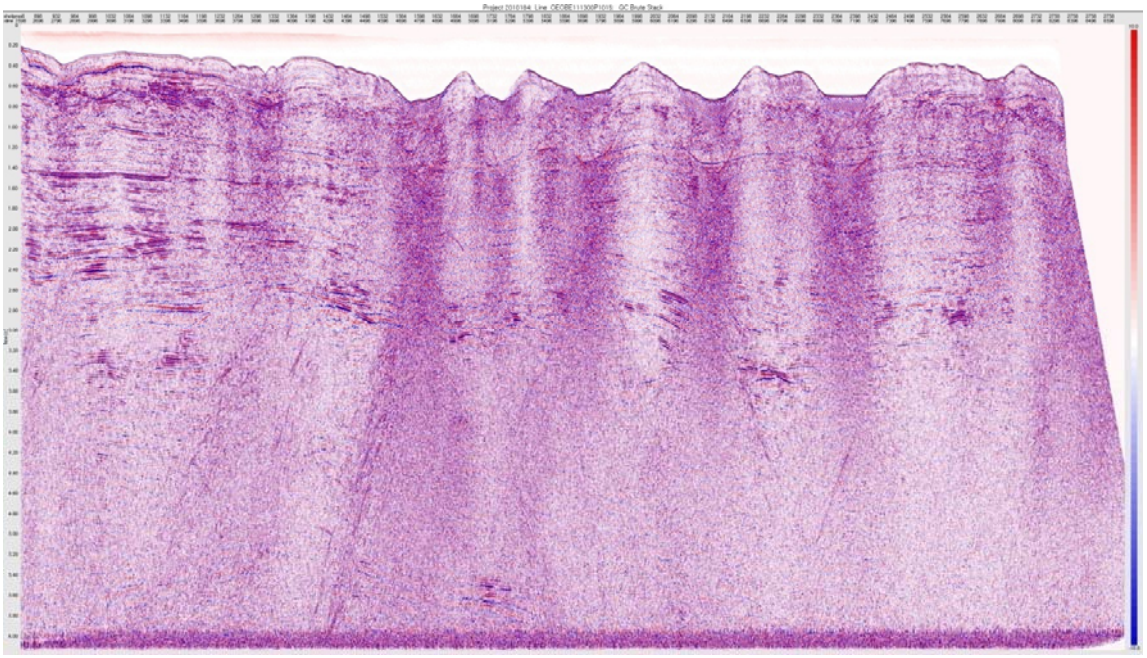
A trace closest to a pre-defined near offset distance was taken from every shot and every streamer and was partially NMO corrected to that offset before being accumulated into a cube dataset. The cube was thoroughly interrogated using PGS' proprietary HoloSeis 3D visualization software in the time-slice, cross-line, and in-line directions to verify the continuity of the data.

10.8 Brute stack QC

The object of the 2D brute stack processing was to stack one source-streamer CDP line per pre-plot sail line, using the power of stack and minimal additional processing in order to attenuate noise. Stacks were used to analyse the potential effects of noise on the data quality.

Examples of noise that can adversely affect the seismic data include seismic interference, ship noise, swell, currents, streamer strum, and turn noise. Evaluation of the brute stacks and the signal/noise cancellation effect of the stacking process is a standard QC product and used as a benchmark for noise evaluation. For lines affected by marginal swell noise (e.g. seq 008 and 009), a comparison post SINK stack display was generated to aid swell noise evaluation and acceptability decisions.

Example Brute Stack Line OEOBE111300P1015



11 QC Processing

The acquisition QC processing involved several different aspects of data analysis including:

- Real-time monitoring of acquisition using online gAS (geophysical Acquisition System) and Viper.
- QC of RMS windows, auxiliary channels, near traces and raw shots.
- Offline Production of a 2D brute stack for one selected sub-surface line.
- Seismic/navigation merge, navigation QC and production of SEGY format data to disk.
- Generation of Common Offset and RMS Attribute Areal Volumes in HoloSeis.
- Comprehensive investigation of any acquisition related issues.

11.1 Online QC

gAS was used to provide real time QC displays for the observers and the QC geophysicists to monitor, covering all required aspects of QC:

- Real time shot gather displays for all shots, all streamers (cycled), with user interactive ability to highlight data and check header values.
- Real time data recording status displayed in an instrument analysis window to highlight gun errors such as misfires, auto-fires, internal time breaks or recording problems such as parity errors.
- Streamer depth and spread stability.
- Noise anomaly display, used to highlight major differences from shot to shot, ideal for observing source problems such as auto fires, or external noise such as seismic interference or ship noise.
- Water column and end of record RMS windows showing data from all streamers to highlight RMS levels and indicate any variations due to noise from external sources.
- Stacked display of the auxiliary channels over full record length in order to investigate any possible source problems, including auto-fires.
- Layered displays of the auxiliary channels over the first 300 ms of data in order to investigate any possible source problems, including air-leaks, pressure problems or gun arrays at the incorrect depth.
- Single trace display of a near offset channel from 1 streamer.
- Shot to shot comparison windows for two signal windows used to confirm source accuracy and consistency, highlighting air-leaks.
- Gun string pressure, volume and depth.

The gAS system was used to monitor and pass seismic data real-time to Viper where it was recorded to disk. After a line was recorded, Viper was used for offline QC processing.

GAS real-time RMS calculations were performed for all channels of each shot in four different time windows using a 3-6-90-120 Hz band pass trapezoidal filter. Although data was recorded for all channels for further analysis in Viper the windows were offset limited to provide the best possible results and avoid contamination from direct arrival or reverberation energy. All RMS windows could be monitored on-line using gAS to check for and quantify any external noise, such as current noise, ship noise, swell noise, and seismic interference.

11.2 Offline QA/QC sequence

The gAS/Viper system was utilised for the subsequent offline QC processing. At the end of each line, the following displays were produced on-screen:

- Raw Shot displays for a selected incremental number of shots rotating through the streamers.
- Time-break QC.
- Stacked auxiliary traces from each sub-array.
- Raw auxiliary traces from each sub-array for every shot.
- RMS computations and displays of a) raw data b) FK filtered data c) FK and SINK filtered data.
- RMS areal displays made to determine shot and channel edits.
- Shot to shot source comparisons taken from gAS computed signal window RMS values.
- 2D QC Stack plot for selected stacking streamer.
- Navigation Merge and SEGY reformat of data. Edits flagged in headers only.
- Common Offset Cube generated in HoloSeis.
- Display of any QC matters requiring further investigation.

11.2.1 2D QC stack

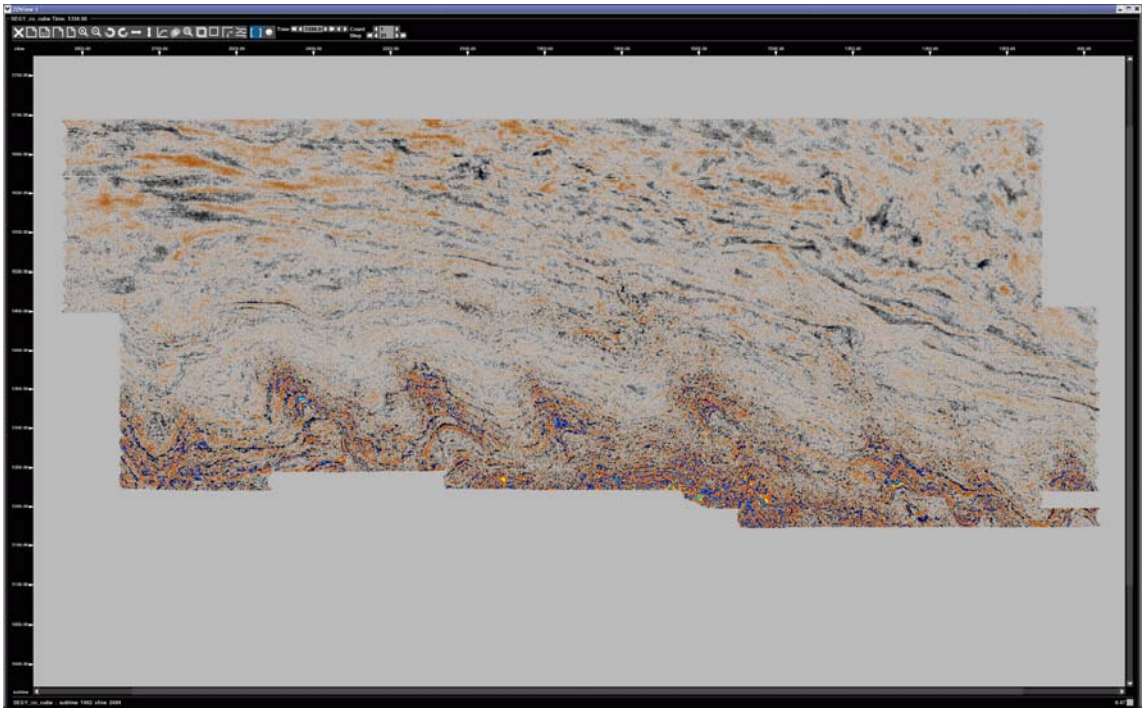
Parallel 3D Seismic Processing & QC System: Viper 5.0-2

- SEGD Input - SEGD Real Time Capture
- Output Format - Viper Internal Format (2ms)
- Sub-sample recording skew applied
- Select rotating one source / one streamer CDP line
- Apply Nominal Geometry 12.5 Trace Interval
- Removal of Recording System Delay
- Shot and Channel Edits Applied
- Low cut 6Hz-18dB Butterworth filter
- WBT assigned to traces for first break mutes and Deconvolution
- Spherical Divergence compensation using a $1/tv^2$ function
- DB Gain +1dB per Sec applied 0-3500ms, constant thereafter
- Minimum Phase Predictive Deconvolution: 240ms operator length/24ms gap
- Normal NMO Applied using picked velocity functions
- Post NMO Stack Mute Applied
- Stack Output Sample = (sum of all input samples) / (no. of non zero samples contributing to sum)
- Normalisation Value : 0.5
- Gun and Cable Static Shift
- QC Display within interactive 2D Viewer
- Output to SEGY format file for archive

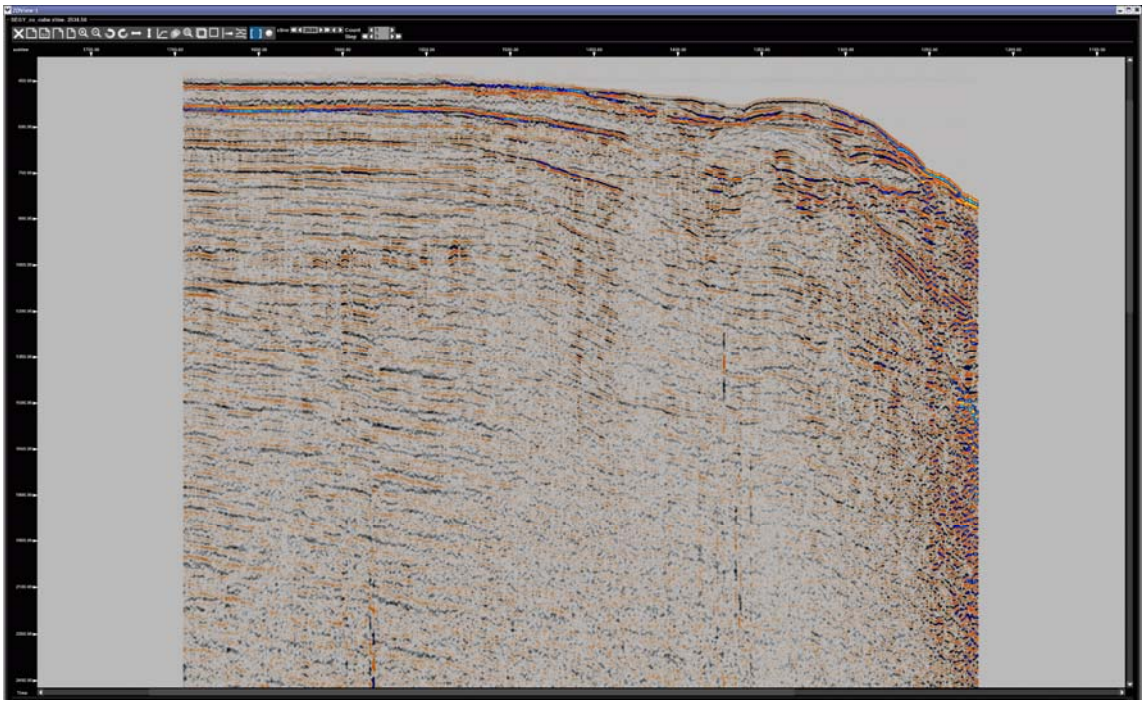
Nominal geometry is normally used by default in order to generate a stack rapidly after the end of line.

11.2.2 3D QC stack

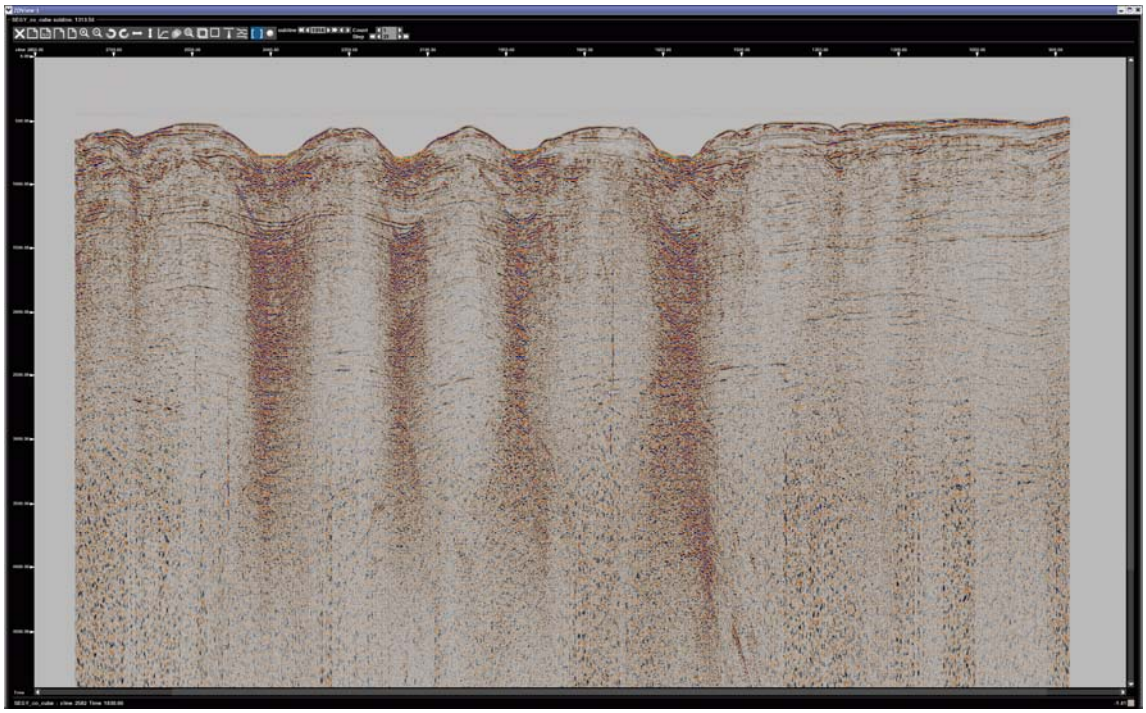
Common Offset Cube 3D HoloSeis Display – Timeslice 1334ms



Common Offset Cube Cross-line Display X-line 2534



Common Offset Cube Sub-line Display. Sub-line 1314



11.2.3 Common offset cube

A nominal offset, single fold 3D cube dataset was prepared using the Viper system and subsequently loaded into the HoloSeis visualization software. HoloSeis provides a robust QC viewing tool to check the navigation/seismic merge and also survey coverage.

The data record length was truncated to 6 seconds at a 2ms sample rate. A single regional velocity function was used for a partial NMO correction.

Once the data for each sequence were loaded, time-slice, cross-line, and in-line displays were then created for QC purposes. These were subsequently checked for potential navigation problems, miss-merge problems, and overall coverage.

The process of accumulating a CO cube data set from traces output by the SEGY production job flow acts as a further QC tool checking all traces and edits passed to the SEGY product.

Attributes such as sequence number, water depth, shot point number, field file number, gun mask, vessel azimuth, water speed, streamer number and RMS window values can also be loaded to the cube to create 2D areal images

11.2.4 Other QC products

The output from the near field hydrophones mounted on the gun strings and the system time-break signal was recorded on the auxiliary channels in order to identify air leaks and gun-timing errors. Using the gAS system, the auxiliaries of all gun strings were displayed in real time as an aux layer plot to highlight bubble period changes that could indicate air leaks, and as an aux stack plot to highlight gun firing errors such as auto fires. These displays were repeated offline using the Viper system to check in further detail any subtle variations that may have been overlooked while online. In addition the near field hydrophones were also displayed in raw format for every shot in the.

11.3 SEG-Y sequence

SEG-Y navigation-merge was performed using the onboard Viper system and written to disk for PGS Data Processing to access. Very little trace manipulation was performed to the data prior to being written to disk. The primary purpose of the SEG-Y tape merge was to provide final navigation values loaded into the trace headers. All data not intended for inclusion in subsequent processing as specified by the contract and onboard clients was also identified by modifying a header value to identify the problem data as bad. The basic processing steps are described below.

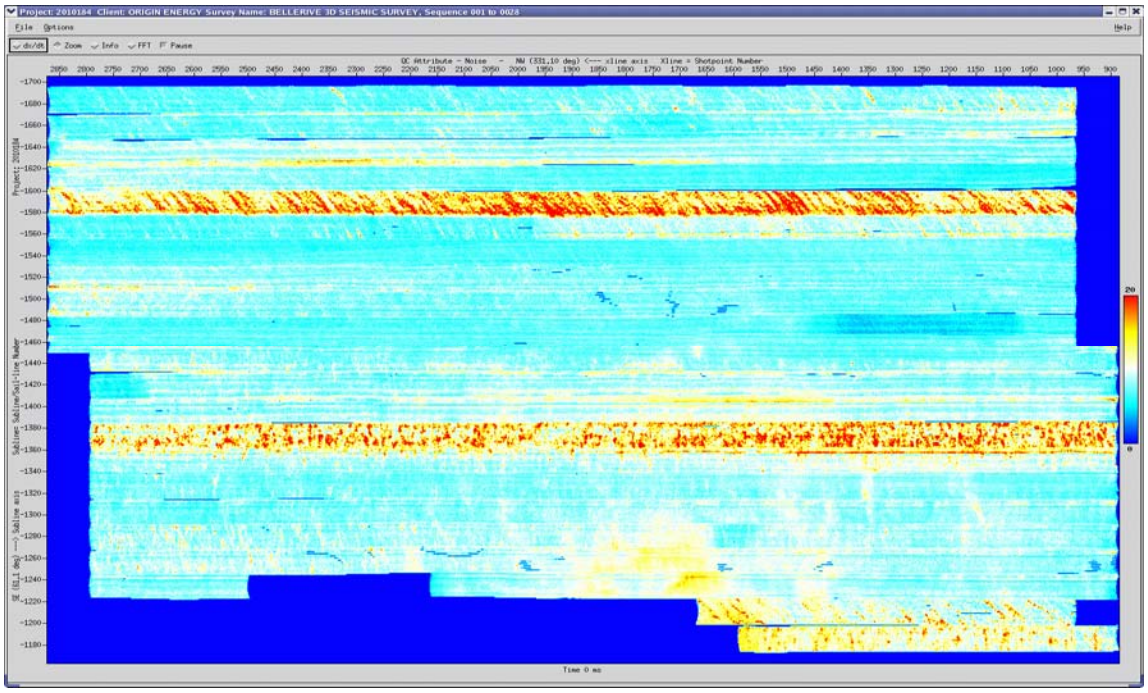
1. SEG-D REFORMAT,SKEW CORRECTION APPLIED,REC. DELAY CORR.(-58MS) NOT APPLIED
2. BAD CH/SHOT EDITS FLAG trid=2, REVERSE CH FLAG trid=-1, SEISMIC/NAVIGATION MERGE
3. OUTPUT TO 3592 SEGY TAPE

11.4 RMS and noise analysis

A number of RMS displays were also produced with the Viper processing system to show from, an areal perspective, the variations in signal and noise levels across the survey as acquisition progressed. The RMS values were calculated using a water column noise, a shallow signal and a deep signal window.

The RMS noise display below shows the survey was acquired with generally very low background ambient noise levels, however two sequences with increased noise levels due to swell noise can be observed at sail lines 1372 (seq 008) and 1588 (Sequence 009). These two lines stood out from the rest with an average 15µB RMS noise in marginal conditions. The last two sequences acquired, lines 1180 and 1588, shot in herringbone fashion also showed some noise as the weather deteriorated at the end of the survey, but not to the same extent.

Raw RMS (with basic 3-6Hz Filter) (scale 0-10 µbar)



11.5 Computer systems

QC System	**mamba, python, hol01, hol02, cpu01, cpu02**
Software:	Viper 4.0.3-4, HoloSeis 10.31.12, Centos 4.6
Hardware:	4 x IBM Intel Xeon X3650 Type 7979
	2 x HP XW 9400 Dual Xenon 3.0GHz
PC	2 x Lenovo ThinkCentre Intel Core 2
Hard Disk (workstations):	18.6 terabytes RAID Infotrend
Monitors:	4 x HP Flexscan SX3031W
Tape drives:	4 x IBM 3592

12 Appendix

12.1 Data shipments

Date	Proforma	Content	Boxes	Wt (kg)	Shipping address	Comment
	STE36000917A	SEG D data tapes set 1 Obs Logs (DVD) P190 tape P294 tape	1	8	DownUnder GeoSolutions Pty Ltd Level 3 76 Kings Park Rd West Perth WA 6005 Australia Matt Lamont +61892874100	Shipped off in Portland on the 21 February 2011
	STE36000918A	SEG D data tapes set 2 Obs Logs (DVD) P190 tape P294 tape	1	7	Origin Energy Level 10 135 Coronation Drive Milton Qld 4064 Australia Neil Millar +61738580667	Shipped of from Dampier on 23 March 2011
	STE36000921A	SEGY Reformat 3592 Tapes 104051JA-104077JA Plus QC Deliverables SEGY Brute stacks, NT Cube, Obs Logs	1	10	DownUnder GeoSolutions Pty Ltd Level 3 76 Kings Park Rd West Perth WA 6005 Australia Matt Lamont +61892874100	Shipped off in Portland on the 21 February 2011

12.2 Source modelling

SIGNATURES FROM MARINE AIRGUN SOURCE LIBRARY
NUCLEUS+ 2.0.0 - Marine Source Modeling 1.4.0
Modeling by Ashish Misra, approved by _____,
PGS Technology – Geophysical Support, January 2011

Survey name	:	Bellerive 3D - Origin Energy
PGS project No	:	2010184
Survey area	:	Otway Basin
Vessel	:	MV RAMFORM STERLING
Array	:	3090T__070_2000_100
Source type	:	Bolt 1900 LLXT
Source volume	:	3090 cu.in.
Air pressure	:	2000 psi
Source depth	:	7.0 m
Subarray separation	:	10.0 m
Recording filter	:	Hydroscience, 4.6(6)-206(276) Hz (dB/oct.)
Receiver depth	:	8.0 m
Hydrophone group length	:	12.5 m
Full system response* filter name	:	Hydroscience, 4.6(6)-206(276) Hz (dB/oct.)
Sea temperature	:	15.0 ° C

Enclosed are:

Figure 1: Array configuration top view, i.e. positive Y denotes starboard.

Figure 2: Modeled far-field signature and amplitude spectrum with Hydroscience recording filter (without receiver ghost).

Figure 3: Modeled far-field signature and amplitude spectrum with DFS-V recording filter (without receiver ghost).

Figure 4: Modeled far-field signature and amplitude spectrum with recording and hydrophone filter effect applied (without receiver ghost).

Figure 5: Far-field signature listing with 2 ms sampling interval (without receiver ghost).

Figure 6: Modeled far-field signature and amplitude spectrum with recording and hydrophone filter effect applied (with receiver ghost).

Figure 7: Far-field signature listing with 2 ms sampling interval (with receiver ghost).

Figure 8: Directivity plot for constant azimuth of 0° and 90°.

* The full system response filter includes the effect of connecting the hydrophones to the modules in addition to the recording system filter setting. Therefore the resulting signature includes all phase effects arising from streamer electronics, and should be used for designature filter design.

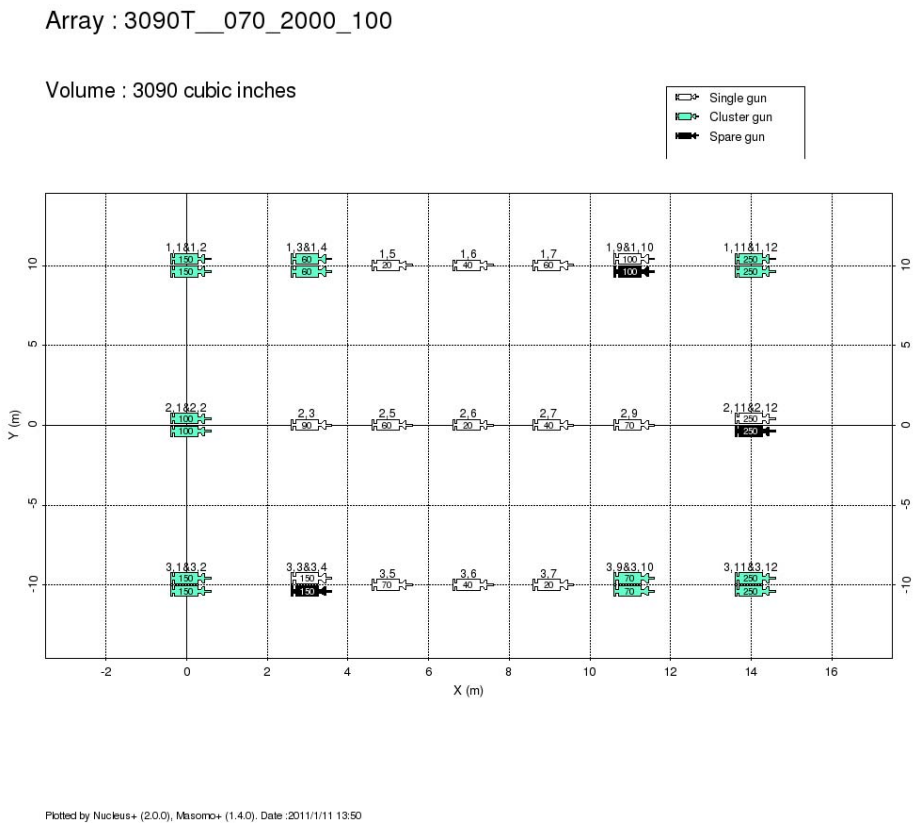


Figure 1: Array configuration top view, i.e. positive Y denotes starboard.

SOURCE ARRAY PARAMETERS:

Project	:	Origin-Energy
Dataset	:	3090T__070_2000_100
Number of subarrays	:	3
Total number of guns	:	31
Total chamber volume	:	3590.0
Effective volume	:	3090.0
Subarray number	:	1
Subarray name	:	1140T__040_2000_SUB
Number of guns	:	11
Subarray volume	:	1240.0
Effective volume	:	1140.0

GUN	TYPE	X(m)	Y(m)	Z(m)	Volume	Pressure	Delay	CluNo	Activ	Group
1	Bolt 1900 LLXT airgun	0.00	10.40	7.00	150.0	2000.0	0.0	1	1	1
2	Bolt 1900 LLXT airgun	0.00	9.60	7.00	150.0	2000.0	0.0	1	1	1
3	Bolt 1900 LLXT airgun	3.00	10.40	7.00	60.0	2000.0	0.0	2	1	1
4	Bolt 1900 LLXT airgun	3.00	9.60	7.00	60.0	2000.0	0.0	2	1	1
5	Bolt 1900 LLXT airgun	5.00	10.00	7.00	20.0	2000.0	0.0	0	1	1
6	Bolt 1900 LLXT airgun	7.00	10.00	7.00	40.0	2000.0	0.0	0	1	1
7	Bolt 1900 LLXT airgun	9.00	10.00	7.00	60.0	2000.0	0.0	0	1	1
9	Bolt 1900 LLXT airgun	11.00	10.40	7.00	100.0	2000.0	0.0	0	1	1
10	Bolt 1900 LLXT airgun	11.00	9.60	7.00	100.0	2000.0	0.0	0	0	1
11	Bolt 1900 LLXT airgun	14.00	10.40	7.00	250.0	2000.0	0.0	3	1	1
12	Bolt 1900 LLXT airgun	14.00	9.60	7.00	250.0	2000.0	0.0	3	1	1

Subarray number : 2
Subarray name : 0730T__040_2000_SUB
Number of guns : 9
Subarray volume : 980.0
Effective volume : 730.0

GUN	TYPE	X(m)	Y(m)	Z(m)	Volume	Pressure	Delay	CluNo	Activ	Group
1	Bolt 1900 LLXT airgun	0.00	0.40	7.00	100.0	2000.0	0.0	4	1	1
2	Bolt 1900 LLXT airgun	0.00	-0.40	7.00	100.0	2000.0	0.0	4	1	1
3	Bolt 1900 LLXT airgun	3.00	0.00	7.00	90.0	2000.0	0.0	0	1	1
5	Bolt 1900 LLXT airgun	5.00	0.00	7.00	60.0	2000.0	0.0	0	1	1
6	Bolt 1900 LLXT airgun	7.00	0.00	7.00	20.0	2000.0	0.0	0	1	1
7	Bolt 1900 LLXT airgun	9.00	0.00	7.00	40.0	2000.0	0.0	0	1	1
9	Bolt 1900 LLXT airgun	11.00	0.00	7.00	70.0	2000.0	0.0	0	1	1
11	Bolt 1900 LLXT airgun	14.00	0.40	7.00	250.0	2000.0	0.0	0	1	1
12	Bolt 1900 LLXT airgun	14.00	-0.40	7.00	250.0	2000.0	0.0	0	0	1

Subarray number : 3
Subarray name : 1220T__040_2000_SUB
Number of guns : 11
Subarray volume : 1370.0
Effective volume : 1220.0

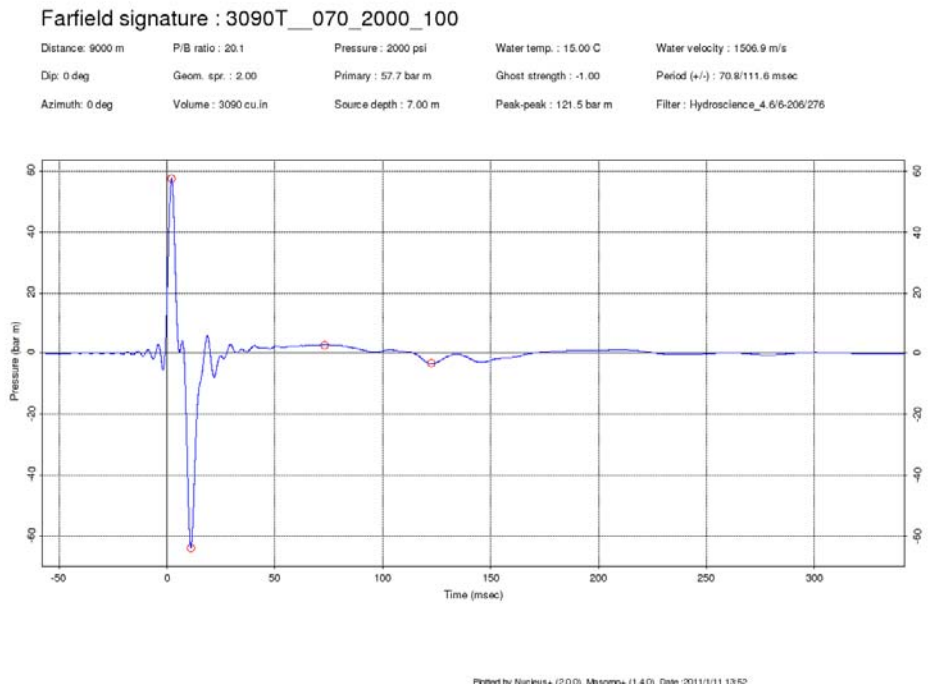
GUN	TYPE	X(m)	Y(m)	Z(m)	Volume	Pressure	Delay	CluNo	Activ	Group
1	Bolt 1900 LLXT airgun	0.00	-9.60	7.00	150.0	2000.0	0.0	5	1	1
2	Bolt 1900 LLXT airgun	0.00	-10.40	7.00	150.0	2000.0	0.0	5	1	1
3	Bolt 1900 LLXT airgun	3.00	-9.60	7.00	150.0	2000.0	0.0	0	1	1
4	Bolt 1900 LLXT airgun	3.00	-10.40	7.00	150.0	2000.0	0.0	0	0	1
5	Bolt 1900 LLXT airgun	5.00	-10.00	7.00	70.0	2000.0	0.0	0	1	1
6	Bolt 1900 LLXT airgun	7.00	-10.00	7.00	40.0	2000.0	0.0	0	1	1
7	Bolt 1900 LLXT airgun	9.00	-10.00	7.00	20.0	2000.0	0.0	0	1	1
9	Bolt 1900 LLXT airgun	11.00	-9.60	7.00	70.0	2000.0	0.0	6	1	1
10	Bolt 1900 LLXT airgun	11.00	-10.40	7.00	70.0	2000.0	0.0	6	1	1
11	Bolt 1900 LLXT airgun	14.00	-9.60	7.00	250.0	2000.0	0.0	7	1	1
12	Bolt 1900 LLXT airgun	14.00	-10.40	7.00	250.0	2000.0	0.0	7	1	1

Gun types used :

Bolt 1900 LLXT airgun

Units:

Coordinates : meter
Chamber volume : cubic inch
Chamber pressure : psi
Firing delay : ms



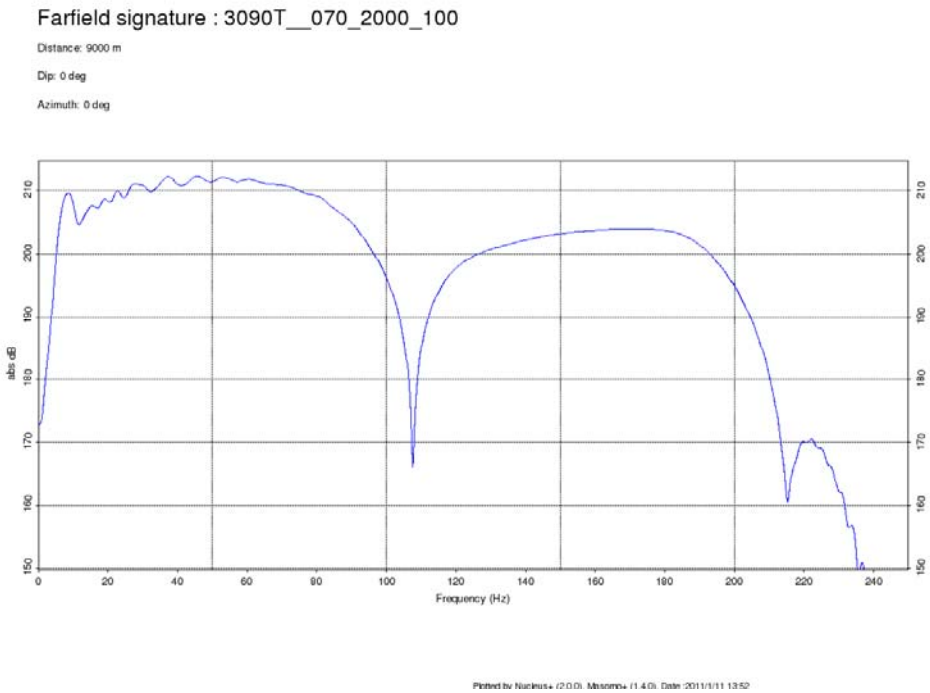
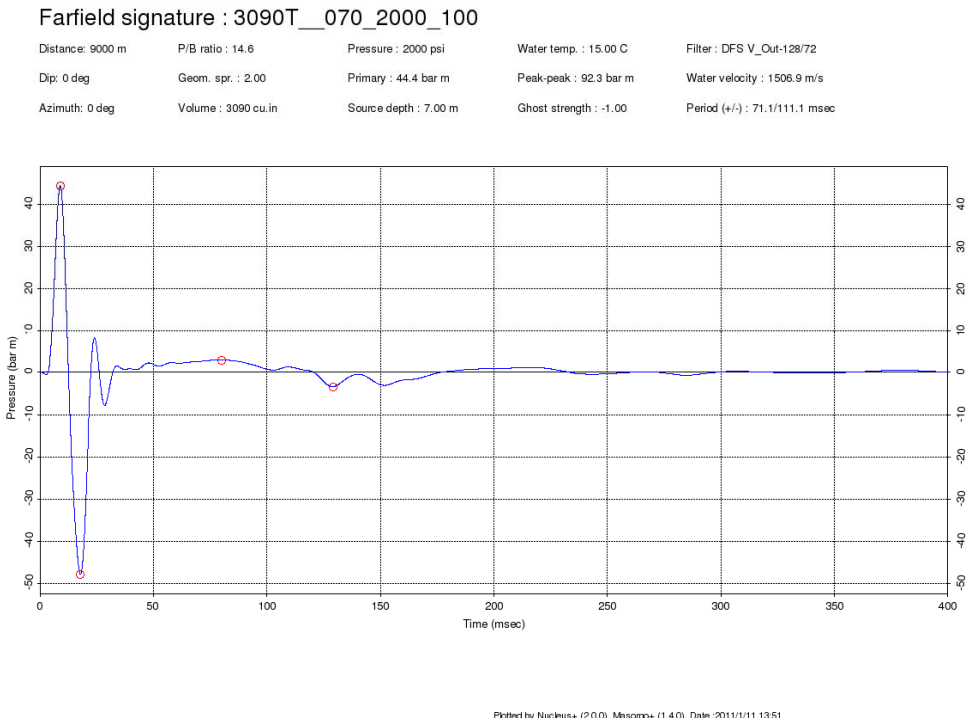


Figure 2: Modeled far-field signature and amplitude spectrum with Hydroscience recording filter (without receiver ghost).



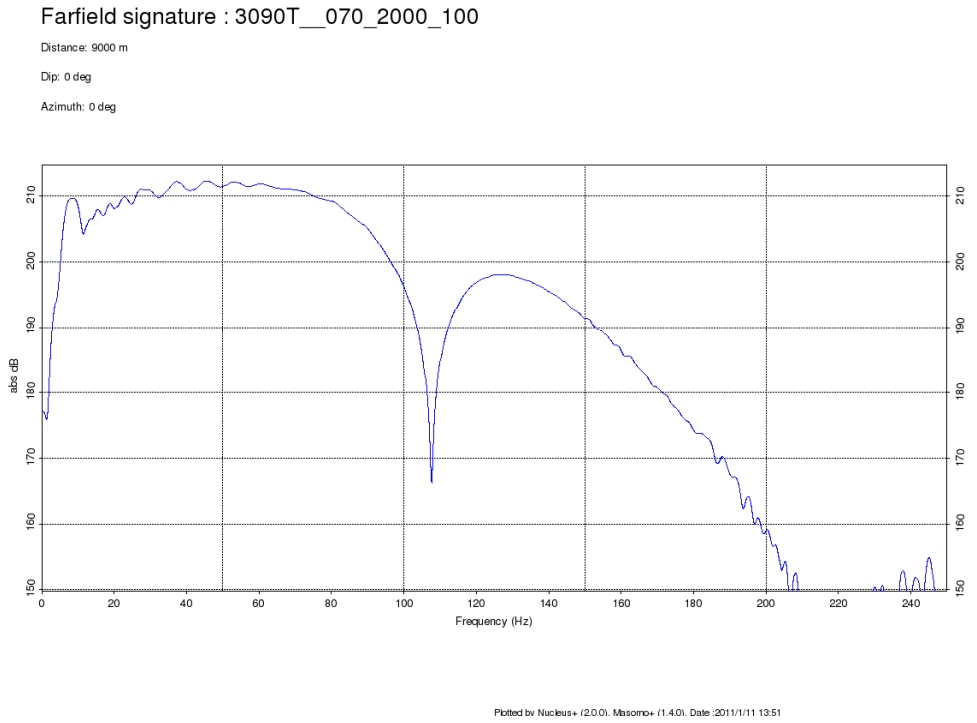
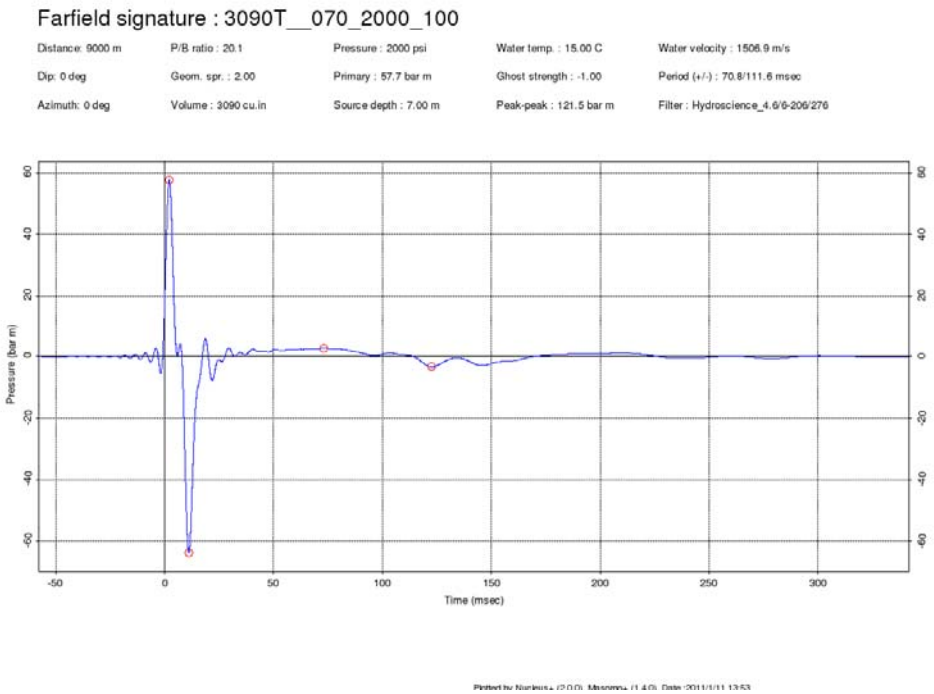


Figure 3: Modeled far-field signature and amplitude spectrum with DFS-V recording filter (without receiver ghost).

Full system response with source ghost only



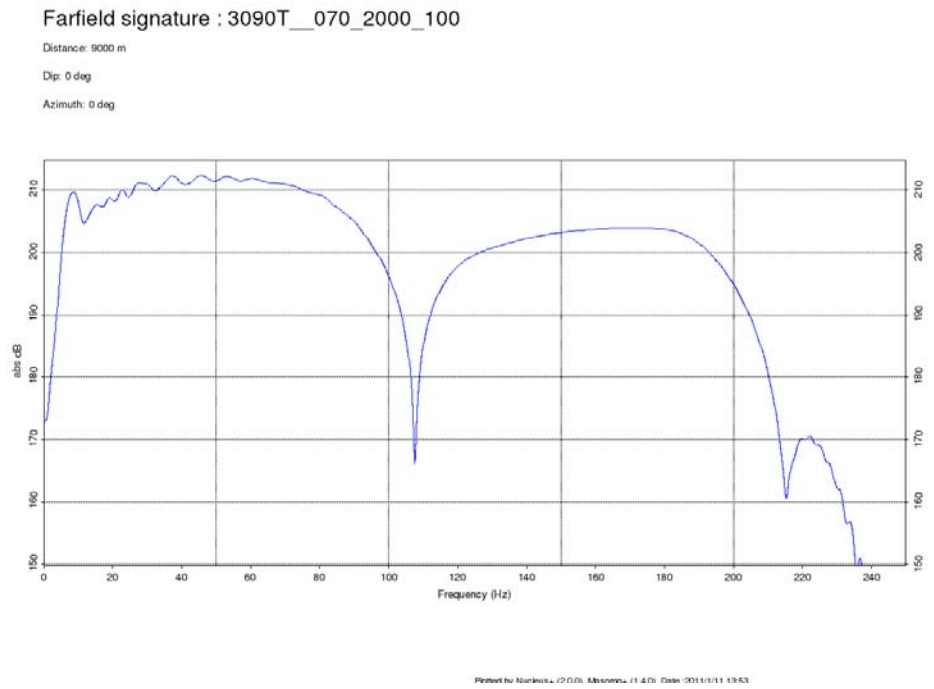


Figure 4: Modeled far-field signature and amplitude spectrum with full system response filter effect applied (without receiver ghost).

Full system response with source ghost only

FARFIELD SIGNATURE LISTING

Farfield signature was generated by Nucleus+ version 2.0.0
Farfield signature was generated by Marine source modelling version 1.4.0

Name of farfield dataset	:	3090T__070_2000_100
Source array name	:	3090T__070_2000_100
Total array volume (cu.in.)	:	3090.0
Source average depth (m)	:	7.0
Average pressure (psi)	:	2000.0
Ghost strength	:	-1.00
Primary amplitude (bar m)	:	57.72
Peak-peak amplitude (bar m)	:	121.51
Pulse/Bubble ratio	:	20.06
Bubble period (+) (ms)	:	70.75
Bubble period (-) (ms)	:	111.62
Geometrical spreading	:	2.00
Sea water temperature (C)	:	15.0
Sea water velocity (m/s)	:	1506.9
Filter parameters		
Filter type	:	Hydroscience_4.6/6-206/276
Low cut frequency (Hz)	:	4.6
High cut frequency (Hz)	:	206.0
Low cut slope (dB/oct)	:	6.0
High cut slope (dB/oct)	:	276.0
Start time (ms)	:	-58.0
Index of time zero	:	117
Sample interval (ms)	:	0.5
Farfield position		
Farfield distance (m)	:	9000.0
Dip angle (degrees)	:	0.0
Azimuth angle (degrees)	:	0.0

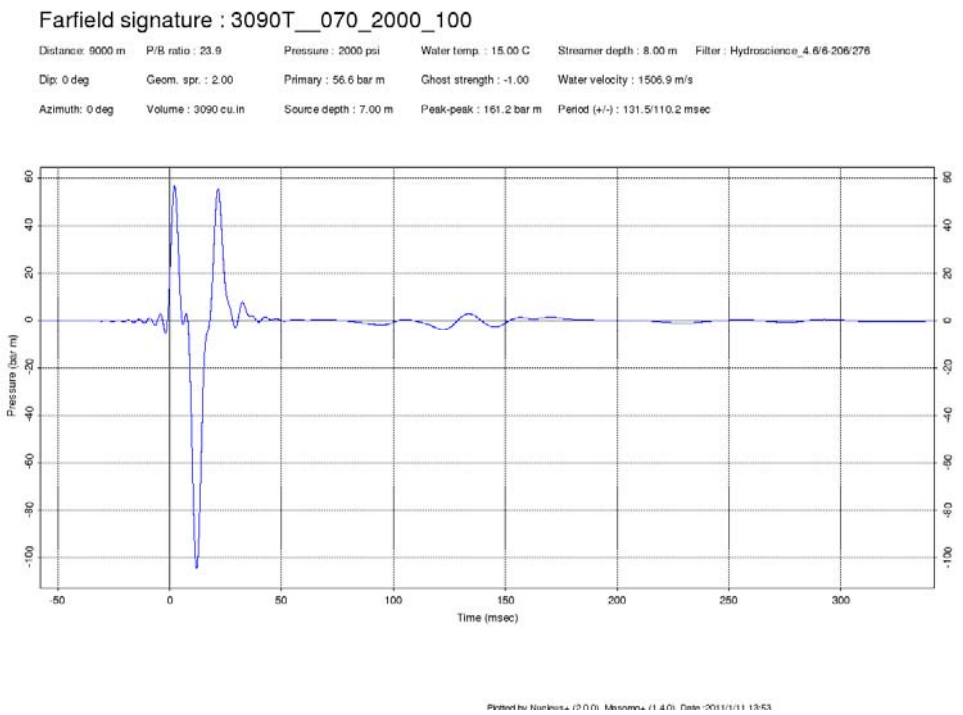
Amplitudes are in bar m
Time is increasing horizontally

-0.000	-0.002	-0.005	-0.010	-0.013	-0.017	-0.019
-0.021	-0.022	-0.023	-0.023	-0.023	-0.023	-0.023
-0.022	-0.022	-0.021	-0.021	-0.021	-0.021	-0.020
-0.018	-0.017	-0.016	-0.016	-0.015	-0.012	-0.008
-0.003	0.004	0.008	0.010	0.008	0.002	-0.006
-0.012	-0.013	-0.007	0.006	0.022	0.035	0.040
0.032	0.013	-0.010	-0.029	-0.035	-0.022	0.007
0.042	0.069	0.073	0.050	0.004	-0.047	-0.083
-0.084	-0.044	0.025	0.097	0.141	0.134	0.071
-0.028	-0.123	-0.172	-0.147	-0.048	0.088	0.207
0.252	0.194	0.044	-0.142	-0.285	-0.317	-0.210
0.006	0.245	0.405	0.404	0.224	-0.075	-0.372
-0.534	-0.471	-0.186	0.221	0.579	0.722	0.560
0.128	-0.410	-0.824	-0.908	-0.583	0.059	0.767
1.223	1.181	0.585	-0.377	-1.314	-1.781	-1.473
-0.383	1.127	2.417	2.799	1.835	-0.393	-3.162
-5.204	-5.030	-1.391	6.244	17.378	30.449	43.119
52.833	57.496	56.066	48.883	37.609	24.789	13.150
4.837	0.814	0.620	2.542	4.168	3.140	-2.101
-11.827	-24.913	-39.141	-51.822	-60.539	-63.785	-61.322
-54.162	-44.199	-33.626	-24.328	-17.426	-13.108	-10.757
-9.323	-7.765	-5.445	-2.318	1.107	4.008	5.591
5.397	3.477	0.378	-3.044	-5.900	-7.543	-7.738
-6.690	-4.924	-3.075	-1.670	-0.972	-0.935	-1.271
-1.591	-1.567	-1.047	-0.094	1.051	2.074	2.706
2.810	2.420	1.714	0.943	0.342	0.057	0.115
0.428	0.842	1.195	1.370	1.330	1.120	0.841
0.610	0.527	0.636	0.926	1.333	1.763	2.125
2.353	2.420	2.343	2.172	1.972	1.801	1.697
1.671	1.704	1.759	1.799	1.797	1.747	1.665
1.584	1.541	1.563	1.658	1.812	1.993	2.160
2.276	2.320	2.290	2.207	2.101	2.009	1.955
1.951	1.992	2.060	2.131	2.185	2.209	2.205
2.182	2.157	2.147	2.160	2.198	2.252	2.312
2.362	2.396	2.409	2.407	2.401	2.400	2.413
2.444	2.489	2.540	2.588	2.624	2.642	2.642
2.630	2.613	2.599	2.594	2.602	2.621	2.647
2.673	2.694	2.706	2.709	2.705	2.696	2.685
2.677	2.670	2.665	2.658	2.649	2.634	2.614
2.587	2.557	2.523	2.488	2.452	2.415	2.375
2.331	2.283	2.229	2.170	2.108	2.043	1.978
1.914	1.849	1.784	1.717	1.647	1.573	1.494
1.411	1.324	1.234	1.143	1.052	0.960	0.869
0.779	0.692	0.609	0.533	0.466	0.411	0.373
0.351	0.349	0.365	0.401	0.453	0.520	0.599
0.685	0.776	0.866	0.950	1.025	1.086	1.130
1.154	1.158	1.143	1.111	1.064	1.007	0.942
0.875	0.809	0.747	0.691	0.643	0.604	0.573
0.547	0.524	0.500	0.471	0.431	0.378	0.308
0.217	0.104	-0.032	-0.193	-0.379	-0.590	-0.825
-1.081	-1.354	-1.638	-1.926	-2.209	-2.477	-2.720
-2.930	-3.101	-3.228	-3.310	-3.345	-3.337	-3.289
-3.204	-3.088	-2.944	-2.778	-2.595	-2.399	-2.196
-1.990	-1.785	-1.585	-1.394	-1.215	-1.049	-0.899
-0.766	-0.650	-0.554	-0.476	-0.419	-0.381	-0.363
-0.365	-0.386	-0.427	-0.487	-0.566	-0.665	-0.784
-0.922	-1.076	-1.244	-1.422	-1.605	-1.790	-1.970
-2.141	-2.300	-2.445	-2.572	-2.681	-2.770	-2.838
-2.885	-2.909	-2.910	-2.888	-2.844	-2.779	-2.697

```
-2.600    -2.492    -2.380    -2.266    -2.156    -2.053    -1.959
-1.877    -1.806    -1.747    -1.698    -1.657    -1.624    -1.597
-1.574    -1.553    -1.534    -1.516    -1.497    -1.476    -1.451
-1.422    -1.387    -1.345    -1.296    -1.238    -1.173    -1.101
-1.024    -0.942    -0.857    -0.772    -0.686    -0.602    -0.520
-0.441    -0.365    -0.294    -0.226    -0.163    -0.103    -0.048
 0.004     0.052     0.096     0.138     0.177     0.214     0.249
 0.283     0.315     0.346     0.377     0.407     0.436     0.463
 0.489     0.513     0.535     0.556     0.574     0.591     0.608
 0.625     0.642     0.660     0.678     0.697     0.716     0.734
 0.751     0.767     0.781     0.794     0.806     0.817     0.827
 0.837     0.846     0.854     0.862     0.869     0.875     0.880
 0.883     0.885     0.886     0.887     0.887     0.887     0.887
 0.887     0.886     0.886     0.887     0.888     0.889     0.892
 0.896     0.901     0.907     0.916     0.925     0.936     0.947
 0.960     0.972     0.986     1.000     1.014     1.028     1.043
 1.058     1.072     1.085     1.098     1.109     1.119     1.128
 1.134     1.139     1.143     1.144     1.144     1.141     1.136
 1.129     1.120     1.109     1.095     1.079     1.062     1.043
 1.021     0.998     0.973     0.945     0.915     0.883     0.848
 0.811     0.773     0.732     0.690     0.646     0.600     0.553
 0.505     0.456     0.405     0.354     0.302     0.249     0.196
 0.144     0.091     0.039    -0.012    -0.062    -0.110    -0.157
-0.202    -0.243    -0.282    -0.317    -0.349    -0.377    -0.401
-0.422    -0.439    -0.453    -0.464    -0.472    -0.478    -0.482
-0.485    -0.486    -0.486    -0.486    -0.485    -0.483    -0.481
-0.478    -0.475    -0.471    -0.467    -0.462    -0.457    -0.451
-0.444    -0.436    -0.427    -0.417    -0.405    -0.391    -0.375
-0.358    -0.338    -0.317    -0.294    -0.270    -0.246    -0.222
-0.198    -0.174    -0.150    -0.128    -0.105    -0.084    -0.062
-0.042    -0.022    -0.003     0.015     0.031     0.046     0.060
 0.072     0.082     0.091     0.099     0.105     0.110     0.113
 0.115     0.114     0.112     0.108     0.101     0.093     0.082
 0.070     0.055     0.040     0.022     0.003    -0.018    -0.041
-0.065    -0.092    -0.121    -0.152    -0.184    -0.218    -0.254
-0.290    -0.326    -0.363    -0.398    -0.433    -0.466    -0.497
-0.527    -0.554    -0.578    -0.600    -0.618    -0.632    -0.643
-0.650    -0.652    -0.651    -0.645    -0.636    -0.623    -0.606
-0.586    -0.564    -0.538    -0.511    -0.482    -0.451    -0.419
-0.386    -0.353    -0.320    -0.287    -0.253    -0.220    -0.187
-0.155    -0.123    -0.092    -0.062    -0.033    -0.005     0.022
 0.047     0.072     0.095     0.116     0.137     0.155     0.172
 0.187     0.200     0.212     0.222     0.231     0.239     0.246
 0.252     0.256     0.259     0.260     0.259     0.257     0.253
 0.248     0.242     0.235     0.227     0.218     0.209     0.199
 0.188     0.177     0.165     0.153     0.141     0.129     0.117
 0.106     0.096     0.086     0.076     0.067     0.058     0.049
 0.041     0.033     0.025     0.018     0.011     0.006     0.001
-0.004    -0.008    -0.012    -0.017    -0.021    -0.026    -0.031
-0.036    -0.040    -0.045    -0.049    -0.054    -0.058    -0.063
-0.067    -0.072    -0.078    -0.083    -0.089    -0.095    -0.101
-0.107    -0.113    -0.120    -0.126    -0.132    -0.138    -0.145
-0.151    -0.156    -0.161    -0.166    -0.170    -0.173    -0.176
-0.178    -0.180    -0.182    -0.183    -0.184    -0.184    -0.184
-0.183    -0.182    -0.180    -0.177    -0.174    -0.171    -0.167
-0.162    -0.157    -0.152
```

Figure 5: Far-field signature listing with 2 ms sampling interval (without receiver ghost).

Full system response with source and receiver ghost



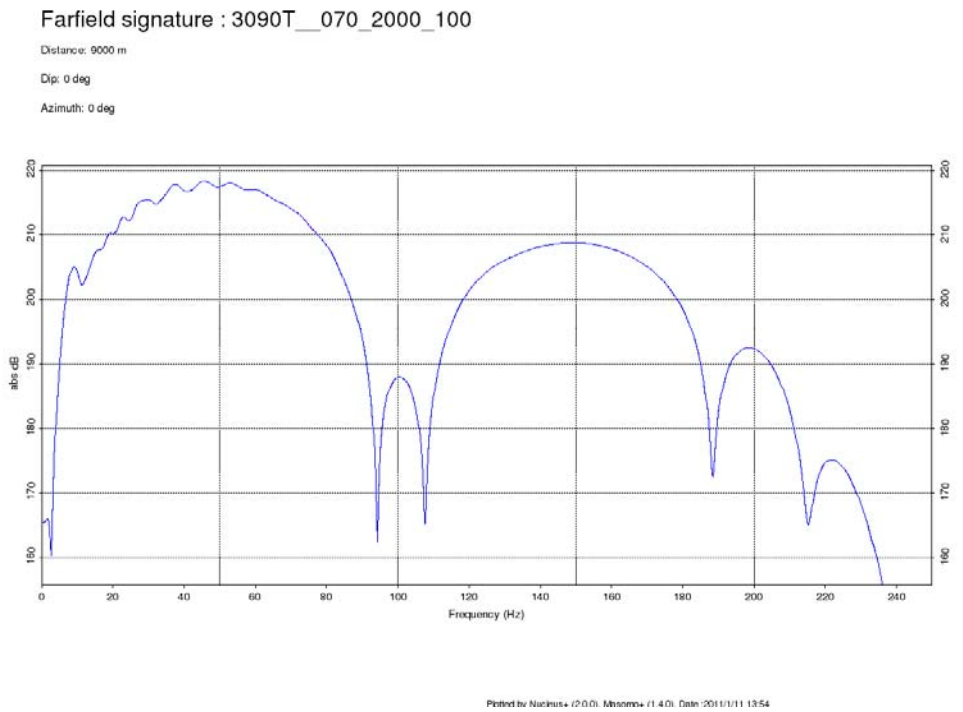


Figure 6: Modeled far-field signature and amplitude spectrum with recording and hydrophone filter effect applied (with receiver ghost).

Full system response with source and receiver ghost

FARFIELD SIGNATURE LISTING

Farfield signature was generated by Nucleus+ version 2.0.0

Farfield signature was generated by Marine source modelling version 1.4.0

Name of farfield dataset	:	3090T__070_2000_100
Source array name	:	3090T__070_2000_100
Total array volume (cu.in.)	:	3090.0
Source average depth (m)	:	7.0
Streamer depth (m)	:	8.0
Streamer group length (m)	:	12.5
Average pressure (psi)	:	2000.0
Ghost strength	:	-1.00
Primary amplitude (bar m)	:	56.60
Peak-peak amplitude (bar m)	:	161.21
Pulse/Bubble ratio	:	23.90
Bubble period (+) (ms)	:	131.50
Bubble period (-) (ms)	:	110.25
Geometrical spreading	:	2.00
Sea water temperature (C)	:	15.0
Sea water velocity (m/s)	:	1506.9
Filter parameters		
Filter type	:	Hydroscience_4.6/6-206/276
Low cut frequency (Hz)	:	4.6
High cut frequency (Hz)	:	206.0
Low cut slope (dB/oct)	:	6.0
High cut slope (dB/oct)	:	276.0
Start time (ms)	:	-58.0
Index of time zero	:	117
Sample interval (ms)	:	0.5
Farfield position		
Farfield distance (m)	:	9000.0
Dip angle (degrees)	:	0.0
Azimuth angle (degrees)	:	0.0

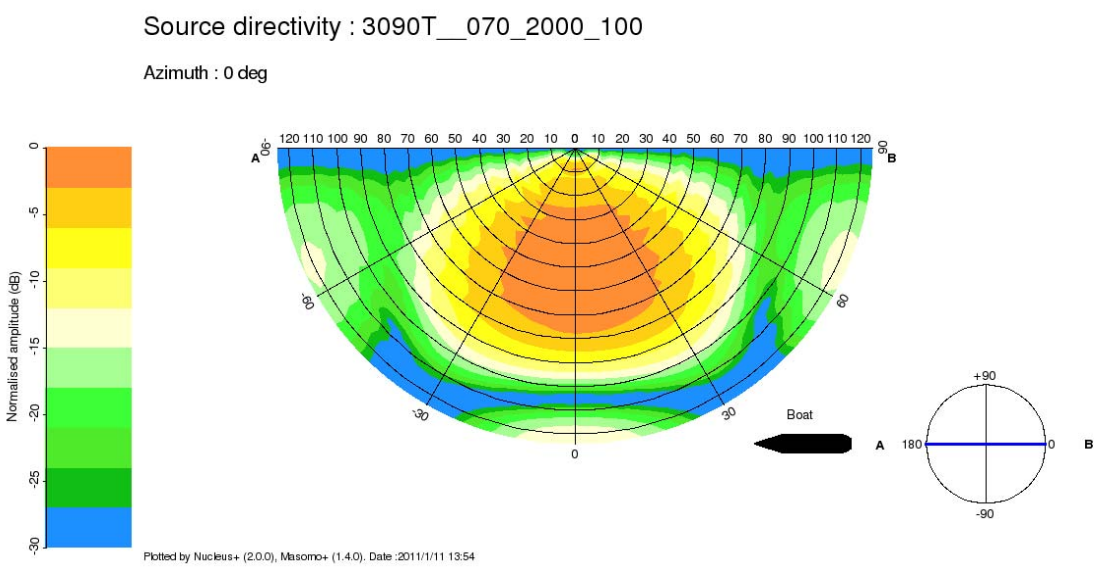
Amplitudes are in bar m

Time is increasing horizontally

-0.000	-0.002	-0.005	-0.010	-0.013	-0.017	-0.019
-0.021	-0.022	-0.023	-0.023	-0.023	-0.023	-0.023
-0.022	-0.022	-0.021	-0.021	-0.021	-0.021	-0.020
-0.018	-0.016	-0.012	-0.007	-0.002	0.003	0.010
0.018	0.025	0.031	0.033	0.031	0.025	0.017
0.010	0.008	0.014	0.027	0.043	0.056	0.060
0.051	0.031	0.006	-0.013	-0.020	-0.009	0.016
0.046	0.067	0.066	0.040	-0.004	-0.050	-0.078
-0.073	-0.031	0.033	0.094	0.123	0.102	0.033
-0.061	-0.141	-0.167	-0.122	-0.015	0.113	0.207
0.218	0.131	-0.028	-0.197	-0.300	-0.282	-0.135
0.089	0.299	0.397	0.324	0.094	-0.210	-0.458
-0.529	-0.371	-0.026	0.373	0.650	0.666	0.381
-0.112	-0.617	-0.902	-0.811	-0.332	0.368	1.001
1.268	0.993	0.219	-0.779	-1.579	-1.777	-1.172
0.111	1.611	2.669	2.675	1.342	-1.079	-3.757
-5.433	-4.748	-0.670	7.124	18.028	30.531	42.510
51.712	56.303	55.343	49.038	38.708	26.467	14.702
5.483	0.049	-1.488	-0.163	2.107	3.007	0.405
-7.107	-19.840	-36.881	-56.241	-75.249	-91.090	-101.373
-104.612	-100.499	-89.939	-74.829	-57.637	-40.884	-26.635
-16.116	-9.529	-6.111	-4.404	-2.672	0.628	6.449
14.906	25.256	36.091	45.693	52.474	55.363	54.057
49.066	41.548	32.987	24.810	18.053	13.170	10.023
8.054	6.552	4.936	2.958	0.754	-1.242	-2.502
-2.624	-1.504	0.605	3.174	5.557	7.198	7.793
7.354	6.175	4.701	3.369	2.465	2.062	2.030
2.123	2.097	1.804	1.245	0.553	-0.067	-0.427
-0.428	-0.088	0.465	1.049	1.489	1.677	1.597
1.318	0.961	0.650	0.474	0.460	0.579	0.760
0.920	0.995	0.953	0.801	0.578	0.335	0.125
-0.018	-0.080	-0.067	-0.002	0.086	0.171	0.236
0.276	0.299	0.317	0.345	0.390	0.454	0.524
0.582	0.609	0.592	0.528	0.425	0.305	0.195
0.118	0.090	0.116	0.185	0.278	0.373	0.449
0.495	0.510	0.500	0.478	0.456	0.442	0.440
0.446	0.453	0.453	0.441	0.417	0.386	0.353
0.327	0.310	0.305	0.306	0.307	0.300	0.280
0.244	0.196	0.141	0.086	0.038	0.001	-0.024
-0.041	-0.055	-0.074	-0.103	-0.144	-0.197	-0.261
-0.330	-0.401	-0.470	-0.534	-0.594	-0.650	-0.705
-0.760	-0.817	-0.877	-0.938	-0.999	-1.060	-1.120
-1.178	-1.236	-1.292	-1.349	-1.405	-1.459	-1.511
-1.558	-1.598	-1.629	-1.647	-1.653	-1.643	-1.618
-1.574	-1.513	-1.431	-1.329	-1.208	-1.068	-0.911
-0.743	-0.566	-0.387	-0.212	-0.046	0.106	0.241
0.355	0.447	0.516	0.562	0.584	0.583	0.561
0.520	0.460	0.386	0.299	0.204	0.101	-0.006
-0.116	-0.229	-0.343	-0.458	-0.574	-0.691	-0.809
-0.929	-1.051	-1.177	-1.310	-1.453	-1.609	-1.781
-1.970	-2.177	-2.398	-2.629	-2.862	-3.089	-3.299
-3.482	-3.630	-3.733	-3.786	-3.785	-3.727	-3.613
-3.443	-3.219	-2.945	-2.624	-2.261	-1.860	-1.428
-0.971	-0.498	-0.017	0.460	0.923	1.359	1.758
2.109	2.405	2.639	2.808	2.912	2.952	2.931
2.853	2.723	2.546	2.326	2.068	1.776	1.456
1.113	0.754	0.386	0.015	-0.350	-0.703	-1.036

```
-1.345    -1.624    -1.869    -2.078    -2.249    -2.381    -2.471
-2.521    -2.529    -2.494    -2.417    -2.298    -2.139    -1.942
-1.712    -1.455    -1.178    -0.889    -0.597    -0.310    -0.036
 0.220     0.452     0.659     0.840     0.993     1.120     1.220
 1.295     1.345     1.370     1.372     1.353     1.314     1.260
 1.196     1.126     1.057     0.993     0.940     0.900     0.877
 0.869     0.878     0.900     0.934     0.978     1.028     1.081
 1.136     1.190     1.243     1.292     1.336     1.375     1.406
 1.430     1.445     1.449     1.443     1.427     1.400     1.365
 1.323     1.275     1.222     1.168     1.112     1.056     1.001
 0.948     0.896     0.845     0.797     0.751     0.709     0.669
 0.633     0.602     0.574     0.550     0.529     0.511     0.493
 0.477     0.460     0.443     0.425     0.407     0.389     0.371
 0.355     0.339     0.325     0.313     0.301     0.289     0.276
 0.263     0.248     0.232     0.214     0.196     0.177     0.159
 0.141     0.125     0.110     0.097     0.086     0.076     0.069
 0.063     0.059     0.056     0.057     0.059     0.063     0.070
 0.079     0.089     0.101     0.114     0.128     0.143     0.158
 0.172     0.187     0.200     0.213     0.223     0.232     0.238
 0.241     0.242     0.239     0.232     0.223     0.210     0.194
 0.174     0.152     0.128     0.100     0.071     0.039     0.005
-0.031    -0.068    -0.107    -0.148    -0.189    -0.232    -0.275
-0.319    -0.364    -0.408    -0.452    -0.496    -0.539    -0.582
-0.624    -0.665    -0.704    -0.743    -0.780    -0.815    -0.849
-0.881    -0.911    -0.938    -0.962    -0.982    -0.999    -1.012
-1.020    -1.024    -1.022    -1.016    -1.004    -0.987    -0.965
-0.937    -0.905    -0.869    -0.829    -0.785    -0.739    -0.691
-0.641    -0.590    -0.538    -0.486    -0.435    -0.384    -0.335
-0.287    -0.242    -0.199    -0.159    -0.121    -0.087    -0.056
-0.028    -0.002     0.021     0.043     0.064     0.085     0.105
 0.126     0.147     0.169     0.191     0.213     0.236     0.258
 0.280     0.301     0.321     0.340     0.357     0.374     0.389
 0.403     0.415     0.426     0.433     0.438     0.440     0.438
 0.433     0.424     0.412     0.398     0.380     0.361     0.340
 0.318     0.293     0.268     0.240     0.212     0.181     0.149
 0.116     0.082     0.047     0.012    -0.024    -0.061    -0.097
-0.134    -0.171    -0.210    -0.248    -0.287    -0.327    -0.366
-0.404    -0.440    -0.475    -0.507    -0.535    -0.560    -0.582
-0.599    -0.613    -0.622    -0.626    -0.625    -0.620    -0.608
-0.590    -0.567    -0.537    -0.501    -0.460    -0.413    -0.361
-0.305    -0.246    -0.185    -0.122    -0.058     0.006     0.070
 0.132     0.193     0.251     0.307     0.359     0.408     0.452
 0.492     0.527     0.558     0.583     0.604     0.620     0.631
 0.637     0.639     0.638     0.633     0.624     0.612     0.597
 0.580     0.560     0.539     0.516     0.492     0.467     0.441
 0.414     0.386     0.358     0.329     0.299     0.269     0.238
 0.207     0.176     0.146     0.116     0.086     0.058     0.031
 0.005    -0.020    -0.044    -0.066    -0.088    -0.108    -0.127
-0.144    -0.159    -0.172    -0.183    -0.192    -0.199    -0.205
-0.208    -0.210    -0.211    -0.210    -0.208    -0.205    -0.200
-0.194    -0.187    -0.180    -0.172    -0.164    -0.157    -0.150
-0.144    -0.138    -0.133    -0.128    -0.123    -0.118    -0.114
-0.110    -0.107    -0.104    -0.103    -0.102    -0.102    -0.103
-0.105    -0.106    -0.108    -0.110    -0.112    -0.114    -0.115
-0.116    -0.117    -0.118    -0.118    -0.117    -0.116    -0.114
-0.112    -0.109    -0.105    -0.101    -0.096    -0.090    -0.084
-0.078    -0.070    -0.062    -0.053    -0.044    -0.034    -0.024
-0.013    -0.003     0.008
```

Figure 7: Far-field signature listing with 2 ms sampling interval (with receiver ghost).



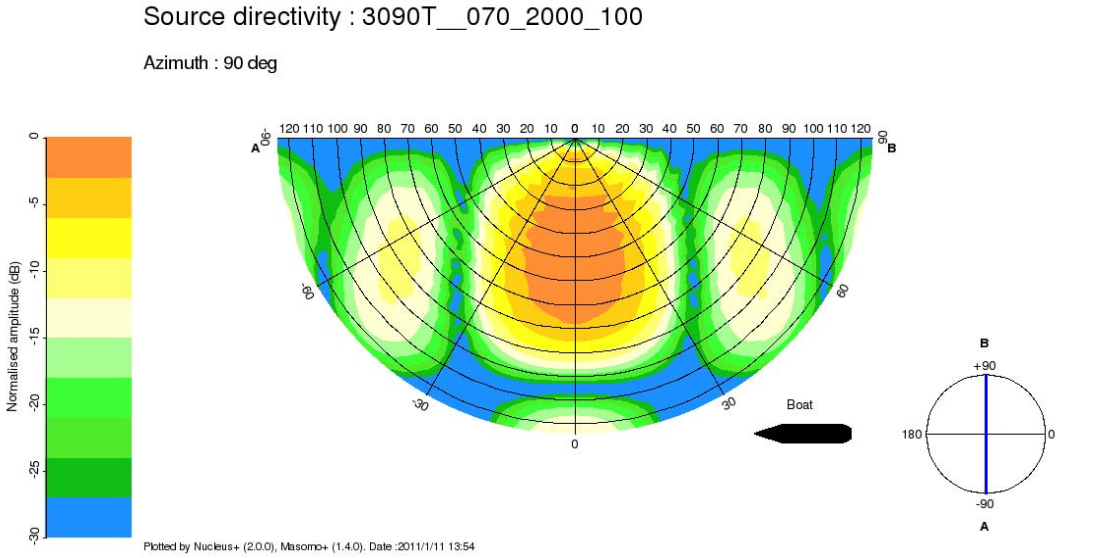


Figure 8: Directivity plot for constant azimuth of 0° and 90°.

12.3 SEG-D header

Example SEG-D Header:

```
------------------------------------------------------------------------------
GENERAL HEADER #1                       Starting byte 0
Bytes     Description                   Value
------------------------------------------------------------------------------
01-02     File Number                   1000
03-04     SEGD Format                   8036
          Bits Per Sample               24
05-10     General Constants
11        Year                          2011
12        Additional Header Blocks      2
12-13     Day                           41
14        Hour                          11
15        Minute                        34
16        Second                        26
17        Manufacturer's Code           41
18-19     Manufacturer's Serial Number  17
20-22     Not Used
23        Base Scan Interval (ms)       2.0
24        Polarity
25        Scan/Block Exponent
26        Record Type                   Normal Record
27        Record Length (ms)            0xfff - In General Header 2
28        Scan-types / Record           1
29        Channel Sets/Scan Type        13
30        Skew Blocks                   0
31        Extended-Header Blocks        0xFF
32        External-Header Blocks        0xFF
------------------------------------------------------------------------------
GENERAL HEADER #2                       Starting byte 32
Bytes     Description                   Value
------------------------------------------------------------------------------
01-03     Expanded File Number          0
04-05     Extended Channel Sets         0
06-07     Extended Header Blocks        1649
08-09     External Header Blocks        206
10        Reserved
11-12     SEG-D Revision Number         Rev. 2.1
13-14     General Trailer
15-17     Extended Record Length        6144
18-19     General Header Block Number   2
20        Reserved
21-22     Sequence Number               4
32       Extended Record Length       60
                                                                    ------------
REEL NUMBER HEADER                      Starting Byte 704
Bytes     Description                   Value
------------------------------------------------------------------------------
01-02     Shot Time: Day                41
03        Shot Time: Hour               11
04        Shot Time: Minute             34
05        Shot Time: Second             26
06-08     Shot Time: Microseconds       0
09        Acquisition Hardware          Seatrak System
10-12     Not Used
13        External Header 1             Nav & GCS90 Combined
14        External Header 2             Digicourse Header
15        External Header 3             Not Defined
16        External Header 4             Not Defined
17-32     Reel Number
```

```
-------------------------------------------------------------------------------
CLIENT NAME               Starting Byte 736
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-32     Client Name                 ORIGIN ENERGY
-------------------------------------------------------------------------------
CONTRACTOR NAME           Starting Byte 768
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-32     Contractor Name             PGS GEOPHYSICAL


-------------------------------------------------------------------------------
SURVEY NAME               Starting Byte 800
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-32     Survey Name                 BELLERIVE 3D SEISMIC SURVEY
-------------------------------------------------------------------------------
PROJECT CODE              Starting Byte 832
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-16     Project Code                2010184
17-18     Line Type                   Off Line
19-24     Swath Number                00.00
25-32     Sequence Number             4
-------------------------------------------------------------------------------
NAVIGATION HEADER #1                  Starting Byte 0
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-02     Master Block ID             $1
03-06     Length of Message           1808
07-10     Program Revision            0003
11-12     Shot Switch                 On-Line
13-26     Shot Time                   113426.08688520110210
34-36     Time Reference              UTC
37-42     Shot Number                 001774
43-58     Current Line Name           OEOBE111420P1004
59-69     Master Latitude              -39.698869
70-80     Master Longitude             143.128951
81-86     Water Depth (meters)         168.8
87-97     Source Latitude              -39.693740
98-108    Source Longitude             143.125200
109-113   Master Gyro (degrees)       148.1
114-118   Master CMG (degrees)        151.0
119-122   Master Speed (knots)         4.9
123-125   Source Vessel Id            001
126-130   Atmospheric Pressure        1010

-------------------------------------------------------------------------------
GCS90 GUN-CONTROLLER HEADER #1        Starting Byte 53405
Bytes     Description                 Value
-------------------------------------------------------------------------------
01-06     ID String                   *GCS90
07-10     Length of Block             1682
11-16     Line Number                 0P1004
17-20     Shot Number                 1774
21-22     Active Array Mask           38
23        Trigger Mode                External
24-25     Current Sequence Number     02
26-28     Number of Sub-Arrays        006
29-31     Number of Guns in Array     072
32-34     Number of Active Guns       028
35-37     Number of Delta-Errors      000
```

38-40	Number of Auto-Fires	000
41-43	Number of Mis-Fires	000
44-46	Delta Spread	003
47-52	Volume Fired	003090
53-66	Spare	
67-70	Manifold Pressure	0000
71-74	Deep Tow	0000
75-78	Sub-Array String Pressure	2025
79-82	Sub-Array String Pressure	2016
83-86	Sub-Array String Pressure	2005
87-90	Sub-Array String Pressure	2008
91-94	Sub-Array String Pressure	2015
95-98	Sub-Array String Pressure	2022

12.4 SEG-Y HEADER

Example Viper QC SEG-Y EBCDIC Header:

```
C 1 CLIENT:ORIGIN ENERGY COMPANY:PGS GEOPHYSICAL MARINE ACQUISITION
C 2 VESSEL:MV RAMFORM STERLING AREA:BELLERIVE 3D PGS PROJECT NO:2010184
C 3 LINE:OEOBE111684P1001 DATE SHOT:040 11:35:12 2011  SPS:1000-2895 DIR:331.00
C 4 ====================ACQUISITION & RECORDING PARAMETERS====================
C 5 ACQUISITION SYSTEM: Seatrak  RECORDING DELAY: 58.0ms
C 6 RECORDING FORMAT: SEGD REV 2.1-8036  TRCS/RECORD: 4896 AUX TRCS/RECORD: 0048
C 7 RECORD LENGTH: 6144ms  SAMPLE INTERVAL: 2.0000ms  SAMPLES/TRACE: 3072
C 8 FILTERS: LO 4.60Hz/6.00dB/OCT HI 206.0Hz/276.0dB/OCT SRC TYPE: Bolt
C 9 VOLUME: 3090.0cu in  SHOT INT: 18.75m (FLIP/FLOP)  PRESSURE: 2000.0 psi
C10 DEPTH: 7.0m SEPN: 50.0m  NBR OF ARRAYS: 02  ACTIVE SRC : 1=STBD, 2=PORT
C11 NBR OF STRS: 12  NBR OF GROUPS: 0408  GROUP INTERVAL: 12.50m  NBR COMP: 1
C12 STR SEPARATION: 100.0m  STR DEPTH: 8.0m  STR LENGTH: 5100.0m  CDP/SHOT: 3/1
C13 CDP FOLD: 68 INLINE OFFSET: 130m  POLARITY: COMPRESSION=NEGATIVE VALUE
C14 NAV SYSTEM:Orca Version 1.8.1  DGPS1:Skyfix XP DGPS2:Starfix HP
C15 ==========================PROCESSING PARAMETERS=========================
C16 PROCESSED BY PGS GEOPHYSICAL USING VIPER V.5.0-2 ONBOARD RAMFORM STERLING
C17 01. REFORMAT FROM SEGD TO VIPER INTERNAL FORMAT/WITH SKEW CORRECTION APPLIED
C18 02. RECORDING DELAY OF -58.0ms *NOT* REMOVED (DATA NEED TO BE SHIFTED UP)
C19 03. BAD CH/SHOT EDITS FLAG trid=2, REVERSED CH FLAG trid=-1, SEIS/NAV MERGE
C20 04. OUTPUT TO 32-BIT SEGY REV. 0 FORMAT (TIME DOMAIN) TO 3592 TAPE
C21 ALL DEPTHS ARE RAW WITH NO CORRECTIONS AS P190 NAVIGATION DATA
C22 ALL CO-ORDINATES & ELEVATIONS IN DECIMETRES, ALL TRACE VALUES IN MILLIVOLTS
C23 AUXILIARY TRACES NOT INCLUDED IN SEGY TAPES
C24 TRACE HEADER BYTE POSITIONS 1-196 ACCORDING TO SEGY FORMAT REV. 1
C25 NON STANDARD SEGY HEADER BYTE POSITIONS:  DESCRIPTION/LOCATION/FORMAT/LENGTH
C26 ACQSEQNO, 197, I2; SVID, 199, I2; CABLE, 201, I2; GRND_STA, 203, I2;
C27 SENSOR, 205, I2; ARR_FIRE, 207, I2; ARRVOL, 209, I2; DROPOUT1, 211, I2;
C28 W_DEPTH,213, I4; VCMG,217, I2; AZIMUTH,219, F4; VSPEED,223, F4; SPID,227, I2
C29 ===============GEODETIC REFERENCE & PROC. GRID DEFINITION==================
C30 SURVEY DATUM: GDA94  ELLIPSOID: GRS80
C31 SEMIMAJOR AXIS: 6378137m  PROJECTION: Transverse Mercator
C32 SCALE FACTOR: 0.9996  CENTRAL MERIDIAN: 147 deg E
C33 LAT. OF ORIGIN: 0 deg N  FALSE NORTHING: 10000000m  FALSE EASTING: 500000m
C34 GRID ORIGIN:   X: 679447.4  Y: 5577297.5  XL: 1776  SL: 808
C35 CORNER 2:      X: 656113.9  Y: 5619566.0  XL: 9501 SL: 808
C36 CORNER 3:      X: 679751.4  Y: 5632614.6  XL: 9501 SL: 1888
C37 CORNER 4:      X: 703084.9  Y: 5590346.1  XL: 1776 SL: 1888
C38 SL NUMBER INCREMENT: 1  XL NUMBER INCREMENT: 1
C39 SL BIN SIZE: 25m  XL BIN SIZE: 6.25m  AZIMUTH: 331.10deg
C40 END EBCDIC
```

12.5 P1/90 Header

```
H0100 SURVEY AREA               BLOCK T30P TASMANIA, OTWAY BASIN, AUSTRALIA
H0101 GENERAL SURVEY DETAILS    ONE VESSEL, DUAL SOURCE, 12 STREAMERS
H0102 VESSEL DETAILS            M/V RAMFORM STERLING       1
H0103 SOURCE DETAILS            STERLING STBD SOURCE       1   1
H0103 SOURCE DETAILS            STERLING PORT SOURCE       1   2
H0104 STREAMER DETAILS          STREAMER  1 408CH (STBD)   1       1   1
H0104 STREAMER DETAILS          STREAMER  2 408CH          1       2   2
H0104 STREAMER DETAILS          STREAMER  3 408CH          1       3   3
H0104 STREAMER DETAILS          STREAMER  4 408CH          1       4   4
H0104 STREAMER DETAILS          STREAMER  5 408CH          1       5   5
H0104 STREAMER DETAILS          STREAMER  6 408CH          1       6   6
H0104 STREAMER DETAILS          STREAMER  7 408CH          1       7   7
H0104 STREAMER DETAILS          STREAMER  8 408CH          1       8   8
H0104 STREAMER DETAILS          STREAMER  9 408CH          1       9   9
H0104 STREAMER DETAILS          STREAMER 10 408CH          1       A   A
H0104 STREAMER DETAILS          STREAMER 11 408CH          1       B   B
H0104 STREAMER DETAILS          STREAMER 12 408CH (PORT)   1       C   C
H0105 OTHER DETAILS             N/A
H0200 DATE OF SURVEY            07 FEBUARY 2011  - CONTINUING
H0201 DATE OF ISSUE OF TAPE     DD MMMMMM YYYY
H0202 TAPE VERSION IDENTIFIER   OEOBE11P011
H0203 LINE PREFIX               OEOBE11
H0300 CLIENT                    ORIGIN ENERGY
H0400 GEOPHYSICAL CONTRACTOR    PGS GEOPHYSICAL, MARINE ACQUISITION
H0500 POSITIONING CONTRACTOR    FUGRO SURVEY AS
H0600 POSITIONING PROCESSING    PGS GEOPHYSICAL, MARINE ACQUISITION
H0700 POSITIONING SYSTEM        NAV SYSTEM 1: SKYFIX.XP
H0700 POSITIONING SYSTEM        NAV SYSTEM 2: STARFIX.HP
H0700 POSITIONING SYSTEM        INTEGRATED NAV SYSTEM: ORCA VERSION 1.8.1
H0800 COORDINATE LOCATION       CENTER OF SOURCE
H0900 OFFSET SYS TO NAV REF PT     1   2    0.00    0.00
H0901 OFFSET SYSTEM TO SOURCE 1    1   2  -25.00 -650.00
H0902 OFFSET SYSTEM TO SOURCE 2    1   2  -25.00 -650.00
H0903 OFFSET SYSTEM TO E/S    2    1   2    0.33   44.51
H1000 CLOCK TIME                GMT
H1100 RECEIVER GROUPS PER SHOT  4896
H1400 GEODETIC DATUM AS SURVEY  GDA94       GRS1980      6378137.000 298.2572221
H1401 DATUM SHIFT TO WGS84        -0.0   0.0   0.2 0.020 0.017 0.021-0.0017480
H1500 GEODETIC DATUM POSTPROC.  GDA94       GRS1980      6378137.000 298.2572221
H1501 DATUM SHIFT TO WGS84        -0.0   0.0   0.2 0.020 0.017 0.021-0.0017480
H1600 DATUM SHIFT H1400 - H1500    0.0   0.0   0.0 0.000 0.000 0.000 0.0000000
H1700 VERTICAL DATUM            ES                      ECHO SOUNDER POSITION
H1800 PROJECTION                002 UTM SOUTH
H1900 ZONE                      54S
H2000 GRID UNITS                1 INTERNATIONAL METERS    1.000000000000
H2001 HEIGHT UNITS              1 INTERNATIONAL METERS    1.000000000000
H2200 CENTRAL MERIDIAN          141 0 0.000E
H2600*********************************************************************
H2600 DATUM TRANSFORMATION VALUES USED (GDA94 TO WGS84) ARE BASED ON THE
H2600 GEOSCIENCE AUSTRALIA DOCUMENT I.T.R.F. TO GDA94 COORDINATE TRANSFORMATION
H2600 BY DAWSON AND STEED (2004)
H2600
H2600 EPSG CRS CODE             28354
H2600 NOMINAL GUN DEPTH         7 METERS
H2600*********************************************************************
H2600 THE Z OFFSET OF THE RAMFORM STERLING'S ECHO SOUNDER TRANSDUCER IS -7.4 m
H2600 FROM THE VESSEL REFERENCE POINT AT SEA LEVEL.
H2600
H2600 TRANSDUCER DEPTH CORRECTIONS, TIDE OR SOUND VELOCITY, WERE NOT APPLIED TO
H2600 WATER DEPTHS.
H2600
```

```
H2600 THE SOUND VELOCITY SET IN THE ECHO SOUNDER WAS 1500 METERS/SECOND.
H2600
H2600 THE ECHO SOUNDER DEPTH DATA HAS BEEN CORRECTED FOR HEAVE IN THE ECHO
H2600 SOUNDER PRIOR TO BEING PASSED TO THE INTEGRATED NAVIGATION SYSTEM.
H2600
H2600*************************************************************************
H2600             FORMAT OF SHOT RECORDS
H2600      COLUMN           DESCRIPTION
H2600           1           'V', 'E', 'Z', 'S' OR 'T'
H2600                       V=VESSEL REFERENCE POINT
H2600                       E=ECHOSOUNDER POSITION
H2600                       Z=INDIVIDUAL SOURCE POSITON
H2600                       S=CENTER OF SOURCE
H2600                       T=TAILBUOY POSITION
H2600         2-13          LINE NAME
H2600           17          VESSEL IDENTIFIER
H2600           18          SOURCE IDENTIFIER
H2600           19          TAILBUOY/OTHER IDENTIFIER
H2600        20-25          SHOT POINT NUMBER
H2600        26-35          LATITUDE (DDMMSS.SS)
H2600        36-46          LONGITUDE (DDDMMSS.SS)
H2600        47-55          MAP GRID EASTING IN METERS
H2600        56-64          MAP GRID NORTHING IN METERS
H2600        65-70          WATER/GUN DEPTH
H2600        71-73          JULIAN DAY
H2600        74-79          TIME HHMMSS
H2600
H2600             FORMAT OF RECEIVER RECORD
H2600            1            'R'
H2600          2-5            RECEIVER NUMBER
H2600         6-14            MAP GRID EASTING IN METERS
H2600        15-23            MAP GRID NORTHING IN METERS
H2600        24-27            RECEIVER DEPTH REFERENCED TO SEA LEVEL
H2600        28-31            RECEIVER NUMBER
H2600        32-40            MAP GRID EASTING IN METERS
H2600        41-49            MAP GRID NORTHING IN METERS
H2600        50-53            RECEIVER DEPTH REFERENCED TO SEA LEVEL
H2600        54-57            RECEIVER NUMBER
H2600        58-66            MAP GRID EASTING IN METERS
H2600        67-75            MAP GRID NORTHING IN METERS
H2600        76-79            RECEIVER DEPTH REFERENCED TO SEA LEVEL
H2600           80            STREAMER CODE
H2600*************************************************************************
H2600 STREAMER AND TAILBUOY NUMBERING INCREMENTS FROM STARBOARD TO PORT.
H2600
H2600 STREAMER  1: RECEIVERS NUMBERED  408 (FAR) TO    1 (NEAR)
H2600 STREAMER  2: RECEIVERS NUMBERED  816 (FAR) TO  409 (NEAR)
H2600 STREAMER  3: RECEIVERS NUMBERED 1224 (FAR) TO  817 (NEAR)
H2600 STREAMER  4: RECEIVERS NUMBERED 1632 (FAR) TO 1225 (NEAR)
H2600 STREAMER  5: RECEIVERS NUMBERED 2040 (FAR) TO 1633 (NEAR)
H2600 STREAMER  6: RECEIVERS NUMBERED 2448 (FAR) TO 2041 (NEAR)
H2600 STREAMER  7: RECEIVERS NUMBERED 2856 (FAR) TO 2449 (NEAR)
H2600 STREAMER  8: RECEIVERS NUMBERED 3264 (FAR) TO 2857 (NEAR)
H2600 STREAMER  9: RECEIVERS NUMBERED 3672 (FAR) TO 3265 (NEAR)
H2600 STREAMER  A: RECEIVERS NUMBERED 4080 (FAR) TO 3673 (NEAR)
H2600 STREAMER  B: RECEIVERS NUMBERED 4488 (FAR) TO 4081 (NEAR)
H2600 STREAMER  C: RECEIVERS NUMBERED 4896 (FAR) TO 4489 (NEAR)
H2600
H2600 STREAMER ROTATIONS HAVE BEEN APPLIED ON A SHOT BY SHOT BASIS.
H2600
H2600 CALCULATED STREAMER INLINE MISCLOSURES ARE DERIVED ON A SHOT BY SHOT
H2600 BASIS. THESE INLINE MISCLOSURES ARE DISTRIBUTED LINEARLY OVER THE ACTIVE
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H2600 STREAMER LENGTH. THE CORRECTED STREAMER LENGTH IS USED TO COMPUTE THE
H2600 FINAL RECEIVER POSITIONS.
H2600*************************************************************************
H2600 PGS JOB NUMBER 2010184
H2600
H2600 LINES CONTAINED IN THIS FILE:
H2600
H2600 LINE:                       SEQUENCE:        FSP:          LSP:
H2600
H2600 FOR SEISMIC DATA EDITS, PLEASE SEE THE OBSERVERS LOG.
H2600
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12.6 Production log

Date	Daily 3D total km	3D Prime km	Infill km	Sea State Beaufort	Location	Comments
08 Feb.11	0.000	0.000	0.000	7	Transit to Otway Basin	Transit to project 2010184 (BLK T34P), delay in transit d/t weather.
09 Feb.11	12.300	12.300	0.000	6	Prospect	In production: 01.
10 Feb.11	118.181	118.181	0.000	6	Prospect	In production: 01 - 04.
11 Feb.11	102.188	102.188	0.000	4	Prospect	In production: 04 - 08.
12 Feb.11	97.181	97.181	0.000	5	Prospect	In production: 08 - 10.
13 Feb.11	18.750	18.750	0.000	5	Prospect	In production: 11 (Aborted due to Port Super Wide Break).
14 Feb.11	94.988	94.988	0.000	5	Prospect	In production: 12 - 15.
15.feb.11	117.131	117.131	0.000	5	Prospect	In production: 15 - 18.
16 Feb.11	98.944	98.944	0.000	4	Prospect	In production: 18 - 21.
17 Feb.11	98.944	0.000	98.944	4	Prospect	In production: 22 - 24.
18.feb.11	45.094	20.850	24.244	7	Prospect	In production: 26 - 28 - Down for weather, Client terminated project.
19.feb.11	0.000	0.000	0.000	8	East of Prospect	Waiting for suitable weather to retrieve streamers.
20 Feb.11	0.000	0.000	0.000	8	East of Prospect	Waiting for suitable weather to retrieve streamers.
21 Feb.11	0.000	0.000	0.000	4	East of Prospect	Retrieving equipment.
22 Feb.11	0.000	0.000	0.000	4	East of Prospect	All equipment onboard, Demobilised 2010184.