South Africa Wave Tests **ANNEXURE C**

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Start-of-Program Wave Test

A wave test needs to be done at the start of the Zululand seismic program to determine optimal source operating parameters, to acquire trace gathers that illustrate the quality of the field data, and to verify choices of source and receiver station intervals. This test is often done by deploying receiver stations at small intervals (commonly 2 meters) over a linear distance **L** of 100 meters or so. A vibrator source is then positioned at one end of this receiver line and then moved away to occupy stations at distances of **2L**, **3L**, **4L**, . . . until it reaches an offset distance slightly larger than the depth of the deepest target of interest, which would be at least 2000 meters for the Zululand Basin. A simpler approach is to deploy a 2D line of receiver stations equal to depth of deepest target (2000 m or more) and positioning the seismic source at one end of this 2D profile. This latter data-acquisition option is recommended for the Zululand source test. Key elements of this wave test are described below.

1. Vibrator sweep: A fundamental objective of a wave test is to determine the parameters that should be used to operate a vibrator source. In particular, it is important to determine which vibrator sweep parameters ensure the low-frequency portion of the illuminating direct-SV wavefield produced at each source station will be robust and have high energy content.

    - Low-end start frequency: Because of the importance of low-frequency energy to ensure that robust SV waves are produced, data should be acquired with several choices for the low-end start frequency of a vibrator sweep. These choices should be 2, 4, 6, and 8 Hz. A contractor may not wish to do a 2-Hz start frequency because undue mechanical stress on the vibrator may occur. Initial thinking for this project is that a start frequency should not be higher than 4 Hz.

    - High-end stop frequency: It is essential that illuminating wavelets have a frequency spectrum that spans at least 3 octaves in order to ensure that compact, high-resolution wavelets are produced. A logical choice for a high-end stop frequency is 96 Hz, which would result in a bandwidth of 5.5, 4, and 3.5 octaves for start frequencies of 4, 6, and 8 Hz, respectively.

    - Sweep rate: Sweep rates can be linear or non-linear. A linear sweep rate means a vibrator uses the same amount of sweep time to generate each frequency in the specified sweep range. A non-linear rate means a vibrator dwells a longer period of time to generate each successively higher frequency component of a sweep. Non-linear sweep rates were developed to ensure that a higher amount of source energy would exist in the higher frequencies of an illuminating wavelet. This philosophy is in direct conflict with the strategy that we wish to use for Zululand data, where we wish to ensure that robust energy is in the lower-frequency content of an illuminating wavelet. Although non-linear sweep rates will not be used in acquiring the field data, both linear and non-linear sweeps should be recorded in the wave test to document differences in the frequency spectra of each illuminating wavelet. At each choice for a low-end start frequency, only one non-linear sweep rate needs to be recorded, this being an increase in dwell time of 3 dB per octave.

- Sweep length: Long sweeps of the order of 20-sec or more are preferred for the field program, but this opinion needs to be verified by real test data. For each low-end start frequency, data should be recorded with sweep lengths of 8, 12, 16, 20, and 24 seconds.

- Listen time: A listen time of 8 sec should be used. We have no hard data as to what the V_S shear velocity is in the Zululand Basin. We want to be sure that we allow sufficient listen time to capture S-S reflections from basement. A shorter listen time will be considered if justified by source-test results.

- Number of sweeps to sum: Four sweeps need to be recorded for each combination of vibrator parameters that are tested. These data need to be preserved in a form in which individual sweeps can be summed in a data-processing shop to compare how data quality improves with number of sweeps that are summed. Alternately, 1, 2, 3, and 4 traces can be summed in the field by the vibrator correlator. Hopefully a 2-sweep sum will provide good-quality data.

- Taper lengths: This parameter is left to the decision of the contractor. A 300-ms taper is usually used.

2. Receiver type: Three-component (3C) geophones should be used in this wave test, even if a decision has been made to use only vertical geophones to record the field data. By using 3C geophones, test data will be collected that can be used to influence future seismic operations concerning the potential value, or lack of value, provided by direct-S modes produced by vertical vibrators in the Zululand Basin.

3. Receiver interval: A receiver interval of 4 meters is desired in the field program. For the source test, receivers should be deployed at intervals of 4-m along the 2000-m receiver profile. Alternate traces can then be extracted to simulate data recorded with an 8-m receiver interval, and interpolation can be done to simulate data recorded with a 2-m receiver interval.

On-Site Data Processing

The contractor needs to have an on-site data-processing capability that permits them to create wiggle-trace displays and frequency spectra of wave-test data in quasi-real-time so that test results can be evaluated quickly by remote participants. Graphical versions of processed results will be satisfactory for conference call purposes. Digital versions of the test data, and accompanying detailed observer notes, need to be shipped to Battelle and SANEDI as soon as possible for more detailed analysis.

Possible Additional Wave Tests

The physical location where a start-of-program wave test is done should be representative of surface conditions across the area where all 2D profiles will be acquired. If there are dramatic changes in surface conditions across the project area, it may be necessary to do a wave test in each dominant surface environments. The decision that more than one wave test will be needed can be made only by on-site personnel who inspect the area.