

DEP SPECIFICATION

SITE PREPARATION AND EARTHWORKS INCLUDING TANK FOUNDATIONS AND TANK FARMS

DEP 34.11.00.11-Gen.

September 2011

DESIGN AND ENGINEERING PRACTICE



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TABLE OF CONTENTS

1.	INTRODUCTION	5
1.1	SCOPE	5
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	5
1.3	DEFINITIONS	5
1.4	CROSS-REFERENCES	6
1.5	SUMMARY OF MAIN CHANGES	6
1.6	COMMENTS ON THIS DEP	8
1.7	DUAL UNITS	8
2.	GENERAL	9
2.1	EXISTING SITE CONDITIONS, SERVICES AND FACILITIES	9
2.2	CONSTRUCTION SURVEY CONTROL AND SITE LEVELS	9
2.3	DESIGN INCLUDING SEISMIC ASPECTS	11
2.4	CONSTRUCTION SAFETY	12
3	SITE PREPARATION	13
3.1	DEMOLITION AND SITE CLEARANCE	13
3.2	STRIPPING OF TOPSOIL	14
3.3	REROUTING OF EXISTING DITCHES AND WATER COURSES	14
3.4	TREATMENT OF UNDERGROUND CAVITIES	14
3.5	PROVISION OF TEMPORARY SITE DRAINAGE	15
3.6	PERMANENT DEWATERING AND DRAINAGE WORKS	15
3.7	DITCHING AND INSTALLATION OF OPEN DRAINAGE CHANNELS	15
3.8	INSTALLATION OF PIPES AND LAND DRAINS	16
3.9	PROVISION OF TEMPORARY ACCESS	17
3.10	TEMPORARY PARKING, LAY-DOWN AND STOCKPILE AREAS	17
3.11	EROSION CONTROL DURING CONSTRUCTION	18
3.12	SCOUR PROTECTION, COASTAL DEFENCE AND RIVER WORKS	18
3.13	GEOTEXTILES	19
4	EARTHWORKS	20
4.1	GENERAL	20
4.2	CONTROL OF EARTHWORKS	20
4.3	SUITABLE FILL MATERIALS	22
4.4	STRUCTURAL FILL MATERIALS	22
4.5	GENERAL COHESIVE FILL MATERIALS	23
4.6	GENERAL GRANULAR FILL MATERIALS	24
4.7	COARSE GRANULAR FILL MATERIALS	24
4.8	BEDDING MATERIALS	25
4.9	WATER	25
4.11	SHORING AND PROTECTION OF EXCAVATIONS	26
4.12	EXCAVATION IN ROCK	26
4.13	PLACEMENT OF FILL AND EMBANKMENT	27
4.14	PREPARATION OF SOIL BEARING FOUNDATIONS	28
4.15	EARTHWORKS IN AREAS WITH FOUNDATIONS	29
4.16	MOUNDS FOR BURIED VESSELS	29
4.17	ROAD WORKS	29
4.18	FINAL GRADING AND LANDSCAPING	30
5.	BUNDED AREAS AND FOUNDATIONS FOR TANKS	31
5.1	BUNDED AREAS FOR TANKS	31
5.2	IMPOUNDING BASIN	31
5.3	BUNDS AND BUNDWALLS	32
5.4	SURFACE FINISHES OF BUND FLOOR AREAS	34
5.5	TANK FOUNDATIONS	34
5.6	TANK FOUNDATION LEAK DETECTION AND LEAK DETECTION MANAGEMENT SYSTEMS	40
5.7	SPECIAL TANK FOUNDATIONS	41
6.	DRAINAGE OF BUNDED AREAS	43

7.	REFERENCES	44
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APPENDICES

APPENDIX 1	FIELD COMPACTION TRIALS – SUGGESTED PROCEDURE.....	47
APPENDIX 2	INDICATIVE COMPACTION VALUES	48
APPENDIX 3	MIXTURES OF SAND AND BITUMEN FOR TANK FOUNDATIONS	51
APPENDIX 4	TYPICAL CPT VALUES TO VERIFY COMPACTION AND QUALITY OF TANK FOUNDATIONS.....	52
APPENDIX 5	HYDROSTATIC TESTING PROCEDURE FOR TANKS	54
APPENDIX 6	EFFECT OF TANK DIMENSIONS ON SOIL SETTLEMENT.....	57
APPENDIX 7	TYPICAL RING FOUNDATION WITH CONCRETE SLAB	58
APPENDIX 8	SOIL IMPROVEMENT BY GROUND REPLACEMENT.....	59
APPENDIX 9	EXAMPLES OF TANK FOUNDATION CONSTRUCTION.....	61
APPENDIX 10	MATERIALS	64

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design, planning, material selection and construction for site preparation (3) and earthworks (4) of onshore facilities. The DEP also covers the same elements for the civil works of tank farms and tank foundations.

The information contained in this DEP is supplementary to the following civil engineering DEPs:

Earthquake design for onshore facilities - Seismic hazard assessment	DEP 34.00.01.10-Gen.
Structural Design and Engineering	DEP 34.00.01.30-Gen.
Site investigations	DEP 34.11.00.10-Gen.
Geotechnical and Foundation Engineering - Onshore	DEP 34.11.00.12-Gen.
Roads, paving, surfacing, slope protection and fencing	DEP 34.13.20.31-Gen.
Drainage and primary treatment facilities	DEP 34.14.20.31-Gen.

This is a revision of the DEP of the same number dated September 2003; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Bund	walled area enclosing some equipment (e.g. Tanks)
Bund wall	wall forming the outside of a bund
Environmental engineering	engineering to protect the environment of those who may be affected by the activities
Freeboard	an additional height provided by the bund wall to allow for the following affects that may or may not occur: a) storm surge ; b) foam containment; c) collection of rainwater; d) standing water in bunded area ; e) sloshing resulting from sudden collapse of a storage tank.
Tank Farm	a group of tanks contained in a bund
Very toxic (substances)	substances that are very hazardous for the environment or human health, as specified in DEP 01.00.01.30-Gen. (which also identifies "toxic" substances by reference to chemical substances databases).

1.3.3 Definitions of materials

For the definitions of materials, see BS 6100 – 1.0 and BS 6100 – 2.2.2.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets (). Other documents referenced by this DEP are listed in (7).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a revision of the DEP of the same number dated September 2003. The following are the main, non-editorial changes.

Old section	New section	Change
2.2	2.2	Details for survey control plan added
2.3 & 2.4		Removed and information covered in other sections
	2.3	New section on design covers old Section 2.5
	2.4	New section on construction safety
3	3	Chapter updated with section number changes & material moved to informative but without significant change
3.1 & 3.6		Sections removed with material located in new sections
3.2	3.1	Section expanded
	4.3	New section on suitable fill materials added.

Old section	New section	Change
3.3	3.4	Definition of top soil explained.
3.7	3.5, 3.6	Expanded into to new sections.
	3.7	New section on Ditching and installation of open drainage channels added.
	3.8	New section on installation of pipes and land drains added.
3.9	3.10	Details for stock piling added.
	3.11	New section on erosion control during construction added.
	3.13	New section covering Geotextiles
4	4	Chapter updated with material moved to informative but without significant change
4.2	4.2	NGT testing advice added
	4.3	New section on suitable fill materials added.
	4.4	New section on structural fill materials added.
	4.5	New section on general cohesive material added.
	4.6	New section on general granular fill material added.
	4.7	New section on coarse granular fill materials added.
	4.8	New section on bedding materials added.
	4.9	New section on water added.
	4.10	New section on excavation added.
	4.11	New section on shoring and protection of excavations added.
	4.12	New section on excavation in rock added.
	4.13	New section on placement of fill and embankment added.
	4.15	New section on earthworks in areas with foundations added.
	4.17	New section on Road works added.
	4.18	New section on final grading and landscaping added.
5.1.1	5.1.1	Requirements for fire resistance added
5.1.2	5.1.2	Layout and capacity requirements amended
5.3.1	5.3.1	Design requirements updated with more detailed requirements on strength, permeability, penetrations, joints and access
5.3.2	5.3.2	Sand bitumen cement lining option has been removed
5.4	5.4	Tank shoulder requirements amended
5.5.2	5.5.2	Tank shoulder permeability requirements added
5.5.6	5.5.6	Oil sand mix option for hot tanks removed
5.7.1	5.7.1	Sand bitumen layer thickness amended from 5 to 50mm
6		Section removed as maintenance practice
Appendix 3	Appendix 3	Table of Bitumen grades and mixing temperature removed. Oil sand mix for hot tanks removed.

Old section	New section	Change
Appendix 4		Appendix removed as no longer used in tank compound construction
Appendix 7		Appendix removed as now covered by DEP 80.00.10.11-Gen..
Appendix 8		Appendix moved to informative DEP
Appendix 14		Appendix removed as covered by new Appendix 4
Appendix 15		Appendix removed as covered by new Appendix 4

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://www.shell.com/standards> and on the main page of the DEPs DVD-ROM.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

2. GENERAL

2.1 EXISTING SITE CONDITIONS, SERVICES AND FACILITIES

A pre-construction plan shall be submitted to the Principal to address all required site investigations and construction works. The plan shall include all permits, notifications to authorities having jurisdiction, any re-routing of existing utilities, and the schedule to provide these approvals/ notifications prior to beginning site investigations, site preparation works and/or earthworks. All site work construction shall follow the project approved pre-construction plan.

Relevant utility companies and/or local authorities shall be contacted to establish whether they have services in the subject locations. This shall confirm that services in the locality have been made safe, and any services or other facilities adjacent to the proposed work shall be described. In addition, any safety aspects and measures that are to be maintained during the work shall be specified. This shall include ensuring that all aboveground and underground services shall be maintained during the works through physical support if necessary.

Before any excavation all underground utilities, and structures that will potentially be affected by the disturbance shall be located on the drawings and all safety aspects and precautionary measures that are to be maintained during the work shall be noted on the drawings and specifications. If additional utilities or obstructions are located prior to excavation the Principal shall be notified before proceeding with the work.

Where old underground obstructions are located in the field that may form obstructions that prevent the installation of new assets, and these obstructions were not previously located on the drawings a survey shall be conducted to record the location, dimensions (and inclination where relevant) of existing obstruction to ensure new foundations avoid the existing buried structures.

Likewise if unknown underground cavities or streams are detected during the construction scope the Principal shall be notified. The void or stream shall be suitably investigated (3.3) and a proposed mitigation plan shall be proposed to the Principal.

If services or facilities are accidentally cut or damaged, these shall be repaired. Repair methods or temporary works shall be submitted to the Principal for review and comment prior to commencing work.

On completion of performing work and making the utilities safe, they shall be marked on as-built drawings showing locations of routing and terminations of temporary and permanent utilities. As built drawings are to be submitted to the Principal at the completion of the work.

The stability of all supports or excavations shall be proven by calculations based on realistic assumptions and/or available data.

2.2 CONSTRUCTION SURVEY CONTROL AND SITE LEVELS

2.2.1 Site levels

During the process of establishing finished grade levels, the following shall be taken into account:

Surface water should be able to run off under gravity via the plant drainage systems, in accordance with DEP 34.14.20.31-Gen.

Site layout/plot plan and related safety aspects, including safety distances, should be adhered to.

Cut and fill should be economically planned so that cut and fill balancing is optimised, including allowances for earthen structures and general fill, bulking, wastage and unsuitable materials.

Danger of flooding should be avoided or alternatively the area should be adequately protected.

2.2.2 Construction survey control

Prior to all site work a topographic survey should be performed. The existing site or survey data drawings and specifications shall be available for all site construction survey and control scope.

The drawings and specifications shall indicate the location and control elevation of all Temporary Bench Marks (TBMs) or site monuments that are to be used as reference for the site work of the contractor's scope of work. Note that a minimum of four TBMs should be available to act as the main survey control system for the site throughout the planned construction works. TBMs or site monuments shall be designed to be stable given the ground and climatic conditions at the site and their expected service life.

All lines and grade stakes as required for the work shall be extended from controlled benchmarks and base lines which are traceable to the site monuments or TBMs indicated on the drawings.

Where permanent site monuments are required, the drawings shall indicate the number, location and design of permanent monuments based on known national survey datum reference points.

The Survey Control Plan shall be submitted to the Principal for review and comment. The Survey Control Plan shall include the maintenance interval for all monuments and TBMs used by the project scope. The maintenance plan should include the production of a verification survey report that has an acceptable closing error. A verification survey report shall be submitted which includes the comparison of the current to those from each previous surveys to confirm the TBMs are stable.

If it is suspected that any of TBMs or site monuments are not stable, or that the TBM is damaged or destroyed a proposal for immediate replacement/ remediation shall be submitted to the Principal. Any damage to TBMs or site monuments shall be reported to the Principal. The report shall include a proposed plan to immediately repair the damages.

Surveyor Quality Control

All survey work shall be performed by qualified surveyors and under the direct supervision of a locally licensed or certified surveyor.

The scope and accuracy of survey work shall follow regional standards or as directed by the Principal.

The surveyor shall meet the following tolerances when making both vertical and horizontal measurements:

- a) ± 30 mm (0.10 foot) for ground elevations;
- b) ± 75 mm (3 inches) for surface contours;
- c) ± 6 mm (1/4 inch) for measurements on concreted;
- d) ± 3 mm (1/8 inch) for tie-in work and survey of existing facilities.

If any errors are observed either in the field work or in calculations, notes, maps, plats, survey drawings, etc., they shall be corrected.

2.2.3 Dimensional tolerances

The closing error on all verification surveys and settlement monitoring surveys shall be less than ± 3 mm in elevation. Where closure is greater than ± 3 mm, the verification survey shall be repeated.

The elevation of any point and the line of any edge, or centre of excavations and the final grading shall conform to that shown on the drawings within the tolerances stated below:

Table 2.1 Dimensional Tolerances in Earthworks

Description	Tolerance from true level in mm ¹	Tolerance from true line in mm
Site Clearance	+60 -60	+75 -75
Excavations	+30 - 30	+ 30 - 30
Basic Grading	+25 - 25	+ 75 - 75
Embankment	+ 75 - 0	+ 75 - 75
Road Subgrade ²	+ 25 - 25	+ 50 - 50
Road Subbase ³	+ 13 - 13	+ 50 - 50

- NOTES:
1. Irrespective of these tolerances, there shall be no low spots or areas where water may pond on finished surfaces.
 2. Tolerances for levels shall be based on measurements over the finished surface, tested with a 3 meter straightedge applied parallel with and at right angles to the centre line.
 3. The surface of the completed sub-base shall not deviate more than 13 mm from the specified cross section at any point and 13 mm in 30 m from the specified longitudinal grade at any location.

2.3 DESIGN INCLUDING SEISMIC ASPECTS

The design and eventual execution of temporary and permanent site preparation and earthworks shall consider all the relevant design conditions that are expected during the construction works including the relevant seismic conditions and relevant consequences prevalent in the area under consideration. Applicable seismic zones and other design loads may be found in DEP 34.00.01.30-Gen.

Liquefaction potential shall be investigated.

If faults and or other geological disturbances exist at the site, their long-term behaviour, and where applicable, their behaviour during earthquake shall be investigated by a qualified expert. The conclusions of this investigation shall be taken into consideration for the subsequent earthworks, including foundation and structural design.

If the existing engineering properties of the ground may result in liquefaction, unacceptable total and/or differential settlements or bearing capacity failure, consideration shall be paid to the use of ground improvement methods rather than deep foundations.

2.3.1 Engineering and planning for site preparation and earthworks

During the detailed design phase, an Earthworks Construction Plan shall be prepared that describes the following:

1. Plan for performing the earthworks.
2. Drawings indicating the sequence of work.
3. Drawings indicating the location of stockpiles, haul roads, disposal areas and control of ground and surface water.

4. System for segregation of soil types, identification and ticketing system for earthmoving activities.
5. Operations to minimise erosion from surface water and controlling the quality of discharged water.
6. Approach to perform preparations for foundation work, including the methodology of opening up work fronts and maintaining them in a safe accessible state.
7. A review of the main hazards and provide processes by which these hazards can be mitigated and controlled. This shall include hazards associated with excavations, protection of the site and minimizing the environmental impact.

The plan shall be issued to construction site and used in planning activities and in developing Method Statements and other construction documentation.

2.4 CONSTRUCTION SAFETY

The Contractor shall develop a detailed work procedure for the demolition of existing facilities where applicable, including measures to protect personnel and the adjacent facilities and buildings designated to remain after all construction works.

The Contractor shall take appropriate measures to protect personnel from risks associated with airborne contaminants such as asbestos fibres and metal dusts during all demolition works.

All necessary temporary works such as safety barriers, fences, safety nets, coverings and screens shall be provided to protect personnel and adjacent property from injury or damage caused by demolition operations.

All necessary dead or raking shores to support existing work shall be provided during demolition and associated operations. Temporary support shall be provided or backfilling of any voids, buried tanks or old basement structures should be carried out during demolition and site clearance.

Necessary precautions shall be taken to protect adjacent work and structures and to prevent detrimental affects to adjacent foundations. Shoring adjacent to existing underground installations during construction shall be designed and detailed on the drawings based on the project geotechnical report(s). No excavation is permitted under foundations.

To avoid excess surcharge at the top of excavations, no materials, or heavy equipment shall be located near the edge of the excavation. A Geotechnical Engineer shall review for each location the required distance to the edge of the excavation. The exclusion area shall be marked by pegs.

3 SITE PREPARATION

3.1 DEMOLITION AND SITE CLEARANCE

All materials arising from demolition and site clearance work, except materials specified for re-use or as otherwise specified by the Principal, shall be removed from the site as appropriate as the work progresses and shall be disposed of in an agreed and responsible manner. Materials removed from the facility to an external repository shall be disposed of in accordance with all applicable local and national laws and regulations. Such materials should not be permitted to accumulate and the site shall be maintained in a safe and tidy condition at all times.

3.1.1 Demolition

Careful consideration shall be given to the presence of existing foundations to ensure that they do not impact on the installation or performance of new foundations. Demolition procedures drawings and specifications shall be submitted to the Principal for review and comment prior to any demolition in the field.

Where existing strip, pad or raft foundations are present, these shall be broken out and the resulting void filled with compacted structural fill. Alternatively the existing foundation may be incorporated into a new foundation structure provided the impact of the existing structure is allowed for in the design of the new foundation.

Existing derelict piles shall be assessed for their effect on any new foundation as they may form "hard spots". Where existing piles will affect new foundations the area shall be excavated to a level below the new foundation elevation and the existing piles broken down to the base of the excavation. Ground levels shall then be made up to finished levels using compacted structural fill on which the new foundation can be constructed.

Where old piles and caissons may form obstructions that prevent the installation of new piles, a survey shall be conducted to record the location, dimensions (and inclination where relevant) of existing piles to ensure new foundations avoid the existing buried structures.

Care shall also be taken to ensure the site clearance and demolition work does not adversely affect or diminish the capacity of the foundation of the existing adjacent buildings/structures. Any reaction on adjacent structures shall be monitored and mitigation measures shall be taken to ensure no damage is done to adjacent structures.

3.1.2 Site clearance

Site clearance shall include the taking down or grubbing up and satisfactory removal / disposal, of surface obstructions and unsuitable materials. The following terms are typical for site clearance activities:

- Stripping and grubbing is to strip away all vegetation and topsoil. Topsoil when not designated on the drawing shall extend to the bottom of the root zone.
- Areas to be cleared only, typically mean sites to have any vegetation that is protruding through the ground surface flush with, or just below, the surface.

In areas designated for site clearance, typically there will be areas for preservation, or vegetated areas outside the construction area. Construction operations shall carefully protect from abuse marring, or damage, those trees, shrubs and other landscape features outside the construction area and those areas specifically designated for preservation on the drawings and specifications.

The site shall be inspected after clearing and grubbing operations to confirm clearance activities have been completed according to the drawings and specifications, or to identify areas where additional materials require removal.

Before backfilling of depressions and holes, inspection of the surface condition shall be executed and recorded. Backfilling operations shall be performed in accordance with Section 4.14.

All materials arising from demolition and site clearance work, except materials specified for re-use or as otherwise specified by the Principal, shall be removed from the site as appropriate as the work progresses and shall be disposed of in an agreed and responsible manner. Materials removed from the facility to an external repository shall be disposed of in accordance with all applicable local and national laws and regulations. Such materials should not be permitted to accumulate and the site shall be maintained in a safe and workmanlike condition at all times.

Materials required for re-use shall be stored in a safe location and protected from damage or deterioration as agreed with the Principal.

Segregation and quantification of hazardous and non-hazardous waste material and certified disposal of hazardous material shall be carried out in accordance with applicable legislation.

3.2 STRIPPING OF TOPSOIL

Topsoil shall mean natural, friable, fertile, fine, loamy soil containing no less than 1.5 percent organic materials, and generally representative of agriculturally productive soil in the vicinity of the site. Topsoil shall be free from subsoil and objectionable material that would hinder plant growth or maintenance and shall not contain more than 5 percent by volume of stones, lumps, or other objects larger than 50 mm in any dimension.

All areas to be excavated, filled or constructed upon shall be stripped entirely of topsoil to a suitable depth below ground level, as indicated by the site investigation and agreed with the Principal.

Topsoil to be used for construction shall be segregated and stockpiled in accordance with the requirements of the specification. The excess Topsoil from the site shall be removed to an external repository in accordance with all applicable local and national laws and regulations.

Turf intended for re-use, as agreed with the Principal, shall be taken up in strips of a constant breadth with an approved turving tool. Turf intended for re-use shall be removed to a location approved by the Principal where it shall be neatly stacked and regularly watered and tended until required for relaying.

Topsoil intended for re-use, as agreed with the Principal, shall be stock-piled and/or spread at approved locations in limited heights as appropriate to the region to avoid detrimental affects to its chemical and biological composition.

The remaining topsoil and turf shall be disposed of at locations agreed by the Principal, in accordance with national and local laws and regulations.

3.3 REROUTING OF EXISTING DITCHES AND WATER COURSES

Existing drainage ditches and water courses shall be temporarily or permanently rerouted, as specified on the drawings and specifications. Reference is made to Section 3.5.

The design of rerouting plans shall be carried out in accordance with the requirements of DEP 34.13.20.31-Gen. and DEP 34.14.20.31-Gen.

3.4 TREATMENT OF UNDERGROUND CAVITIES

If naturally occurring cavities or man-made cavities are detected under or adjacent to the construction area, they shall be suitably investigated and treated in consultation with the Principal. A thorough investigation and assessment of likely size, distribution (laterally and vertically) and nature (infill type and its stability) of cavities shall be carried out by expert staff along with the development of effective, robust and economical mitigation measures, where needed.

3.5 PROVISION OF TEMPORARY SITE DRAINAGE

Adequate temporary drainage systems shall be provided to accommodate ground water and surface water runoff.

All temporary drainage and dewatering systems shall be complete and functional prior to commencement of earthwork operations, including all excavating and filling for inlets, outlets, diversion ditches and dikes required for construction drainage. The installation, operation, maintenance and removal of dewatering systems shall be conducted without disturbing other parts of the work area. Any damages to the excavation or surrounding areas resulting from failure of the dewatering system shall be rectified.

Groundwater inflows into excavations and high pore pressures in surrounding ground shall be controlled to avoid deterioration of exposed surfaces and erosion. The selected dewatering method shall not have any adverse effect on adjacent existing structures. Necessary dikes or interceptor trenches shall be provided at the top of excavation slopes to prevent surface water from entering excavations. Free water in excavations shall be removed such that works can be conducted in the dry. Surface drainage and water from dewatering systems shall be fed into the surface drainage system such that the site remains workable when it is not raining. Fill material shall be placed in such a manner and in such sequences that ponding of free water shall be prevented.

A contingency plan shall be developed that addresses the failure of any critical components of the dewatering system.

3.6 PERMANENT DEWATERING AND DRAINAGE WORKS

Permanent surface water runoff drainage systems shall be designed in accordance with the requirements of DEP 34.13.20.31-Gen. and DEP 34.14.20.31-Gen.

3.7 DITCHING AND INSTALLATION OF OPEN DRAINAGE CHANNELS

Ditches and trenches shall be installed and maintained at the required locations and within the allowable tolerances for line and level. For channels and ditches, after each section of the route has been excavated, it shall be lined commencing from the highest point, working towards the lowest to minimise the risk of ingress of silts and other unsuitable materials during rain storms. Ditches and channels shall be installed with a continuous slope to prevent ponding of water in sections when there is no flow. The minimum slopes on ditches and channels shall be 1 (vertical) to 1000 (horizontal) or as indicated on the drawings.

Excavation for ditches and channels shall conform to the specified locations, elevations and slopes as indicated on the drawings, allowing for installation works. For the installation of precast concrete sections, sufficient space shall be provided to install bedding layers and necessary gravel drainage blankets as shown on the drawings. No works shall be carried out when water is present in the excavation, or when the trench conditions are unsuitable for such work. Bedding materials shall be fully compacted prior to installation of precast concrete sections, or casting of concrete panels to provide a uniform support. Bedding material shall not be jetted in place, nor hydraulically placed.

Methods for installation of precast concrete sections shall be adopted that shall not damage the concrete. Each segment shall be inspected for defects and cracks before being carefully lowered into the excavation. Any defective, damaged, or unsound segment or any segment that has had its grade disturbed after laying shall be taken up and replaced. Defective segments shall not be incorporated into the works. Special attention shall be given to joints to ensure wash in of silt and fine sand shall not occur.

Where placement of materials to the sides of concrete channels is required, the layer thickness of the materials shall be limited to 150 mm and the plant and equipment used for compaction shall not over stress, or move the concrete channel. Fill material shall be placed on both sides such that there will not be an uneven height difference of more than 300 mm on each side of the concrete channel.

Open ends of ditches and channels shall be protected to prevent soil, or other materials from entering during construction. The ditches and channels shall be free from dirt, excess water and foreign materials during the laying progresses. The ditches and channels shall be left clean at the completion of the installation and protected from inflow of deleterious materials until Hand Over.

Ditches lined with rip rap and geotextile shall have sections of geotextile overlapping by at least 150 mm and the overlap shall have the upstream section placed on the downstream section. The rip rap shall comply with the requirements of the specifications and shall be placed in a tightly interlocking fashion to form the thicknesses shown on the drawings. No geotextile shall be visible on completion of the installation. The rip rap ditches shall be kept clean of rubbish, silt and other deleterious materials until Hand Over.

3.8 INSTALLATION OF PIPES AND LAND DRAINS

Pipes shall be of the size and length shown on the drawings. The prescribed sizes of pipes are nominal inside diameters. The pipelines, fittings, bends, manhole risers and other appurtenances shall be laid and maintained at the required locations and within the allowable tolerances for line and level. For pipelines, installation shall commence at the lowest point for each segment of the route. Pipes shall be installed with a continuous slope to prevent ponding of water in sections of pipe when there is no flow. The minimum slopes on pipes shall be 1 (vertical) to 1000 (horizontal) or as indicated on the drawings.

Excavation for underground pipes shall conform to the specified locations, elevations and slopes as indicated on the drawings, allowing for installation works. The trench depth and width shall be sufficient to allow inspection of the pipe, pipe joints and proper compaction of bedding material at bottom sections and sides of the pipes. For pipes of diameter up to and including 250 mm, the base of the trench shall be at least 300 mm below the bottom of pipe and provide at least 300 mm on each side of the pipe. For pipes of diameter larger than 250 mm, the base of the trench shall extend at least 300 mm below the bottom of pipe and provide at least 500 mm on each side of the pipe. For concrete pipes, excavation for bells and hubs shall be enlarged such that the full load is carried by the pipe barrel and a minimum bedding depth of 300 mm beneath the pipe is maintained.

Bedding material may be placed prior to installation of the pipe segments. Alternatively, supports such as sand bags may be installed, which shall be removed after backfill completion and prior to pipe system testing, and the pipe segments laid on these supports with bedding material being placed after installation. No pipe shall be laid in water or when trench conditions are unsuitable for such work. Whichever method is adopted, the bedding material shall be fully compacted under the pipeline to provide a uniform support which may require tamping sand in from both sides of the pipe to ensure uneven lateral loads do not develop which may result in subsequent movements on sections of the drainage system. Bedding material shall not be jetted in place, nor hydraulically placed.

Methods for installation of piping and placement of bedding material shall be adopted that shall not damage the pipes and protective coatings and shall comply with manufacturer's recommendations for installation. Each pipe segment shall be inspected for defects and cracks before being carefully lowered into the trench. Any defective, damaged, or unsound pipe or any pipe that has had its grade disturbed after laying shall be taken up and replaced. Defective segments shall not be incorporated into the works. Special attention shall be given to joints to ensure excessive stresses cannot build up, or allow wash in of material during operation due to poor connection of joints. Concrete pipes shall be laid with the bell (female) end facing upstream. The joint faces shall remain clean and undamaged at all times. The pipe and drain joints shall be left exposed until the piping has passed all necessary testing and in the case of concrete pipes, for at least twenty-four hours after joints have been made.

The layer thickness of bedding material shall be limited to 150 mm. Plant and equipment shall be used to compact bedding material and subsequent fill materials that will not over stress, or otherwise damage the installed piping. Bedding material shall be placed symmetrically around and above pipes and structures such as culverts to prevent eccentric loading.

Open ends of pipelines shall be protected with covers to prevent soil, or other materials from entering the pipe during construction. The interior of the pipe shall be free from dirt, excess water and foreign materials as the pipe laying progresses. The pipeline shall be left clean at the completion of the installation and protected from inflow of deleterious materials until Hand Over to Company.

3.9 PROVISION OF TEMPORARY ACCESS

Suitable temporary roads shall be laid to provide all-weather access for all construction activities. The temporary roads should preferably coincide with the planned permanent routes.

Temporary access shall be designed to suit climatic, traffic and subsoil conditions. The effects to be taken into consideration shall include heavy traffic along temporary roads and if necessary, suitable precautions shall be taken.

Traffic routing schemes should be established, especially for large-scale works.

Disturbance of permanent surface and subsurface drainage shall be avoided.

3.10 TEMPORARY PARKING, LAY-DOWN AND STOCKPILE AREAS

3.10.1 Temporary parking and lay-down areas

Permanent lay-down areas normally located inside battery or module limits shall be designed and constructed in accordance with DEP 34.13.20.31-Gen.

All temporary lay-down and parking areas required for construction activities should be suitably levelled and provided with suitable access, temporary paving and surface drainage as necessary. These temporary lay-down and parking areas shall be located within the designated Contractor's area.

The temporary lay-down areas shall be drained so that stored materials remain dry at all times, and surface as well as subsurface drainage may be required. Proper access to these areas for lifting equipment and construction vehicles shall be maintained. The bearing capacity of the areas shall be determined such that lifting operations can be planned and carried out safely.

3.10.2 Stockpiled storage areas

To minimise the import and export of material to and from a site, materials identified in the site investigation shall be considered for re-use. Materials required for re-use from other site preparation activities shall be stored in a safe location that is protected from damage or other deterioration as agreed with the Principal. The method of stockpiling of materials shall ensure that the stockpile is kept in a stable condition for work operations and equipment operators. The Method Statement for this scope shall:

- Take into consideration all requirements for protection from the weather and from contamination through mixing.
- Be arranged so as not to obstruct drainage or other construction operations in the vicinity of the works.
- Be placed, graded and shaped with appropriate drainage and maintain the required moisture content and workability. The maximum slope ratio is 2 (horizontal) to 1(vertical).
- Address the changes in weather conditions and surface protection at the end of each day's work.
- Address each material to be temporarily stockpiled. (including topsoil, concrete, asphalt pavement, pressure vessels, piping, electrical utilities).

Stockpiled topsoil or other grubbed material shall not be stockpiled on a prepared subgrade or in excess of 3 m in height.

Segregation and quantification of hazardous and non-hazardous waste material and certified disposal of hazardous material shall be carried out in accordance with applicable legislation.

When specified to be stockpiled topsoil shall be free from subsoil and objectionable material that would hinder plant growth or maintenance and shall not contain more than 5 percent by volume of stones, lumps, or other objects larger than 50 mm in any dimension.

3.11 EROSION CONTROL DURING CONSTRUCTION

All necessary erosion control measures shall be arranged to minimize the quantity of suspended solids in runoff water. The details of the proposed water gathering and disposal procedure shall be submitted to the Principal for review and comment. The procedures shall thereafter be transmitted for onsite execution. The quality of water discharged from the site boundaries shall be compliant with local and national regulations. This shall include all measures to monitor water quality and if necessary, contain and treat water before discharge.

The procedures drawings and specifications shall address if the permanent surface water drainage system is to be used during construction, or if the system is a temporary network. The procedure shall include the construction maintenance requirements of the erosion control measures. Typically, sediment and erosion control facilities are inspected after each rainfall and maintained, to ensure continuous efficiently performance.

Full cleaning to the base of ditches and any necessary reinstatement works shall be completed prior to Handover.

As soon as practicable after completion of construction in an area, the final surface finishing shall be installed to make the surface stable and prevent erosion. All finished areas shall be maintained on a continuous basis until completion of work at which point all drains and silt traps shall be cleaned, all damage to, or erosion of surface areas shall be made good prior to handover.

3.12 SCOUR PROTECTION, COASTAL DEFENCE AND RIVER WORKS

When a facility location is selected that is impacted by external hydraulic process the specifications and drawings shall address the potential detrimental erosion effects for the applicable climatic conditions. The proposed plan to install fortifications to address these hydraulic processes, and their effects, shall be provided to the Principal for review and comment and shall include:

- the environmental impact of the installation and the facility to demonstrate that the required protection has with the least disturbance to the environment and to current and future land use including hydraulic, morphological, geological, geotechnical coastal engineering and environmental aspects.

When analysing the problem, hydraulic, morphological, geological, geotechnical coastal engineering and environmental aspects shall be considered.

Rises in sea level resulting from climatic changes as well as subsidence of the land through tectonic movements (if any) and other processes shall be assessed.

Ways of minimising the life cycle cost shall be considered, including an assessment of the availability and cost of construction materials, construction methods, availability and cost of the Contractor's equipment, and the lifetime maintenance costs. The assessment of the lifetime maintenance cost shall consider the frequency of occurrence of adopted design events with other reasonable combinations and the resulting damage potential to the proposed facility. The impact on the temporary and long-term functionality of the facility and the reparability of the hydraulic structures and damaged parts of the facility resulting from the considered combinations should be assessed in order to determine the optimal economic, technical and safe solution. If an economic evaluation is not carried out, the critical combination having a return period of 100 years shall be adopted for design purposes, subject to the approval of the Principal.

3.13 GEOTEXTILES

The geotextile material used for a specific application shall be based on the individual material having adequate strength, permeability, thickness, porosity and roughness properties necessary to satisfy the requirements for that application.

The Manufacturer/Supplier's product data, including installation, handling, storage and repair instructions shall be submitted to the Principal for review and comment. The installation contractor and manufacturer experience shall also be submitted for review and comment. In locations where there are large differences in temperature between day and night, the Method Statement shall indicate the time of day and precautions to be taken. Typically in these circumstances, the lining is installed in the early morning and covered with sand to avoid excessive rippling of the sheet due to increase in temperature during the day.

For geotextile liners that are required to be impervious, the installation contractor shall provide approval to the design and placement of the sub-base. In addition the following shall also be submitted:

- Shop drawings, which includes the following items;
 - o Panel layout drawing,
 - o Details of joining procedures,
 - o Special construction details;
 - o Anchoring details,
 - o Temporary anchors,
- Qualifications and experience documentation of key field installation personnel;
- Field inspection and handling instructions;
 - o Storage requirements for the materials,
- Sub grade acceptance criteria;
- Seaming / welding procedures for hot wedge welding, extrusion welding);
- Quality control testing methods and test procedure for test welds, non destructive seam testing, double wedge seam air pressure test, vacuum box test, non destructive installed sheet continuity test (if applicable), spark testing, vacuum box testing, destructive testing;
- Post installation general precautions to prevent damage including general operational requirements and placement of drainage or cover material.

Welding of an HDPE geotextile liner shall only be permitted if the following conditions are met:

- temperature of HDPE liner and ambient temperature are higher than 5 °C (40 °F);
- wind speed is lower than 8 m/s (18 miles/hr);
- relative humidity is lower than 90 %;
- no water is present on the HDPE liner.

The friction coefficient and durability of the geotextile shall be considered when designing slopes of topping material above the material. This is important in cold regions where the melting conditions may cause a failure of the topping/ finishing materials. In some cases where an impermeable barrier is required, a three component liner is selected, where the top and bottom layer serve to moderate any impact or liquid effects to the performance of the geotextile layer.

4 EARTHWORKS

4.1 GENERAL

Where suitable material is not available on site, material shall be imported. Unsuitable material arising from site works shall either be stored at a designated location on site, or shall be disposed of in a responsible manner in accordance with all applicable local and national laws and regulations. To minimise the import and export of material to and from a site, materials identified in the site investigation shall be considered for re-use. A study which includes the approximate quantities of import materials shall be determined and laboratory testing of potential sources of fill to determine their engineering properties and mineralogical composition shall be provided to the Principal for review and comment. Before finalizing the design of site fill works site construction trials shall be carried out to satisfactorily demonstrate that the proposed equipment, compaction methods and compliance testing programme fulfil the design requirements.

Earthworks shall be designed, planned and executed in accordance with the Earthwork Specification and/or national/regional codes.

Special attention shall be paid to earthworks in arid environments, humid tropical regions and cold regions with permafrost.

4.2 CONTROL OF EARTHWORKS

The earthworks design shall address the functional requirements, which may include the permitted allowable total and differential settlements, minimum or maximum permeability, minimum factor of safety for stability, special measures to control erosion, etc. The specification shall define the physical characteristics of the suitable materials (grading, angle of friction, etc.).

The specification shall include a defined compliance testing programme stating the type of testing required and the frequency of each test. It shall also provide the ranges of acceptability. The properties to be tested of the stockpiled material shall be appropriate for the type of fill material and may include grading, plasticity, shear strength, angle of friction and moisture content. Testing of the placed material shall include the moisture content, bulk density and dry density, and possibly other properties.

The minimum frequency of inspections and tests to be carried out on exposed formation levels shall comply with the requirements set out in Table 4.1 below. The test method selected and acceptance criteria adopted will be in part dependant on the project location, climatic and soil conditions prevailing at the site.

Table 4.1 Inspections and Tests Performed on Formation Level

Area	Minimum Frequency
Foundations	One inspection/test per 25 m ² area of foundation with a minimum of one test per foundation.
Areas for paving	One inspection/test per 100 m ² area of paving with a minimum of one test per area of paving.
Areas for roads	One inspection/test per 100 m length of road with a minimum of one test per road.
All other areas excluding landscaping	One inspection/test per 200 m ² area of paving with a minimum of one test per area of paving.
Trenches and surface drainage	One inspection/test per 100 m length of trench with a minimum of one test per straight run of trench.
Landscaping	One inspection/test per 400 m ² area of landscaped area with a minimum of one test per area of landscaping.

Prior to commencement of earthworks, a method statement shall be produced and submitted to the Principal for review and comment. The method statement shall describe the proposed equipment, testing method and a compaction trial covering the proposed methods of excavation (for cuttings), placement and compaction (for embankments). The compliance testing programme shall be clearly defined in an inspection and test plan, identifying methods and equipment that shall be used to determine the specified physical and engineering properties, and provide sample Quality Control Record (QCR) sheets stating the information which shall be recorded for each compliance test. The acceptable ranges for each test result shall be identified in the inspection and test plan.

Preferred testing methods for density are Sand Replacement/clay cutter in fine soils, water replacement in coarse materials and Nuclear Density Gauge (NDG).

The following care shall be taken in the use of the NDG:

- They shall be calibrated with trial fill on site at more than one density to ensure accuracy. This should be representative of the fill material used during the main works.
- They shall be cross-referenced regularly with conventional tests, typically one conventional (sand or water) test for every 20-30 NDG tests during filling operations.
- Borrow pits often produce variable fill and testing of the source material shall be completed regularly to ensure that the NDG remains calibrated.

Under no circumstances shall earthworks quality control rely on NDG alone.

The compaction trial shall not be incorporated into the final earthworks. The results of the compaction trial shall be reported to the Principal prior to commencement of the earthworks. If any part of the compaction trial fails to comply with the requirements of the specification, the method statement shall be revised and additional trials conducted until satisfactory results are achieved.

During execution of the earthworks, compliance testing shall be carried out as specified in the inspection and test plan, and the results shall be reviewed against the specified allowable ranges. If results are noncompliant, the Contractor shall propose corrective actions to the Principal that are appropriate for the specific non-compliance.

The compliance test results shall be stored either electronically or in paper records as appropriate to the work scope and location. A summary report shall be produced identifying the areas on a plan in which controlled engineered fill has been placed. For each area, the