Government of the Northwest Territories
Fort Providence, Kakisa Power Line Review

Preliminary Design Report Review

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1. Background and Objective of this Report

In 2013, the Northwest Territories Energy Corporation Ltd. (NT Energy) contracted Midgard Consulting Inc. (Midgard) to prepare a feasibility study and a preliminary design for the Fort Providence to Hay River 72 kV & 25 kV Interconnection Project "FPHR Line". The study includes two options (Refer to Appendix A. Project Map):

- Roadside Route (116 km) that includes 36 km of 25 kV underbuilt (replacing and upgrading the existing distribution system) resulting in an extension of the 3-phase distribution system to the proposed Pellet Plant located approximately 4 km northwest of Enterprise.
- Direct route (81 km) overland to Kakisa Junction without an access road.

The Government of the Northwest Territories (GNWT) has engaged Hatch Ltd. for a review and update of the roadside route of the Preliminary Engineering Report prepared by Midgard.

2. Introduction and Project Overview

The FPHR Line is designed to interconnect the communities of Fort Providence, Dory Point, and Kakisa to the existing transmission grid.

The FPHR Line comprises the following components. Refer also the map provided in Appendix A.

A. New 72 kV Switching Station at the Fort Smith Highway Junction.

B. New 72 kV Transmission Line from Highway-1 / Highway-5 Junction (Point A) to Kakisa Junction (Point C).The proposed line follows Highway-2 in southward direction to Enterprise, then follows Highway 1 in northwest direction to Kakisa Junction (total length of 116 km). Between the Fort Smith Junction (point A) to Pellet Mill (point B), the 72 kV line also includes 36 km of 25 kV underbuilt circuit and neutral.

C. New 72/25 kV Substation at Kakisa Junction.

D. New 25 kV Distribution Line from Kakisa Junction to Fort Providence (length of 54 km).

   Crossing of the Makenzie River will be achieved with insulated cables installed in a rack under the Deh Cho Bridge. Overhead to cable transition structures (riser structures) will be installed at the intersections of overhead line and the insulated cable.

E. Existing Single-Phase 14.4 kV Distribution Line Between Kakisa Junction and Kakisa to be upgraded to 3-phase 25 kV utilizing existing structures. The existing single-phase 14.4 kV line between Dory Point and Kakisa Junction is to be replaced with the new 25 kV circuit.

F. New 25 kV/4160 V substation in Fort Providence.

G. New Kakisa 25 kV substation (secondary voltage is not available).

H. New Dory Point 25 kV substation (secondary voltage is not available).

3. Project Description

The details for the various components defined in Section 2 are as follows:

3.1 A. New 72 kV Switching Station (Fort Smith HWY Junction Switching Station)

3.1.1 Station Proposed in Midgard Report

A new 72 kV switching station is proposed in the Midgard report at the Fort Smith Highway Junction south of Hay River (Junction of Highway - 5 and Highway - 2). The new switching station shall include three (3) 72 kV bays to accommodate the following lines:

- 72 kV line from the Pine Point substation;
- 72 kV line to the Hay River substation; and
- the proposed new 72 kV line to the Kakisa Junction substation.

Transmission dead end structures (just outside the new substation) shall be utilized to reduce the line tension so as to enable slack spans onto the 72 kV bays in the switching station.

A single circuit breaker was proposed in this station for Kakisa Junction circuit. The Midgard report also proposed two (2) additional circuit breakers included in the proposed switching station to facilitate future expansion and possible reconfiguration into a three-breaker ring bus. A single 72 kV circuit breaker was included in the initial phase to minimize costs, while still providing protection against the line between the switching station and the Kakisa Junction substation.

3.1.2 Substation New Configuration

Based on the technical reviews with Northwest Territories Power Corporation (NTPC), the new 72 kV switching station will be a conventional air insulated substation with a full ring bus configuration. It will include three (3) 72 kV circuit breakers to prevent a single point of failure to trip the new 72 kV line. The new 72 kV switching station will include following major components:

- 72 kV dead-tank circuit breakers Qty.= Three (3);
- 72 kV breaker disconnect switches Qty.= Six (6);
- 72 kV line disconnect switches Qty.= Three (3);
- 72 kV CVTs Qty.= Nine (9);
- 72 kV lightning arrestors on all line terminations Qty.= Nine (9); and
- One Control building including battery banks & chargers, AC/DC panels, protection and control panels and SCDA/Telecom panels

The Fort Smith Junction switching station is fed from NUL substation at Pine Point. The windings of the transformer in NUL substation shall be verified during the detail design stage to confirm the new 72 kV system is a Wye grounded configuration.

3.1.3 Station Site and Civil-Structural Works

Specific geotechnical and soil conditions at the site are unknown. Therefore, general site preparation techniques are assumed at this stage.

Organic soil will be removed from the substation site and replaced with suitable structural fill. A ground grid is installed into the graded and compacted foundation soil, extending at least 1 m outside of the substation fence.

All equipment, bus foundations, and building foundations are designed to mitigate frost-jacking, which can be expected to occur in this climatic zone.

After equipment and building foundations have been installed, the entire substation site is covered with an insulating layer of washed gravel (150 mm thickness) to mitigate step/touch potentials for workers inside the substation during fault conditions. It is assumed that a large number of deep-driven ground rods are needed to achieve effective substation grounding (to be defined during detailed design).

The substation is enclosed with a six (6) ft high wire fence topped with barbed or razor wire. All fence segments, fence posts, and gate posts are bonded to the ground grid.

3.1.4 Control Building

The control building is a pre-fabricated modular structure. Rack space requirement are minimal due to limited P&C, SCADA & Telecom requirements at this substation.

3.1.5 Protection, SCADA, & Voice Communication

Protection schemes applied at the new 72 kV switching station at Fort Smith Junction include:

- 72 kV Line distance protections.
- 72 kV Bus protection (if required).
- 72 kV Breaker failure protections.

It is expected that multifunction digital protection devices are utilized for protection of lines egressing from the 72 kV ring buses at the 72 kV switch station. Built-in protection functions in these relays will be utilized as per requirement that will be finalized during the detail design stage.

SCADA monitoring and control points will be provided for 72 kV breakers for this station. It is assumed that voice and SCADA communication between the system control centre and the new switching station are via leased lines / Power Line Carrier (“PLC”) and communication link provided by Northwestel.

3.1.6 Station Service Power

In general, two (2) separate AC auxiliary power sources will be installed in the switching station. The primary source of auxiliary power shall be obtained from a station service transformer (power PT) connected to 72 kV bus.

The back-up auxiliary power either can be obtained from a local community distribution system or from an on-site diesel generator. Diesel storage shall be provided with the diesel generator.

3.2 B. New 72 kV Transmission Line

New 72 kV transmission line from Highway-1/Highway-5 Junction (Point A) to Kakisa Junction (Point C). The proposed line follows Highway-2 in southward direction to Enterprise, then follows Highway 1 in northwest direction to Kakisa Junction (total length of 116 km). Between the Fort Smith Junction (point A) to Pellet Mill (point B), the 72 kV line also includes 36 km of 25 kV underbuilt circuit.

This line has the following parameters:

The 72 kV line from Pine Point to Hay River has to be sectionalized at the Fort Smith Junction (Point A).

From the new Switching station to be built in Fort Smith junction to Pellet Mill (about 36 km) the line will have an underbuilt 25 kV circuit + neutral.

- 72 kV line:
  - Total line length 116 km.
  - Three (3) phases. 1/0 Raven ACSR conductor (6/1 stranding, ø10.11 mm dia, 62.4 mm² equivalent cross-sectional area).
  - 1,241 wood pole structures (approx.) considering an average span of 100 m.
- 25 kV from Switching station to Pellet Mill:
  - Total circuit length 36 km (installed as underbuilt to the 72 kV circuit).
  - Three (3) phases + neutral. 1/0 Raven ACSR conductor.

(Potential installation of FO under the neutral in some locations to be defined during Detail Design phase).

3.2.1 Right of Way (RoW)

The 72 kV Line will be built on the Highway Right of Way (RoW), which has 30 m from either side of highway’s centerline, following the same alignment of the existing line from Hay River to Enterprise. All new transmission structures must be placed on the same side of the road as the existing distribution circuit with adequate setback from Northwestel Fiber Optic (FO).

Distance from the centreline to the edge of the RoW for the Transmission line is 8.5 m, for an assumed average Ruling Span of 100 m. Additional RoW requirement in longer spans shall be assessed on case by case basis during detailed design. The presence of the existing distribution circuit along Highway 2 and Northwestel Fiber Optic (FO) will increase the effort, complexity, and level of care involved in building the new transmission line between Hay River and Enterprise.

Adequate planning and staging will be required to minimize the impact in Enterprise community and other customers connected to the underbuilt 25 kV line. All new transmission structures must be placed on the same side of the road as the existing distribution circuit. Construction impacts include leaning the existing distribution structures to permit erecting the new transmission structures, and performing all structure construction, guying, and conductor stringing under “energized” or “live-line” conditions and also adequate setback from the FO.

Existing service drops are cut over to the new underbuilt 25 kV circuit after the double circuit transmission/distribution line has been constructed and energized.

During the Hatch site visit on October 30, 2019, it was observed that it was not possible to bury the Northwestel FO in several locations and should be raised and installed in poles where bed rock is near the ground surface due to geotechnical conditions (see Figure 3-1). In those cases, the FPHR line will be located on the other side of the highway or, if feasible after agreement with Northwestel, it may be more economical to install the FO as another underbuilt to the FPHR line.

Figure 3-1: Example of Bed Rock Near the Ground Surface

3.2.2 Structures

Typical structure considered for the 72 kV segment of the FPHR Project is a 3-phase single wood pole type structure. Pole heights are expected to range between 45 ft (13.7 m) and 75 ft (22.9 m), depending on site-specific centerline topography and circuit configuration. Taller poles will likely be required for the 36 km section of line that includes 25 kV underbuilt.

Dead-end type structures are considered at each 6 km or less for anti-cascade protection to limit structure losses in the event of conductor break or tangent structure failure. Nevertheless, during detailed design this condition will be re-evaluated as tension values are lower, then may not be any cascading failure.

Review of the System Studies and assessment of voltage unbalance, transposition structures may be required. This shall be confirmed during detail design.

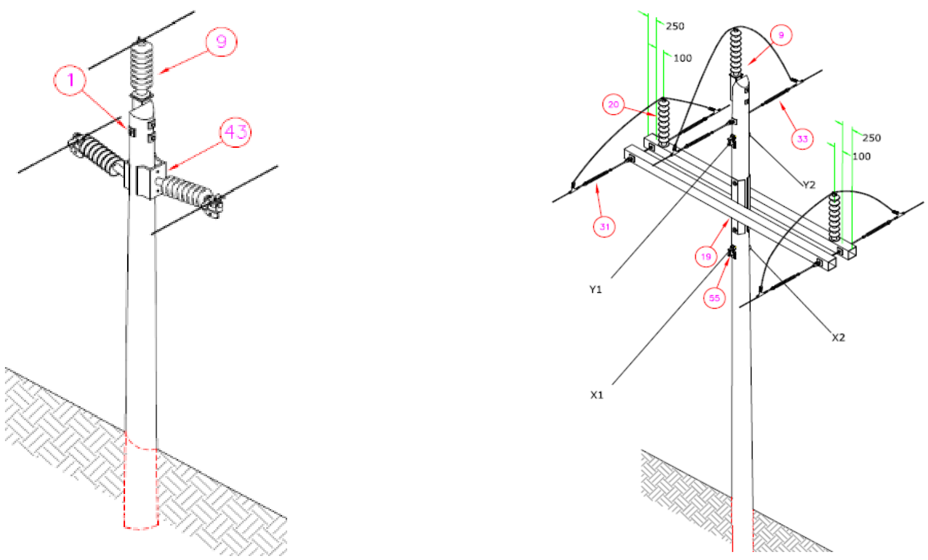


Figure 3-2: Examples of Poles

A total of six (6) different 72 kV structure types are considered as per the following table that summarizes the structure types and associated counts. Typical drawings for each structure type listed are provided in Appendix D. (A detailed listing for each structure is provided in Appendix C of the Midgard report).

Table 3-1: Drawing List

Structure Description	Count		Drawing #
	Single 72 kV Circuit	With Underbuilt Circuit	
Single pole tangent delta with horizontal and vertical posts	212	541	T15-SD-4176
Single pole vertical light angle with post insulators	38	9	T15-SD-4208
Single pole vertical medium angle	14		T15-SD-4210
Single pole light angle delta with horizontal and vertical posts	94	188	T15-SD-4276
Single pole double dead-end tangent with steel arms	9	11	T15-SD-4302
Single pole vertical double dead-end heavy deflection	3	5	T15-SD-4310

3.2.3 Conductors

The original design completed by NUL in 2009 and System Study specified the use of 1/0 Raven ACSR conductor for the 72 kV segment of the project. This conductor type is sufficient for the short span lengths in the line (approximately 80 m - 120 m) that does not requires a heavier cable. The project area is not expected to be subject to significant amounts of either glaze ice deposits or significant wet snow events. In-cloud icing is common in many areas of the Northwest Territories and Yukon. Hence a load case consisting of in-cloud icing, without wind, is included in the line design criteria.

The 25 kV underbuilt is also designed using 1/0 Raven ACSR conductor to match the existing 25 kV circuit terminating at the local Pellet Mill. 1/0 Raven ACSR is also utilized for the neutral conductor.

The characteristics of the 1/0 Raven ACSR conductor are as follows:

- Code Name: Raven
- AWG: 1/0
- Diameter (mm): 10.11
- Section Area (mm²)
  - Aluminum: 53.52
  - Steel: 8.92
  - Total : 62.44
- Weight (Kg/m): 0.216
- Rated Tensile Strength (kN) 19.5

3.2.4 *Insulation*

The preferred insulation to be used for all applications on the 72 kV transmission segment is composite type. It is intended that all insulation be limited to the use of Type J (ANSI 52-5) hardware.

Depending on final design specifications, it may be necessary to utilize porcelain insulators to manage uplift conditions for specific structures. The following insulator types are used for the 72 kV portion of the FPHR line.

1. 72 kV Suspension/Strain Insulators - Tangent applications use insulators with y-clevis-ball end fittings, whereas ball-socket type insulators are to be used for dead end and heavy angle applications.
2. 72 kV Line Post Insulators - The standard end fittings for tangent and light angle applications are drop eye for horizontal posts and trunnion clamps for vertical posts. Horizontal line posts may use optional trunnion clamp end fittings.

3.2.5 *Geotechnical Properties & Foundations*

There is limited access to geotechnical information for pole foundations or anchoring conditions.

The following table shows a breakdown, of soil types, made by Midgard in the 2013 report. The report provides specific recommendations (drawing numbers) for pole foundation and anchoring types.

Hatch will consider two typical solutions for foundations:

- Crib or culvert arrangement (with rock fill), where permafrost and/or bog depth is shallow (i.e., less than the pole burial depth).
- Wooden platform supporting crib or culvert with rock fill and additional side-guying of the structure, where permafrost and/or bog depth is greater than pole burial depth.

This will provide an economical solution without the need for geotechnical field testing at this stage of the project based on preliminary identification of soil conditions. The project plan will include a recommendation on the geotechnical testing.

Suitable anchoring will be defined during detailed design. For this report, anchors included in the Midgard report will be consider.

Table 3-2: Conditions and Recommendations

Line %	Description of Condition	Recommended Pole Foundation	Recommended Anchor Type
33%	4 inches of peat over brown calcareous gravelly loam	T15-SD-9940	T15-SD-9949
26%	Thin organic litter over 2 to 4 inches of yellowish-brown loam, over 16 to 20 inches of yellowish brown stony gravelly sandy loam, over shattered sandstone	T15-SD-9993	T15-SD-9949
14%	3 to 12 inches of peat over mottled calcareous loamy sand or sand	T15-SD-9940	T15-SD-9923
9%	12 to 40 inches of black disintegrated peat; frozen below a depth of about 18 inches	T15-SD-9948	T15-SD-9923
9%	Thin organic litter over 6 to 10 inches of brown gravelly loam, over yellowish-brown very stony gravelly sandy loam that grades into sandstone	T15-SD-9993	T15-SD-9949
6%	6 to 12 inches of peat over calcareous silty clay loam	T15-SD-9993	T15-SD-9923
3%	3 inches of organic litter over 5 inches of grayish silty clay loam, over calcareous grayish silty clay loam.	T15-SD-9993	T15-SD-9949

3.3 C. New 72/25 kV Substation at Kakisa Junction.

To reduce line costs from Kakisa junction to Fort Providence, and also to economically serve loads at Kakisa, Dory Point and along Highway 1, the proposed new Kakisa Junction substation steps down the line voltage from 72 kV to 25 kV.

The substation is proposed to be located on the north side of Highway 1 at the junction of Highway 1 and the road to Kakisa (specifically at UTM coordinates: Zone 11, 488139 m E, 6760360 m N).

The new Kakisa Junction Substation will be a conventional air insulated substation with the following major components:

- 72 kV disconnect switch Qty = Two (2);
- 72 kV CVT Qty = Three (3);
- 72 kV lightning arrestors Qty = Nine (9);
- 72 kV Shunt Reactor Qty = One (1);
- 72 KV Reactor Circuit Switcher Qty = One (1);
- 72 kV CTs Qty = Four (4);
- 72/25 kV 1.5MVA Transformer Qty = One (1);
- 25 kV dead-tank circuit breaker Qty = One (1);
- 25 kV Disconnect Switches Qty = Three (3);
- 25 kV VTs Qty = Three (3);

- 25 kV Voltage Regulator Qty = One (1);
- 25 kV lightning arrestors Qty = Nine (9); and
- One Control building including battery banks & chargers, AC/DC panels, protection and control panels and SCADA/Telecom panels.

3.3.1 Substation Site and Civil-Structural Works

Specific geotechnical and soil conditions at the site are unknown. Therefore, general site preparation techniques are assumed at this stage.

Organic soil will be removed from the substation site and replaced with suitable structural fill. A ground grid is installed into the graded and compacted foundation soil, extending at least 1 m outside of the substation fence.

All equipment, bus foundations, and building foundations are designed to mitigate frost-jacking, which can be expected to occur in this climatic zone.

After equipment and building foundations have been installed, the entire substation site is covered with an insulating layer of washed gravel (150 mm thickness) to mitigate step/touch potentials for workers inside the substation during fault conditions. It is assumed that a large number of deep-driven ground rods are needed to achieve effective substation grounding (to be defined during detailed design).

The substation is enclosed with a six (6) ft high wire fence topped with barbed or razor wire. All fence segments, fence posts, and gate posts are bonded to the ground grid.

For the purpose of this preliminary design it has been assumed that, to the greatest extent possible, substation components are fabricated offsite using modular construction techniques to avoid the high cost and seasonal construction restrictions that would be involved with on-site construction. For example, the control building and low voltage switchgear is fabricated offsite and transported to site fully assembled

3.3.2 72 kV Equipment & Buswork

The Kakisa Junction substation is radially fed via the 72 kV transmission line from the new 72 kV switching station located at the Fort Smith Highway Junction and is not expected to be integrated into a networked power system over a 20-year planning horizon. Given this assumption, no allowance is made for multiple 72 kV line terminations, 72 kV breakers, sectionalizing switches, or other related buswork. It is important to note that although the Draft 2013 Northwest Territories Power System Plan does include a possible transmission grid extension to Fort Simpson, substation components to enable such an expansion are not included as part of this preliminary design. Site acquisition for this substation may consider a large enough footprint to enable future expansion of the 72 kV bus to include a 72 kV breaker and line termination to serve Fort Simpson & Jean Marie River.

The 72 kV bus consists of a simple wire bus from the A-frame to the transformer bushings. A disconnect switch are is utilized to provide transformer isolation, and transformer protections will trip the upstream breakers. The 72 kV bus is equipped with potential transformers and lightning arrestors are connected to the incoming lines. Circuit switcher lightning arrestors and current transformers are used for the reactor protection.

3.3.3 72 kV Shunt Reactor

The 72 kV transmission line is expected to remain lightly loaded relative to the line's Surge Impedance Loading ("SIL") across all forecast load conditions throughout a 20 year planning horizon.

It is therefore assumed that a shunt reactor must be energized at all times to maintain the 72 kV bus voltages within tolerance.

The optimal size and placement of a shunt reactor has not yet been determined. Given the preliminary level of design, the shunt reactor is assumed to be built as part of the Kakisa Junction Substation. The reactor size and placement should be verified by future power system studies.

3.3.4 72/25 kV Transformer & Regulator

A two-winding 3-phase 72/25 kV 1.5 MVA oil insulated transformer will be installed in the Kakisa substation.

The transformer is not equipped with an On Load Tap Changer ("OLTC"). For ease of maintenance and to coordinate with existing spares, a separate voltage regulator is provided to maintain 25 kV line voltages.

A pole-mounted regulator can be installed on the 25 kV side of the Kakisa substation to maintain the voltages at the Kakisa load centre and Fort Providence load centres. An alternative option is to install separate pole-mounted regulators at Kakisa load centre, Dory Point and Fort Providence load centre respectively. The locations and sizing of the regulators shall be verified in detail designs.

3.3.5 25 kV Switchyard

Midgard proposed an enclosed explosion-proof metal clad switchgear for 25 kV side of this substation. As observed during the site visit of other substations, a simple air insulated configuration for 25 kV equipment should be an economical option to avoid large foundation of switchgear and underground 25 kV power cables for connections.

A 25 kV breaker is provided at the Kakisa Junction substation. Two 25 kV circuits (to Kakisa and Fort Providence) are connected to 25 kV breakers with separate disconnect switches.

Due to expected high structure footing resistance, the 25 kV circuit to Dory Point and Fort Providence is equipped with a neutral conductor to provide a positive ground return path and to ensure effective rapid clearing of single-phase faults. The 25 kV neutral conductor is bonded to the substation ground grid

3.3.6 *Protection, SCADA, & Voice Communication*

Protection schemes applied at the Kakisa substation include:

- Transformer differential;
- Transformer primary and secondary instantaneous and time overcurrent;
- Breaker failure protections;
- 72 kV reactor instantaneous and time overcurrent;
- 72 kV bus/line protections; and
- 25 kV feeder protections.

It is expected that multifunction digital protection devices are utilized for protection of electrical equipment in the substation including bus, transformer, reactor and lines. The transformer protection module provides overvoltage protection for the 72 kV bus. Both the transformer and reactor protections trip the 72 kV breakers and other sources feeding this fault.

SCADA monitoring points include 72 kV and 25 kV bus voltages, transformer primary and secondary phase currents, transformer temperature, transformer gas, reactor phase currents and reactor gas (if applicable). Control points are limited to 25 kV breaker trip and close.

It is assumed that voice and SCADA communication between the system control centre and the Kakisa Junction substation are via leased lines / Power Line Carrier ("PLC") and communication link provided by Northwestel. There are few monitoring points and little remotely operable equipment at the substation, therefore, low baud rate offered by a PLC system should not introduce any significant constraints.

3.3.7 *Station Service Power*

In general, two (2) separate AC auxiliary power sources are installed in the switching station. The primary source of auxiliary power shall be obtained from a station service transformer connected to 25 kV bus.

The back-up auxiliary power either can be obtained from a local community distribution system or from an on-site diesel generator. Diesel storage will be provided with the diesel generator.

3.4 D. New 25 kV Distribution Line from Kakisa Junction to Fort Providence

The 25 kV segment of the FPHR Project originates at the proposed Kakisa Junction 72/25 kV substation and terminates at a small substation located outside of Fort Providence for a total line length of 54 km.

This line has the following parameters defined in the NUL 2009 System Study report:

1. Line length of 54 km (including insulated cable for the Makenzie River crossing).

2. Three (3) phases. 266.8 MCM Waxwing ACSR conductor (18/1 stranding, ø15.45 mm, 135/7.5mm² cross -sectional area).
3. Neutral 1/0 Raven ACSR conductor (6/1, ø10.11 mm, 53.52/8.92 mm²).
4. 536 wood distribution poles (approx.) considering an average span of 100 m.
5. 1.7 km of insulated cable to be installed in conduit and/or rack under the Deh Cho bridge to cross the Makenzie River. It is assumed that cable will be 3-phase XLPE. Raiser structures including surge arrestors and switches to be installed in both sides of the bridge. Proper coordination with the Infrastructure Department of the GNWT is required to define use of exiting racks and conduits for the transition can be used.

Figure 3-3: Deh Cho Bridge for Mackenzie River Crossing

The line can be separated into three sections:

1. Kakisa Junction Substation to Deh Cho Bridge (Dory Point):

   The 25 kV circuit originates at the Kakisa Junction substation (UTM Coordinates: Zone 11, 488139 m E, 6760360 m N) in the Highway 1 to Kakisa junction. The centerline follows Highway 1 northwest, across the Kakisa River, until the turn-off north on Highway 3. Highway 3 is followed north to the community of Dory Point located on the southern banks of the Upper Mackenzie River.

2. Deh Cho Bridge Crossing:

The 25 kV circuit is converted to underground cable via a cable riser structure and crosses the Deh Cho Bridge as an insulated cable attached to a rack under the bridge structure.

3. Deh Cho Bridge to Fort Providence Substation:

   A second cable riser structure is utilized to return the 25 kV circuit to the overhead system on the north bank of the Mackenzie River. Highway 3 is followed until the turn-off to Fort Providence at which point the 25 kV circuit follows the road to its termination point at the southernmost 3 phase structure located as part of the existing Fort Providence distribution system. The 25 kV circuit is interconnected with Fort Providence via a small pad-mounted substation (see C above).

   At the north, there is a portion that runs parallel to the Fort Providence Airport. During detailed design proper assessment of aeronautical requirements will be made to ensure the safe operation. At this stage it is assumed that the 25 kV line can be installed in the same alignment of existing distribution line.

The existing road allowance along Highway 1 and Highway 3 is assumed to be of sufficient width for construction of the distribution line. Minimal clearing and brushing may be required at certain locations.

3.4.1 Structures

The typical structure considered for the 25 kV segment of the FPHR Line is a single wood pole type. The majority of poles are expected to be 13.7 m (45 feet) in height. Taller poles (up to 18.29 m or 60 feet) are occasionally required to accommodate crossing specific ground features such as highways or rivers. Dead-ends are included each 6 km or less as anti-cascade protection to limit structure losses in the event of conductor break or structure failure (during detailed design this condition will be re-evaluated as tension values are lower, then may not be any cascading failure).

The Following figure contains sketches of a typical tangent single wood pole structure and a typical dead-end single wood pole structure. For drawings specific to the neutral conductor, see Appendix C (Typical Structures & Foundation Drawings).

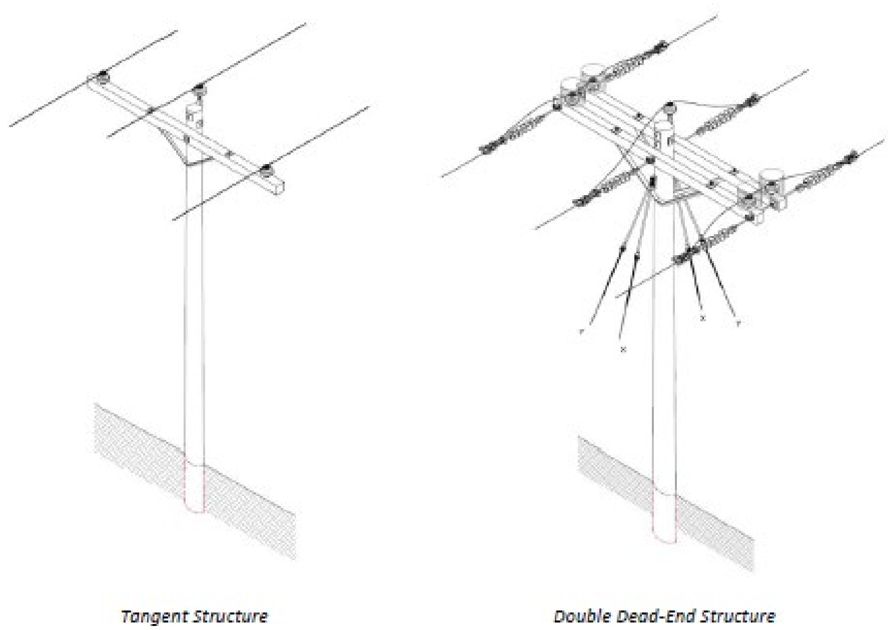


Figure 3-4: Typical Tangent and Dead End Single Wood Pole Structures

Table 3-3: Drawing List

Structure Description	Count	Drawing #
Single Pole Tangent	3	D15-SD-3172
Single Pole Light Angle	369	D15-SD-3274
Single Pole Double Arm Medium Angle	119	D15-SD-3276
Single Pole Tangent Double Dead-End	32	D15-SD-3380
Single Pole Double Dead-End Flat with 90˚ Angle Change	25	D15-SD-3382
3-Phase Riser Pole Underground Dip	9	D15-SD-3903
Custom Structures H-Frame for Kakisa River crossing and connection to Kakisa community	3	

Figure 3-5: Utility Line on North Part of Deh Cho Bridge

In the north part of the bridge, there is a utility line and the Northwestel FO, that doesn't interfere with the 25 kV distribution line that will remain in the eastern most side of the bridge.

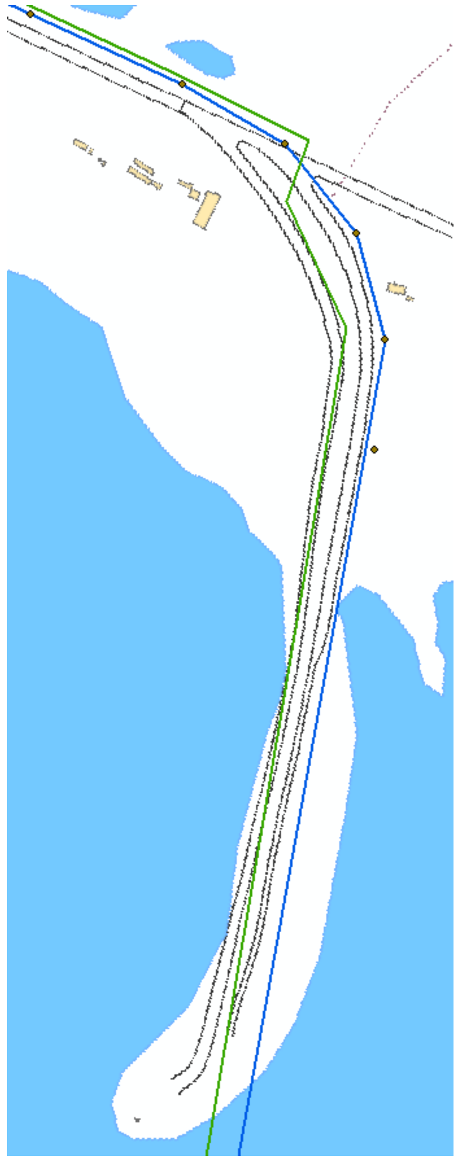


Figure 3-6: 25 kV Line North of Deh Cho Bridge

Currently Kakisa and Dory Point are energized from a diesel plant located in the south of the Deh Cho bridge near to Dory Point. With the new 25 kV line built, the diesel plant will not be the main power source for Kakisa and Dory Point. This diesel plant may remain in operating conditions as power back-up when the new 25 kV line is off. Modifications of the diesel plant switchyard with connections to the new 25 kV line are required to make back-up option work, which also depends on the condition of the existing equipment in the diesel plant.

3.5 E. Existing Single-Phase 14.4 kV Distribution Line to Kakisa

Existing single-phase 14.4 kV distribution line between Kakisa and Kakisa Junction will be upgraded to 3-phase 25 kV utilizing existing structures (about 13 km of line). The existing single-phase 14.4 kV line between Dory Point and Kakisa Junction is to be replaced with the new 25 kV circuit.

The 2013 Report assumes that existing line from Kakisa Junction to Kakisa will be upgraded with the addition of two (2) phases of No. 2 AWG ACSR conductors. Nevertheless, during Hatch's site inspection, it was observed that many poles are severely damaged because of ageing and recent wildfires. Therefore, full replacement of poles is recommended to accommodate the three (3) phases of No. 2 AWG and neutral.

3.6 F. New 25 kV/4160 V Substation in Fort Providence

The Fort Providence 25 kV/4160 V substation consists of a pole mounted 1.5 MVA transformer to step down the line voltage from 25 kV to 4160 V (the assumed distribution voltage at Fort Providence). Pole-mounted 25 kV sectionalizing switches, 4160 V fusible disconnects, and lightning arrestors for both the 25 kV and 4160 V circuits are included in the design. Provision for a 25 kV faulting switch is included, but may not be required (to be determined during detailed design).

At this preliminary stage of design, a pole-mounted transformer station is assumed. The photo below illustrates a typical pole-mounted station.

Figure 3-7:Typical Pole Mounted Transformer Station

If pole-mounted transformer is not feasible for the Fort Providence substation, an enclosed type pad-mounted transformer can be used. Site preparation is minimal and includes a poured concrete foundation with underground conduits to connect with the overhead system. No fencing is required at this site.

The existing diesel generator station will be kept as back-up power supply in case the 72 kV line from the new Kakisa Junction Substation is out of service. This diesel generator station will feed for Providence and the loads in Dory Point and Kakisa through the new 25 kV line.

The only potential modification required at the existing Fort Providence diesel generators will be the installation of a synchronizing system and breaker to ensure that the diesel generators do not attempt to connect to the distribution system when it is already energized via the new 25 kV line from the Kakisa Junction Substation. It may also be necessary to install auto-start capability to ensure rapid restoration following loss of interconnection with the transmission grid. In addition, it may also be necessary to install remote control at the Fort Providence generators (if that does not already exist) to enable them to be de-energized before attempting to energize the 25 kV system from the Kakisa Junction substation.

3.7 G. Kakisa Substation

The existing Kakisa substation (Kakisa load centre) in the Kakisa community was not identified in the Midgard report.

During the Hatch site visit on October 30, 2019, the location of the Kakisa substation was not found. It is assumed that a small pole-mounted transformer is used for supply power to Kakisa community due to the small size of residential community at this place.

With the new 3-phase 25 kV line going to Kakisa, the Kakisa substation will be similar as the new Fort Providence substation with smaller capacity and lower secondary voltage. The secondary voltage will depend upon the capacity and voltage levels of the existing Kakisa substation. The Kakisa substation will consist of a pole mounted transformer, 25 kV lightning arrestors, and fusible disconnects and lightning arrestors for transformer secondary side.

No other protection and communication is required for this substation.

3.8 H. Dory Point Substation

The Midgard report does not address the diesel plant at Dory Point feeding Kakisa and previous ferry loads. During the site visit on October 30, 2019, a diesel plant located south of Deh Cho bridge on Mackenzie River was observed.

As discussed with NTPC, currently Kakisa and Dory Point are energized from this diesel plant. Because the condition and capacity of this diesel plant are unknown, using this diesel plant as redundant back up power for 25 kV distribution may not be suitable. Further assessment should be done if this diesel plant can be maintained for redundant power purpose. An option for connecting the diesel plant to the new 25 kV line could be a tap connection to the new line at the diesel plant location. The configuration of the diesel plant switchyard shall be modified for the connection and a synchronizing breaker to ensure that the diesel plant do not attempt to connect to the new 25 kV line when it is already energized.

The back up power for Fort Providence, Dory Point and Kakisa will come from the diesel plant in Fort Providence as addressed in section G.

4. Power System Studies

Midgard report is based upon a previous study issued by Northland Utilities Limited ("NUL") in 2009 that includes Steady State Analysis (Part 3) and Dynamic Analysis (Part 4).

Hatch has reviewed the report and the comments are provided in this section of the report. It is recommended that Power System Studies are updated to actual values as indicated in the following sections.

4.1 Steady State Analysis

The Single Line Diagram (SLD) of the existing and the proposed system is shown below.

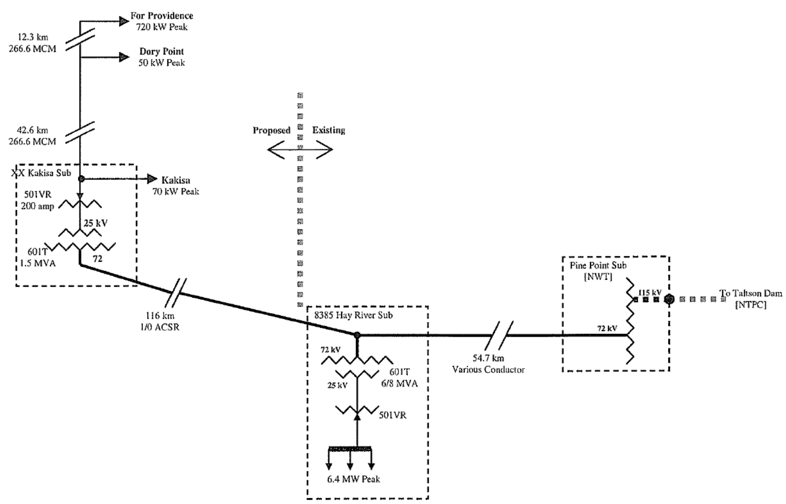


Figure 4-1:Conceptual SLD Proposed Expansion

NUL has requested that ATCO Electric (AE) perform a feasibility study of the connection of Fort Providence, Dory Point, and Kakisa communities to the existing Taltson system, allowing them to be powered by the larger Hydro generation.

It is considered that all the diesel generating stations are on standby and not considered in this study. In the opinion of Hatch, this assumption is valid only for the steady state analysis. However, the presence of the diesel generating stations need to be considered for electrical configuration and protection schemes.

4.1.1 Conductor Size

1/0 ACSR was used for the 72 kV portion of line. 266.6 MCM ACSR was selected for the 25 kV portion of line in order to maintain acceptable service voltages at the end of the line.

Hatch comment: The 25 kV conductor model is different with what mentioned earlier in the report. This may affect the results. Further investigation is required.

4.1.2 Voltage Regulation

200 A regulator is modeled at 72 kV - 25 kV step down transformer, which will be located at the proposed Kakisa substation.

4.1.3 Transformers Size

A 72/25 kV, 1.5 MVA two-winding transformer was modeled.

4.1.4 System Loading

Loads were modeled using historic peaks. 10 % aggregate load growth was added in order to create a conservative model, and to allow for marginal future load growth. Regional operators do not expect substantial future load growth as shown in Table 4-1, nevertheless it is recommended to review this assumptions.

Table 4-1: System Maximum Loading

Community	Peak Load (kW)	Peak Year	Modeled Load (kW)
Hay River	6307	2007	6,938
Kakisa	122	2000	81
Dory Point	122	2000	54
Fort Providence	704	2000	774

Loads were modeled assuming the power factor of 0.9.

4.1.5 Steady State Voltage Analysis

NUL report shows the station voltages for System Maximum and Minimum Loading but in different sections.

Two different results presentation format (table and graph) are used for the system the maximum loading and the low loading. It is recommended that all the results to be summarized in one table.

4.1.5.1 *Maximum Loading:*

The results for the system voltages during the maximum loading are shown in the following.

Table 4-2: Stations Voltages During the Maximum Load Scenario

Community	Peak Load (kW)	Steady State Voltage (pu)
Hay River	6307	0.97
Kakisa	122	1.036
Dory Point	122	1.015
Fort Providence	704	1.009

4.1.5.2 Minimum Loading

Figure 4-1 shows the system voltage during the no load scenario.

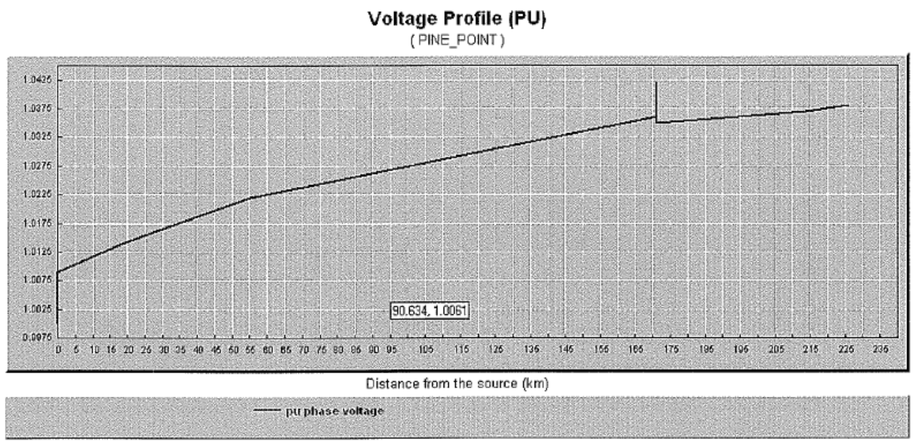


Figure 4-1: System Voltage Profile During the No Load Case

Hatch opinion is that No critical voltage issue is observed for system voltages (the voltage variations are within 5%) during the no load and maximum loading scenario.

Although the results show no concern regarding the system voltage profile, the voltage level and the short circuit level at the Pine Point Sub is not provided which can affect the results and may justify the need for reactive power compensation.

Hatch recommends testing the system with voltage at Pine Point Sub at 1.05 pu for the worst case scenario to ensure the reliability of the system.

4.1.6 Short Circuit Analysis

Table 4-3 shows the short circuit levels at each substation.

Table 4-3: Short Circuit Current Summary

Community	LLL	LLG	LG	LG(20)
Hay River	191	186	165	160
Kakisa (72)	139	135	109	106
Kakisa (25)	139	135	109	106
Dory Point	246	237	209	185
Fort Providence	173	163	134	124

As shown in Table 4-3, the fault current is very low especially towards the line end. Therefore, protection coordination may be difficult, depending on the type and number of protective devices deployed.

Hatch comments to determine the basis for selection of 20 Ω.

4.1.7 Voltage Unbalance

A 2.1% voltage unbalance is observed by placing 0 kW on Phase C, which according to the report, is above IEC requirements.

This illustrates the importance of keeping loads as balanced as reasonably possible. This should also be considered when designing protection, primarily in the application of single-phase protective devices.

Hatch recommends that a transposition is required along the 72 kV line to reduce the effect of system loading on the system voltage imbalance.

4.1.8 Maximum Capacity

The system can support a 41% increase in system loading. According to the report, it is mentioned that the 41% capacity does not consider the load growth on the NTPC system and which may further limit the new system capacity.

It is necessary to provide the basis for the 41% system support for the load growth and clarify why the NTPC load growth may affect the new system loading support capability.

4.1.9 Summary of Hatch Comments (Steady State Analysis)

This section summarizes Hatch’s comments on the report for the power system steady state analysis

- Although the absence of diesel generator for steady state analysis is a valid assumption, these need to be considered for design of protection devises.
- The 25 kV line is different with what mentioned earlier in the report. This may affect the results. Further investigation is required.
- The protection and coordination studies is required in the design early stages due to the system low short circuit level and long transmission line at these voltage level (72 kV and 25 kV).
- The report shows the station voltages for System Maximum and Minimum Loading but in different sections.
- Two different results presentation format (table and graph) are used for the system the maximum loading and the low loading. It is recommended that all the results to be summarized in one table.
- The voltage unbalance needs further investigation and 72 kV line transposition might be required to mitigate the issue.

Although the results show no concern regarding the system voltage profile, the voltage level and the short circuit level at the Pine Point Sub is not provided which can affect the results and may justify the need for reactive power compensation.

Hatch recommends testing the system with voltage at Pine Point Sub at 1.05 pu for the worst case scenario to ensure the reliability of the system.

- Determine the basis for selection of 20 Ω.
- It is necessary to provide the basis for the 41% system support for the load growth and clarify why the NTPC load growth may affect the new system loading support capability.

4.2 Dynamic Studies

The dynamic issues explored in this report are:

1. Line energization issues.
2. Impact of losing the existing four (4) MVar shunt reactors at Pine Point Substation.
3. The MVar impact of the new line on existing operation of the system.
4. Response to faults.

There are other studies to be considered due to the system weakness and the radial configuration (clarify that these have not been received by Hatch; and it is not clear if these have been carried out or not).

1. Breakers Transient Recovery voltage study.
2. Transformer energization study.

4.2.1 Impedance Scans

Impedance scans were taken at the Taltson 115 kV bus to ascertain the likely harmonic response of the system. An impedance scan involves shorting out the voltage source buses and injecting a variable frequency current source at the point of interest. With this data, the input impedance of the system as a function of frequency is generated. The natural resonance points can be identified. If the system is tuned near the 2nd, 3rd or other harmonic frequency, the potential for temporary harmonic resonance leading to an overvoltage may arise if there is a source of current at the frequency in question. The most likely cause of this current would be transformer pickup. Surge arresters could be at risk along with the stressing of transformer insulation and customer equipment. Impedance scans are taken for the following conditions:

1. Existing system up to an including Pine Point but no 72 kV lines.
2. Existing system including Hay River.

The system frequency scan with and without the new extended system are shown in the following figures:

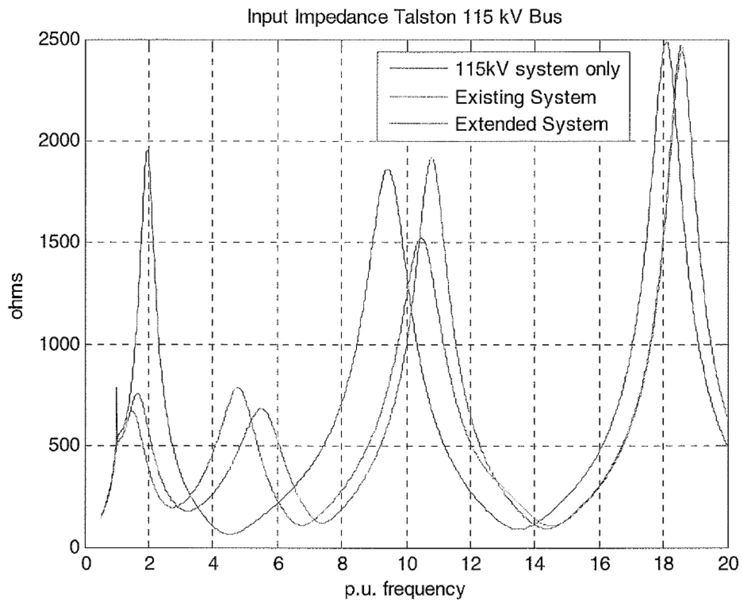


Figure 4-2: System Frequency Scan Without the New System Extension

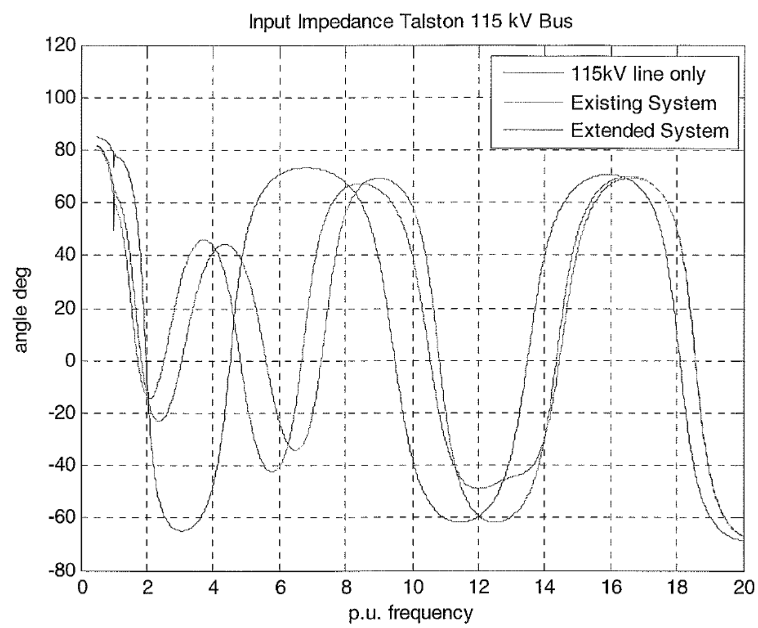


Figure 4-3: System Frequency Scan With the New System Extension

The first peak slightly below 2 per unit frequency (120 Hz) for the case with only the 115 kV system is quite high'. This parallel resonance occurs at 1.98 per unit (119 Hz). The suggested safe margin between the natural peak and an even harmonic is 6 Hz.

As additional lines are added at 72 kV, the lowest natural frequencies shift downward away from the 2nd but an additional peak near the 5th harmonic has been added. The natural frequencies are shown in Table 1.0 of the NUL Report. The existing system has sensitivities near the 5th and 11th harmonic which are typically generated by VFDs and DC converters. Overall the results suggest issues for pick up of the 115 kV system but few if any harmonic issues for the extended system.

- **Hatch Comment:** Another system impedance scan is required at Kakisa transformer station for both series and parallel impedance scan cases.

  Does the frequency scan with the new system considered the 25 kV line as well or only the **addition** of 72 kV line is considered?

  Please provide the reference for suggested safe margin of 6 Hz between the natural peak and an even harmonic.

4.2.2 *Line Pickup from Taltson*

In this section, pickup of the 115 kV line to Pine Point is explored. The 72 kV breaker at NUL is assumed to be open and there is no load on the system, a situation that may arise during restoration of the system. The voltage at the Pine Point 115 kV bus is shown in Figure 4-4.

Meanwhile, the voltage at Hay river 72 kV is shown in Figure 4-5.

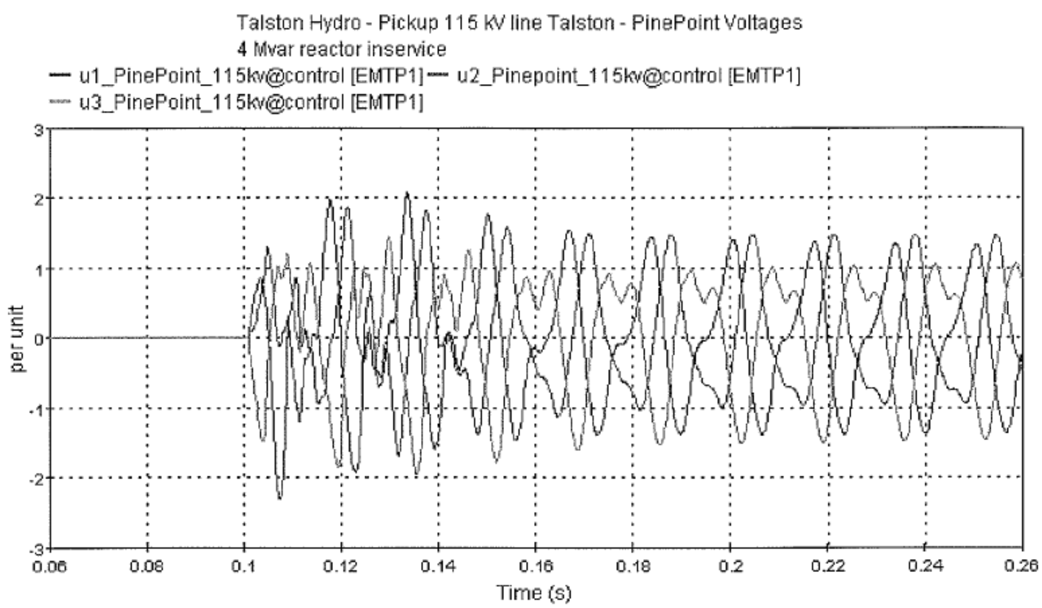


Figure 4-4: Voltage at Pine Point During the 115 kV Line Energization

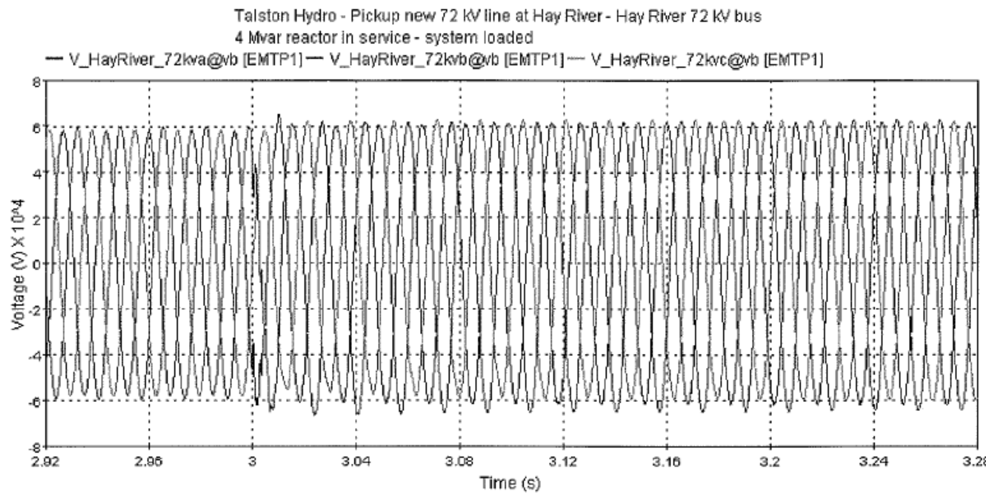


Figure 4-5: Voltage at Hay River Point During the 72 kV Line Energization

Hatch Comment: Although it is shown that the energization of 72 kV line does introduce significant harmonics on the system voltage, it is recommended to test the energization of 115 kV/72 kV and 72 kV/25 kV transformers.

The report also indicates the TOV at 25 kV bus at Kakisa station which could not be fully compensated by the generator exciter action. The need for 2.5 MVar additional reactive power compensation is determined. This can add complexity to protection and coordination. Additional studies are required to investigate the effect of 2.5 MVar compensation.

4.2.3 Impact of Losing Pint Shunt Reactor

The effect of the reactor drop on selected buses are shown in Figure 4-6. The voltage rise can reach to 1.15 pu and reduce to ~1.06 pu by the generator exciter action. As mentioned in the report, the 8.9 MVar reactive power absorption from the generator is expected which is further outside its capability curve.

Hatch Comment: According to this results, since the system is very sensitive to contingencies, further investigation on required reactive power compensation is required.

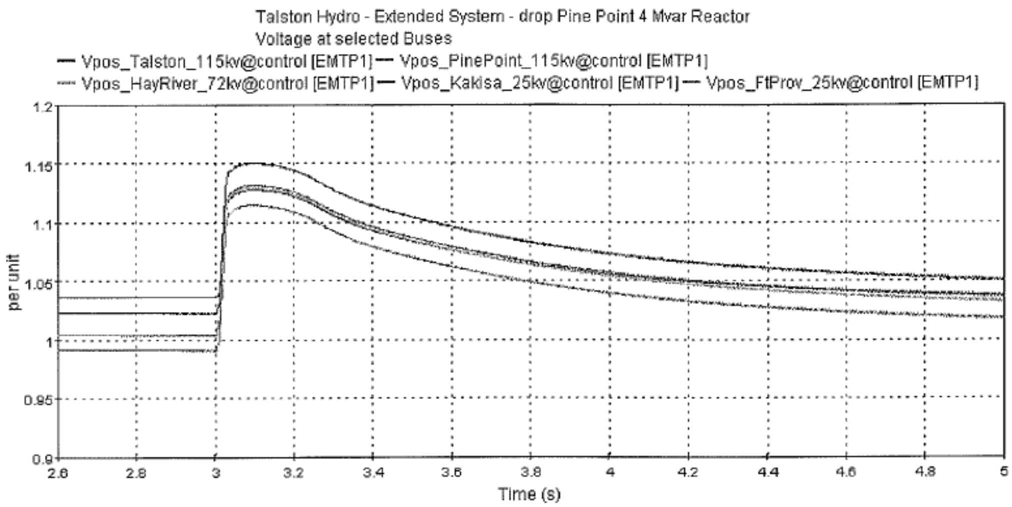


Figure 4-6: Effect of Reactor Drop on Selected Buses

4.2.4 *Response to Faults*

Various fault scenarios are tested. It is observed that the system recovery might be an issue specially for the 3-phase fault.

- **Hatch comment:** It is recommended to provide a summary of all substation fault current levels in addition to the provided ones for benchmarking purposes. Table 4-3 shows the fault current at Dory Point equal to 185 Arms while in this section the fault is 191 Arms. Please provide the detail of the study and the reason for the difference.

4.2.5 *Summary of Hatch Comments (Transient Studies)*

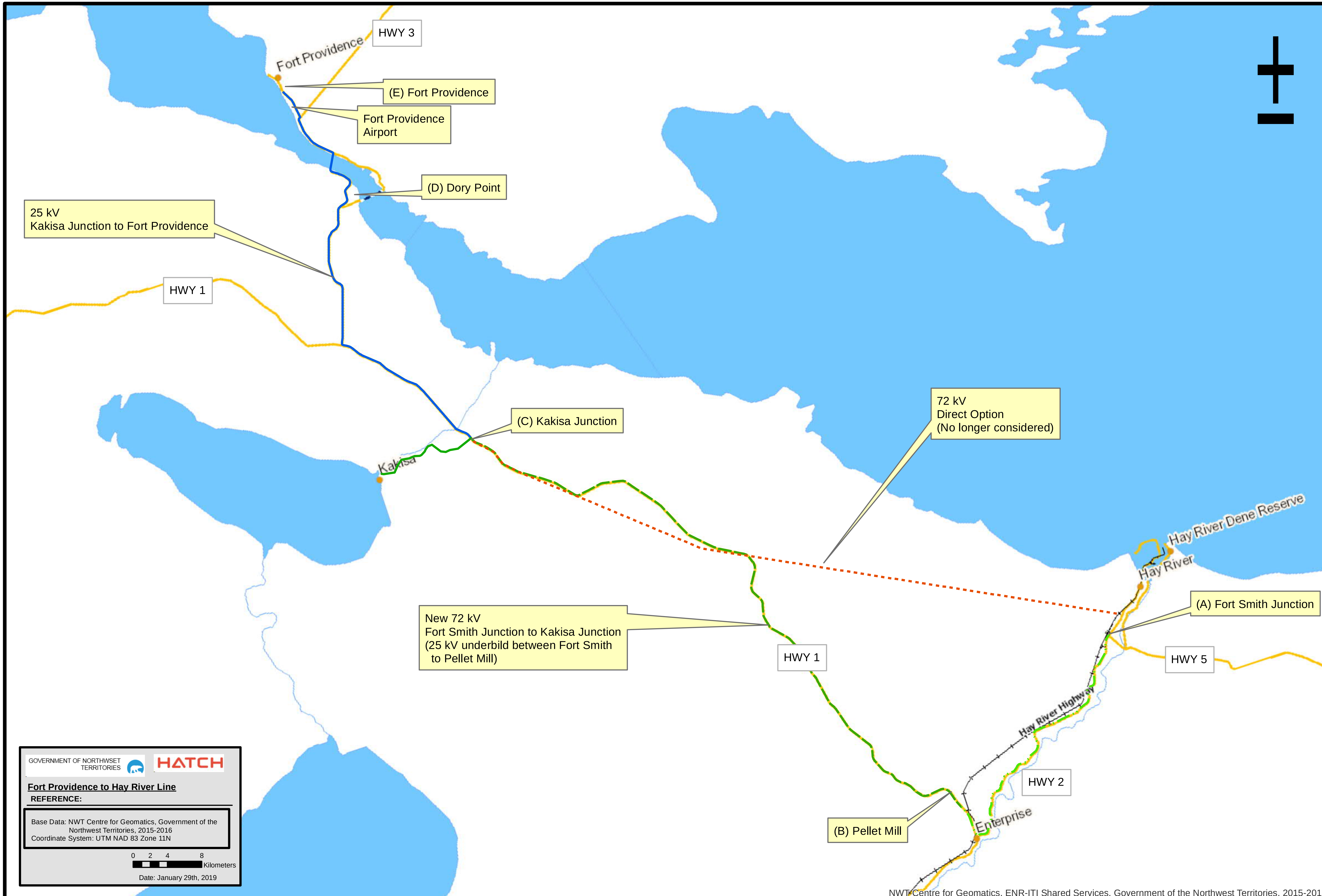
- The study name should be changed to “Transient studies”.
- There are other studies to be considered due to the system weakness and the radial configuration:
  - Breakers Transient Recovery voltage study.
  - Transformer energization study.
- Another system impedance scan is required at Kakisa transformer station for both series and parallel impedance scan cases.
- Does the frequency scan with the new system considered the 25 kV line as well or only the addition of 72 kV line is considered?
- Please provide the reference for suggested safe margin of 6 Hz between the natural peak and an even harmonic.
- Although it is shown that the energization of 72 kV line does introduce a significant harmonics on the system voltage, it is recommended to test the energization of 115 kV/72 kV and 72 kV/25 kV transformers.

The report also indicate the TOV at 25 kV bus at Kakisa station which could not be fully compensated by the generator exciter action. The need for 2.5 MVar additional reactive power compensation is determined. This can add complexity to protection and coordination. Additional studies are required to investigate the effect of 2.5 MVar compensation.

- Since the system is very sensitive to contingencies, further investigation on required reactive power compensation is required.

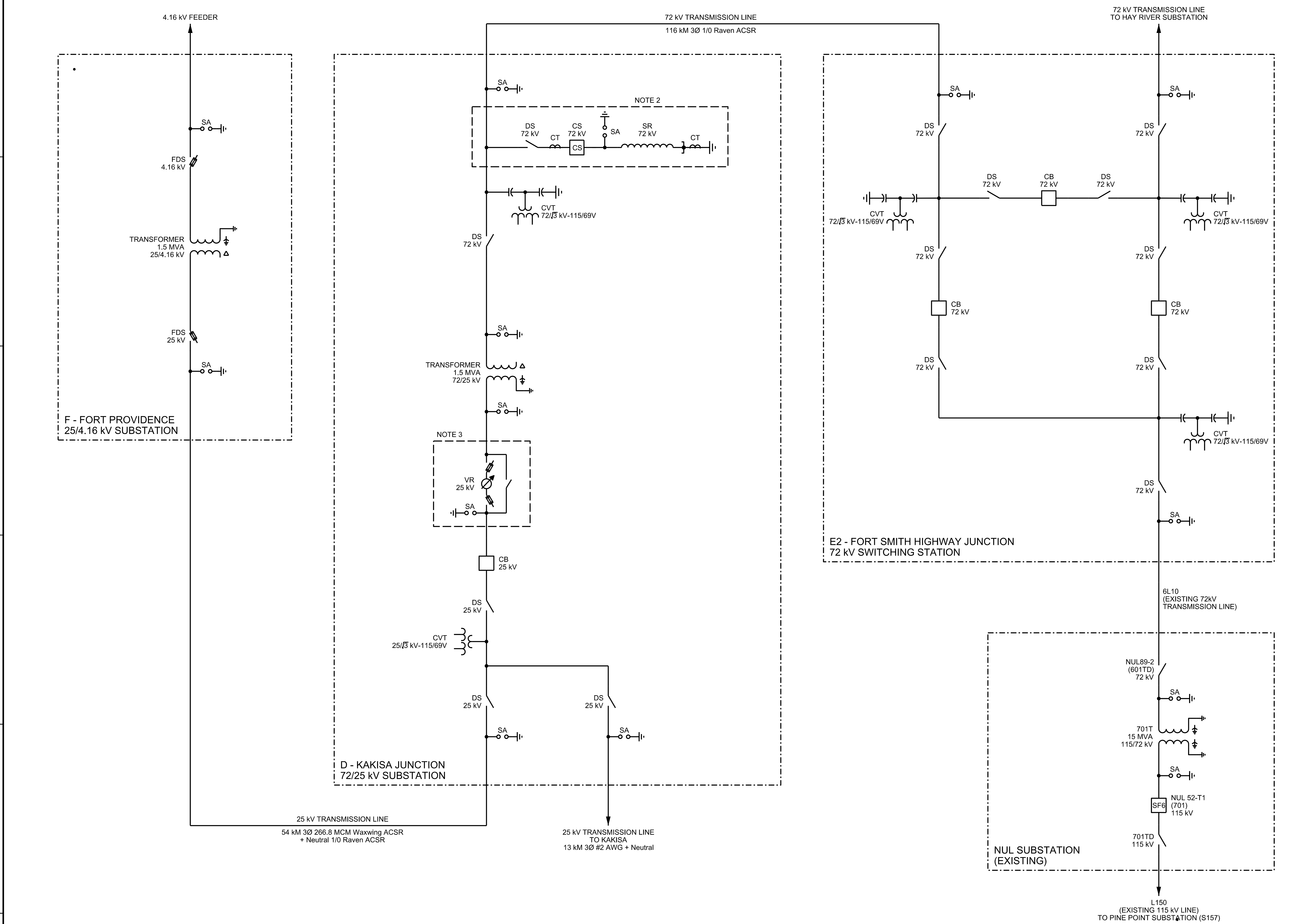
It is recommended to provide a summary of all substation fault current levels in addition to the provided ones for benchmarking purposes. Table 4-3 shows the fault current at Dory Point equal to 185 Arms while in this section the fault is 191 Arms. Please provide the detail of the study and the reason for the difference.

Appendix A: Project Map


HWY 3
Fort Providence
(E) Fort Providence
Fort Providence Airport
(D) Dory Point
25 kV
Kakisa Junction to Fort Providence
HWY 1
(C) Kakisa Junction
Kakisa
72 kV
Direct Option
(No longer considered)
Hay River Dene Reserve
Hay River
(A) Fort Smith Junction
HWY 5
New 72 kV
Fort Smith Junction to Kakisa Junction
(25 kV underbild between Fort Smith
to Pellet Mill)
HWY 1
Hay River Highway
HWY 2
Enterprise
(B) Pellet Mill
GOVERNMENT OF NORTHWSET TERRITORIES
HATCH
Fort Providence to Hay River Line
REFERENCE:
Base Data: NWT Centre for Geomatics, Government of the Northwest Territories, 2015-2016
Coordinate System: UTM NAD 83 Zone 11N
0 2 4 8
Kilometers
Date: January 29th, 2019
NWT Centre for Geomatics, ENR-ITI Shared Services, Government of the Northwest Territories, 2015-2016

Appendix B:
Overall Single Line Diagram

DWG. No. H361430-00000-260-288-0001



NOTES:

1. THIS IS A PRELIMINARY DRAWING, SHOULD BE VERIFIED IN DETAIL DESIGN.
2. REACTOR SIZE AND PLACEMENT SHOULD BE VERIFIED BY POWER SYSTEM STUDY.
3. VOLTAGE REGULATOR SIZE AND PLACEMENT SHOULD BE VERIFIED BY POWER SYSTEM STUDY.

LEGEND:

- CIRCUIT BREAKER (CB)
- CIRCUIT SWITCHER (CS)
- FUSIBLE DISCONNECT SWITCH (FDS)
- DISCONNECT SWITCH (DS)
- SURGE ARRESTOR (SA)
- TRANSFORMER
- SHUNT REACTOR (SR)
- CURRENT TRANSFORMER (CT)
- CAPACITIVE VOLTAGE TRANSFORMER (CVT)
- VOLTAGE REGULATOR (VR) AND BY-PASS SWITCH
- VOLTAGE TRANSFORMER (VT)

PRELIMINARY

NOT FOR CONSTRUCTION

APPROVED FOR USE

HATCH

GOVERNMENT OF THE NORTHWEST TERRITORIES

FORT PROVIDENCE AND KAKISA TL PROJECT

OVERALL SINGLE LINE DIAGRAM

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	J ZENG	NR	2020-02-19
DESIGNER	J ZENG	NR	2020-02-19
CHECKER	D ZHANG		2020-02-19
DESIGN COORD.			
RESP. ENG.			
LEAD DISC. ENG.	D ZHANG		2020-02-19
ENG. MANAGER			
PROJ. MANAGER	D ALMANZA		2020-02-19

DRAWING APPROVAL STATUS: APPROVED FOR USE

No.	DESCRIPTION	BY	CHK'D	DATE

REVISIONS

DRAWING No.	DRAWING TITLE

REFERENCE DRAWINGS

REG. PROFESSIONAL

SCALE NTS OR AS NOTED

DWG. No. H361430-00000-260-288-0001

REV C

SHEET SIZE: A1

$USERNAME$ $DATE$ $FILE$ $TIME$

Appendix C:
Typical Structures & Foundation Drawings

Typical 25 kV Structures (Neutral Conductor Not Shown):

- Drawing D15-SD-3172: Single Pole Tangent Structure
- Drawing D15-SD-3274: Single Pole Light Angle Structure
- Drawing D15-SD-3276: Single Pole Medium Angle Double Arm Structure
- Drawing D15-SD-3380: Double Deadend Inline Single Pole Structure
- Drawing D15-SD-3382: Single Pole Double Deadend Flat with Deflection
- Drawing D15-SD-3903: Three Phase Riser Pole Underground Dip

Typical Neutral Conductor:

- Drawing D15-SD-3914: Neutral Wire Deadend Structure
- Drawing D15-SD-3916: Neutral Wire Angle Structure
- Drawing D15-SD-3918: Neutral Wire Tangent Structure

Typical 72 kV Structures:

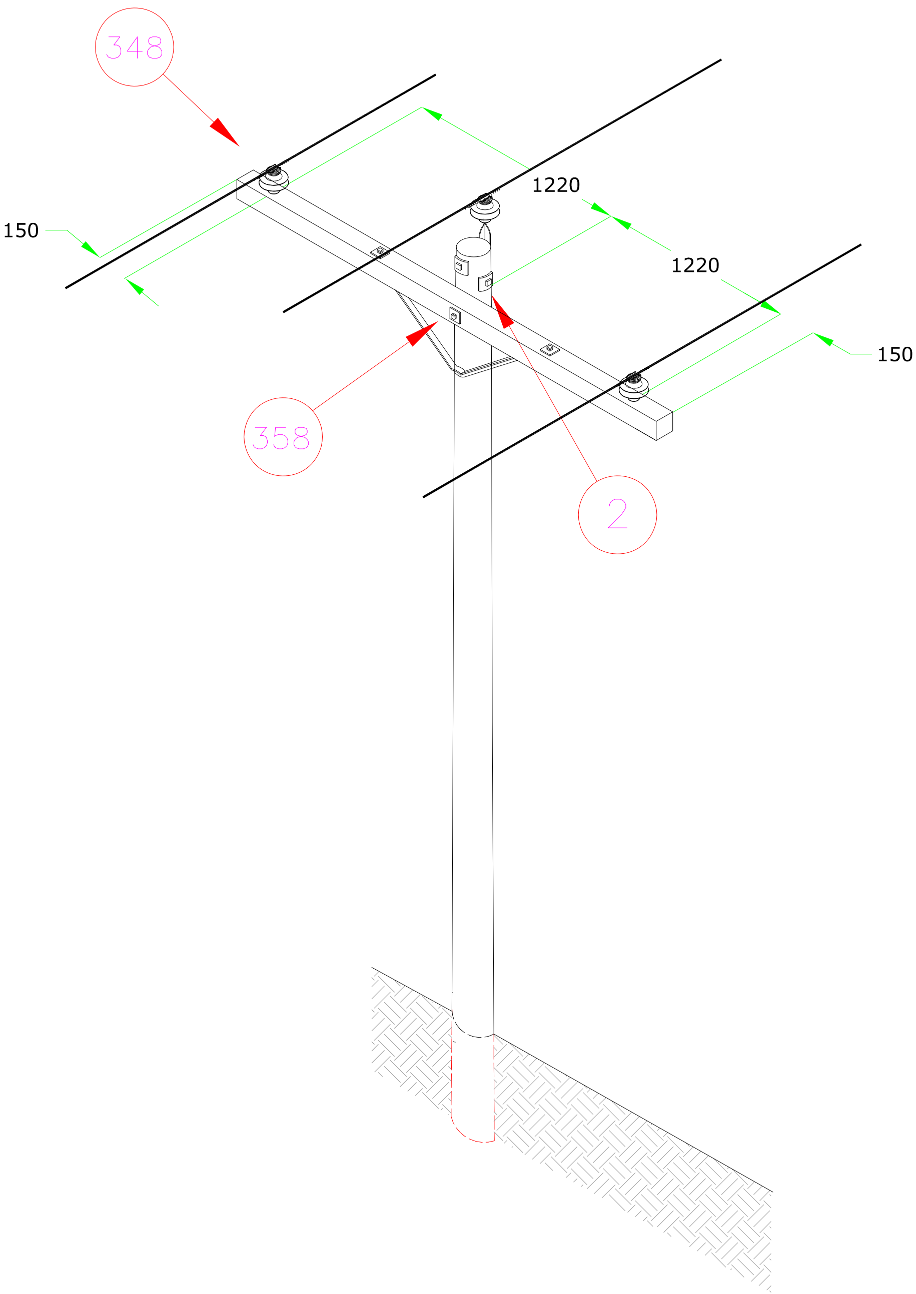
- Drawing T15-SD-4123: Tangent H-Frame Structure with Steel Arm
- Drawing T15-SD-4176: Single Pole Tangent Delta Structure
- Drawing T15-SD-4208: Single Pole Vertical Light Angle Structure with Post Insulators
- Drawing T15-SD-4210: Single Pole Vertical Medium Angle Structure
- Drawing T15-SD-4211: Light Angle H-Frame Structure with Steel Arm
- Drawing T15-SD-4276: Single Pole Light Angle Delta Structure
- Drawing T15-SD-4302: Double Deadend Tangent Single Pole Structure with Double Steel Arms
- Drawing T15-SD-4310: Single Pole Vertical Double Deadend Heavy Deflection Structure
- Drawing T15-SD-4326: Double Deadend Tangent H-Frame Structure with Double Steel Arms
- Drawing T15-SD-4334: Three Pole Double Deadend Structure with Deflection

Typical Pole Foundations:

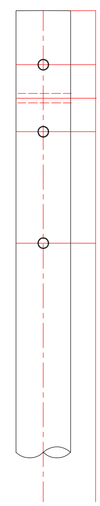
- Drawing T15-SD-9940: Shallow Depth Very Soft / Loose Soil Extra Embedment and Barrel
- Drawing T15-SD-9948: Anchored Structure Foundation in Wet Mineral Soil
- Drawing T15-SD-9993: Typical Culvert Foundation

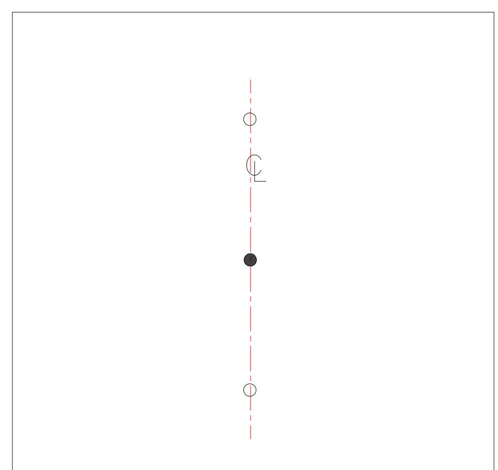
Typical Anchors:

- Drawing T15-SD-9923: Helix Screw Anchor
- Drawing T15-SD-9949: Log Anchor



ALL HOLES TO BE
DRILLED 13/16" UNLESS
OTHERWISE NOTED.





PLAN VIEW

NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- MAX DEFLECTION - TYPICAL < 2°
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: VERTICAL LOAD/PHASE= 3.5kN, TRANSVERSE LOAD/PHASE= 2.7kN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-05	REMOVE CLIENT SPECIFIC NOTES	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

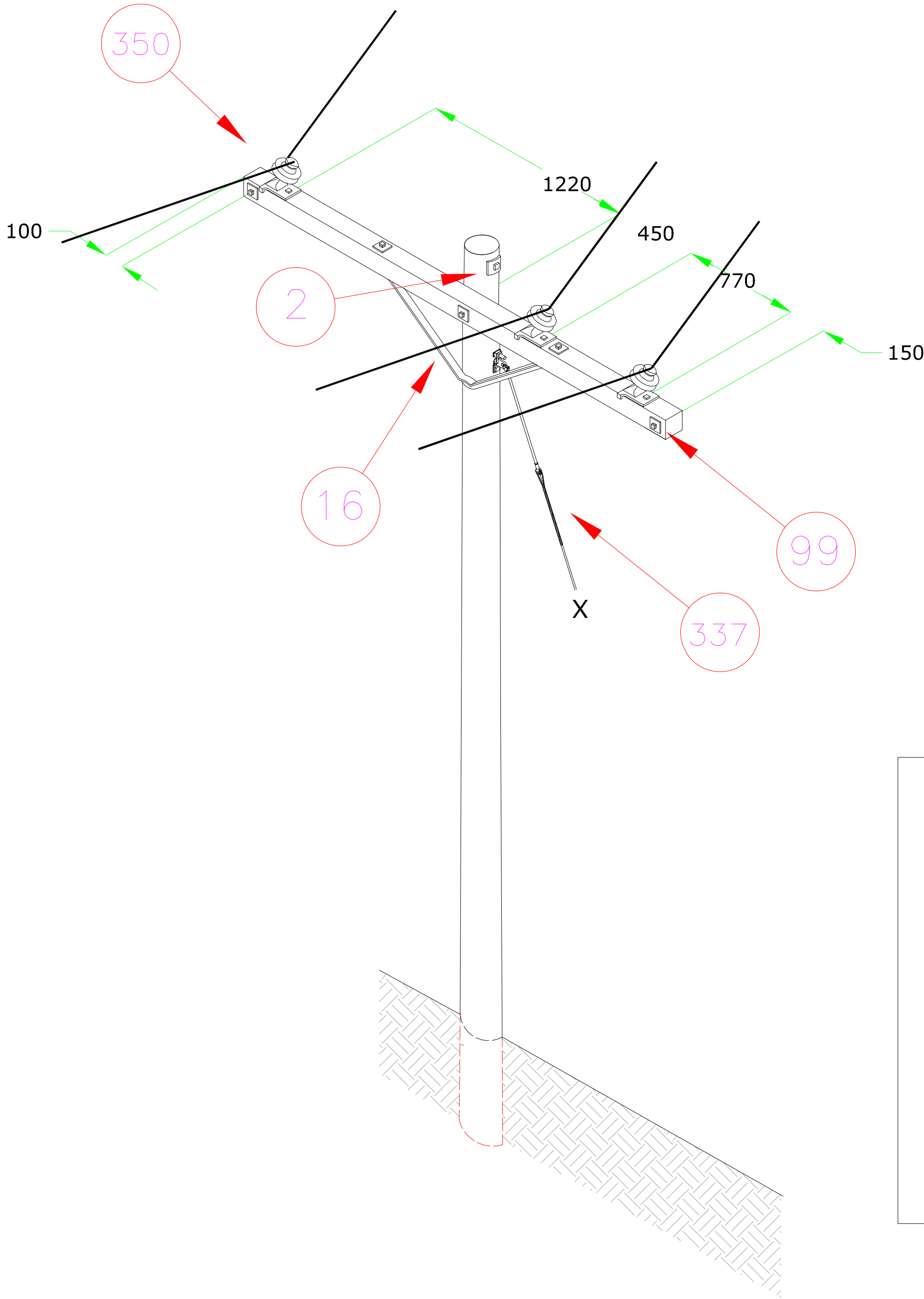
SINGLE POLE TANGENT FOR 25kV 3 PHASE STRUCTURE TYPE 3172

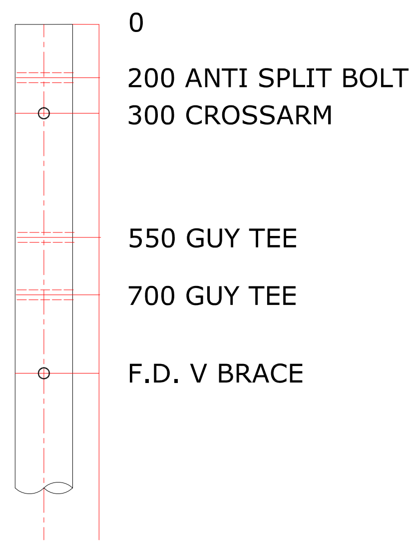
NT ENERGY

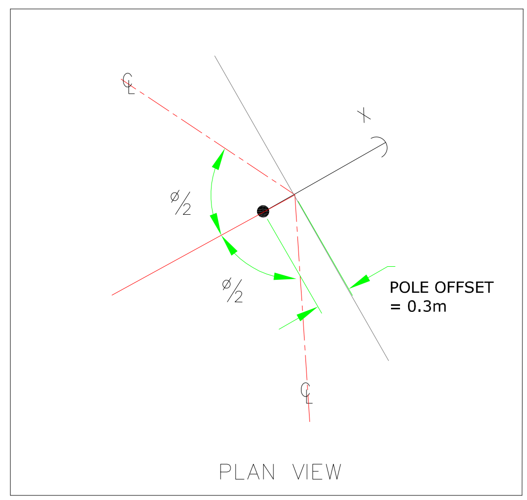
DRAWING NUMBER: D15-SD-3172

REV: R2

ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.







NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS - VERTICAL LOAD/PHASE= 2.4kN, TRANSVERSE LOAD/PHASE = 4.9kN
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

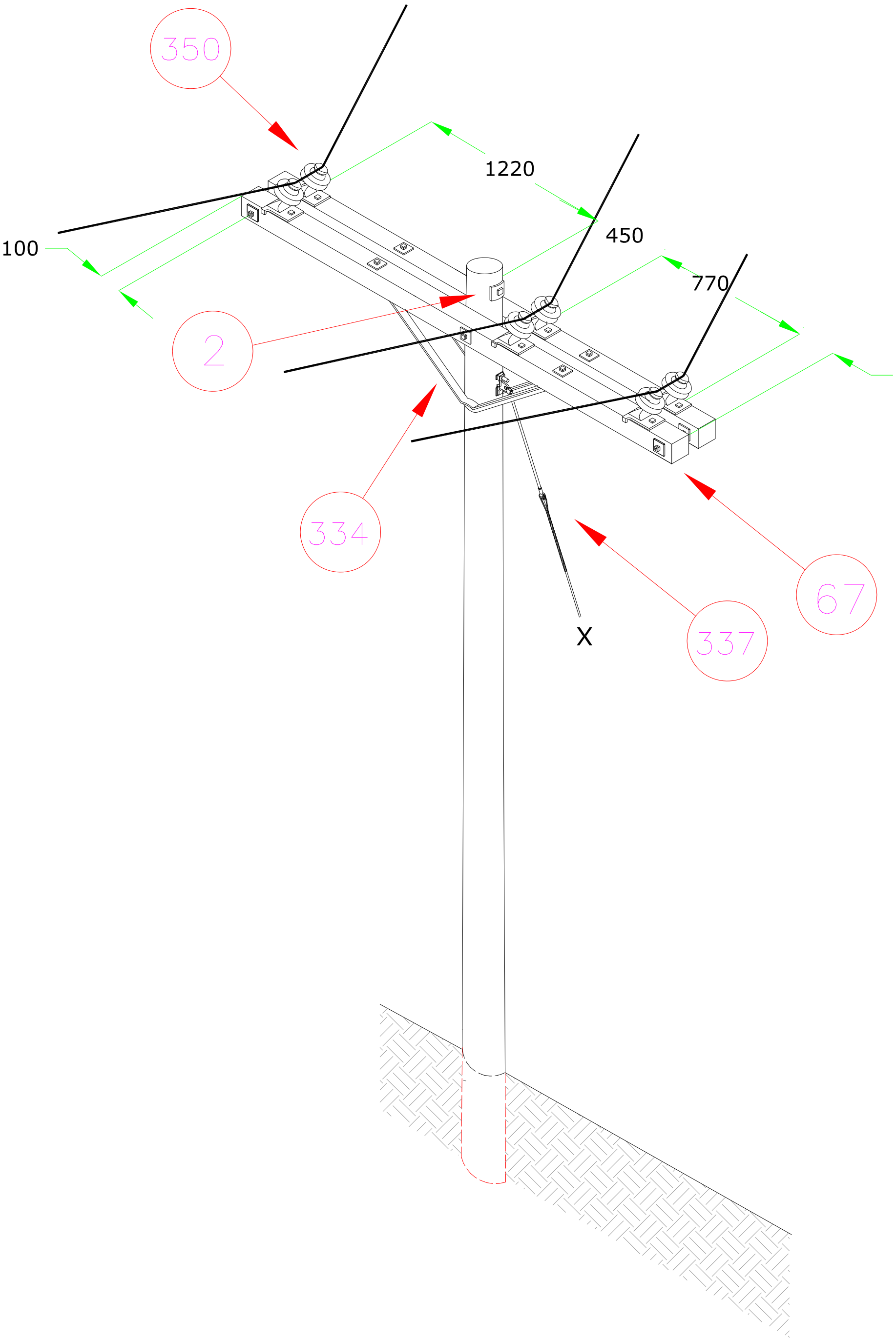
MIDGARD CONSULTING INC

REVISIONS

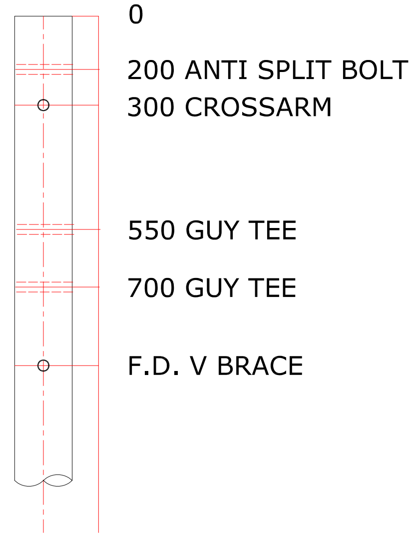
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-05	REMOVE CLIENT SPECIFIC NOTES	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

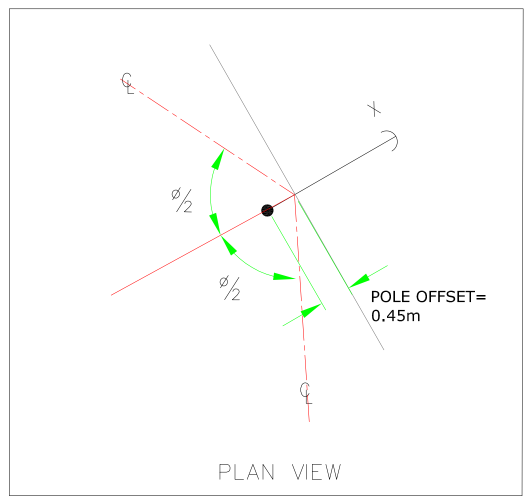
SINGLE POLE LIGHT ANGLE FOR 25kV TYPICAL DEFLECTION: 2° - 12° STRUCTURE TYPE 3274

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3274	R2



ALL HOLES TO BE
DRILLED 13/16" UNLESS
OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS - VERTICAL LOAD/PHASE= 3.2kN, TRANSVERSE LOAD/PHASE= 6.0kN
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

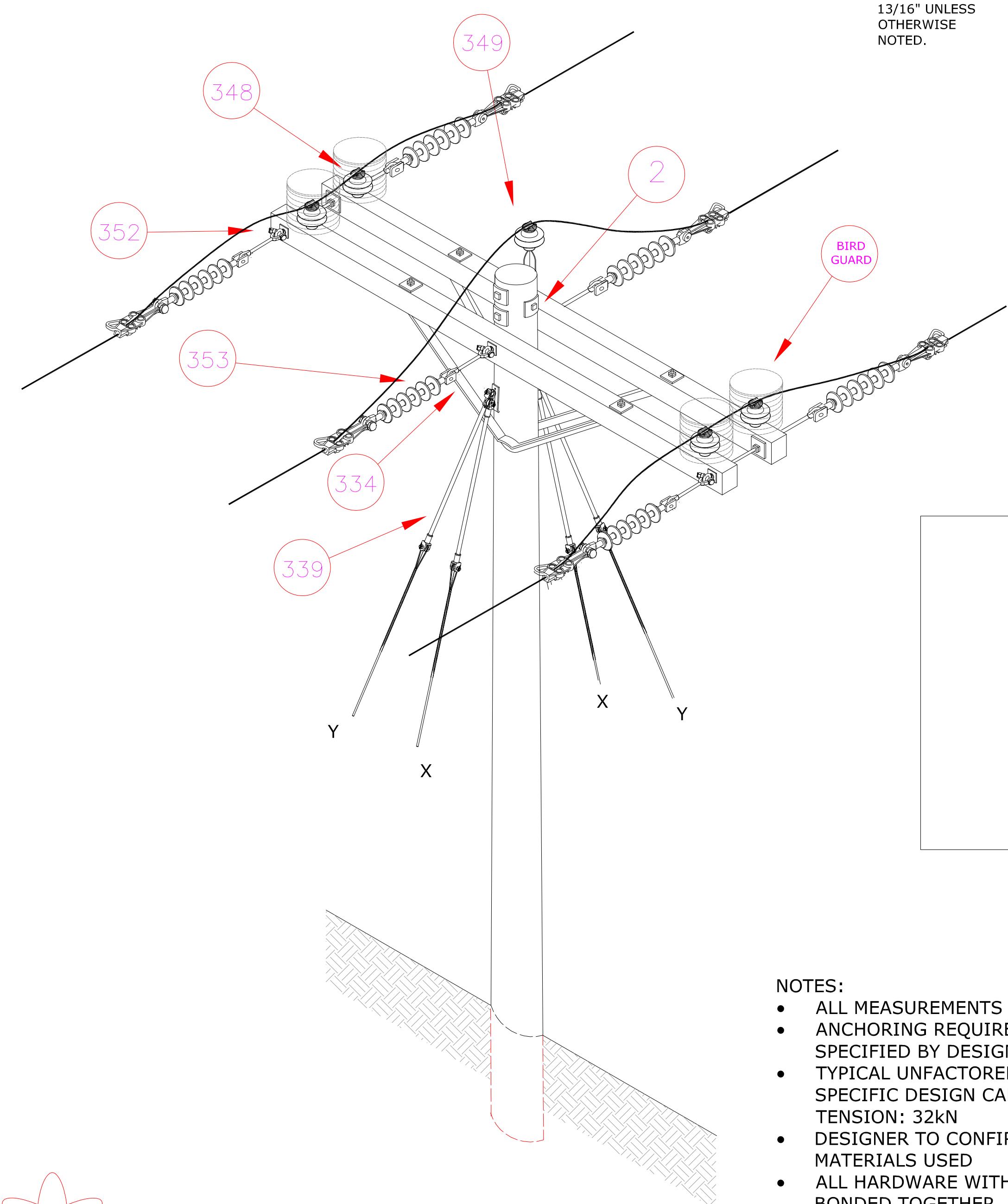
MIDGARD
CONSULTING INC

REVISIONS

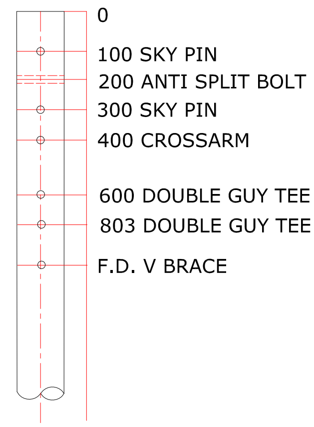
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-05	REMOVE CLIENT SPECIFIC NOTES	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

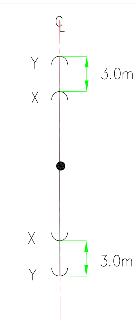
SINGLE POLE MEDIUM ANGLE FOR 25kV
DOUBLE ARM
TYPICAL DEFLECTION: 10° - 25°
STRUCTURE TYPE 3276

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3276	R2



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





PLAN VIEW

NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: MAX DESIGN TENSION: 32kN
- DESIGNER TO CONFIRM ALL DRILL DETAILS AGAINST MATERIALS USED
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

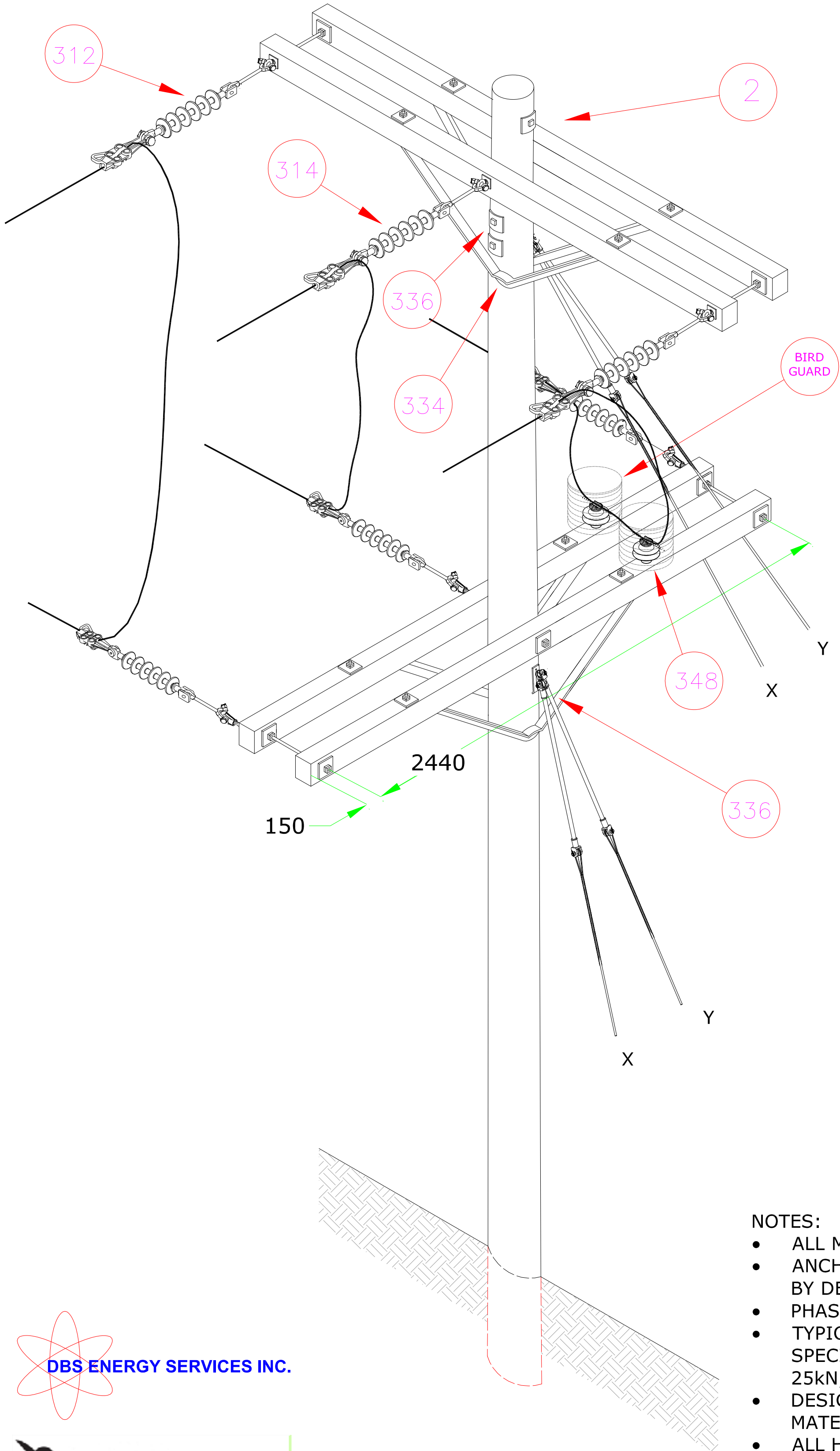
MIDGARD CONSULTING INC

REVISIONS

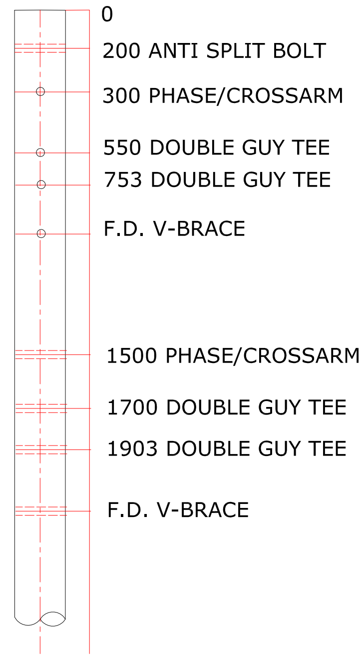
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-05	REMOVE CLIENT SPECIFIC NOTES	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

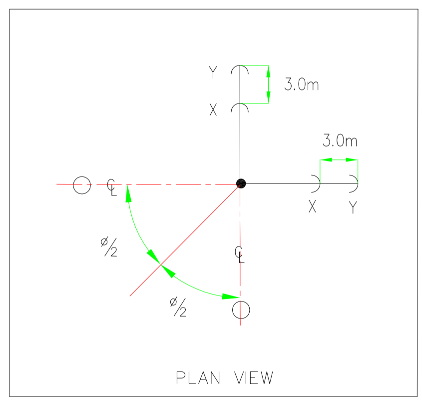
SINGLE POLE INLINE DOUBLE DEADEND
FOR 25kV
STRUCTURE TYPE 3380

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3380	R2



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- PHASING MAY NOT BE AS SHOWN (SEE STRUCTURE LIST)
- TYPICAL UNFACTORED ALLOWABLE MAX LOADS WITHOUT SPECIFIC DESIGN CALCULATIONS: MAX DESIGN TENSION: 25kN, WORKING TENSION: 10kN
- DESIGNER TO CONFIRM ALL DRILL DETAILS AGAINST MATERIALS USED
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

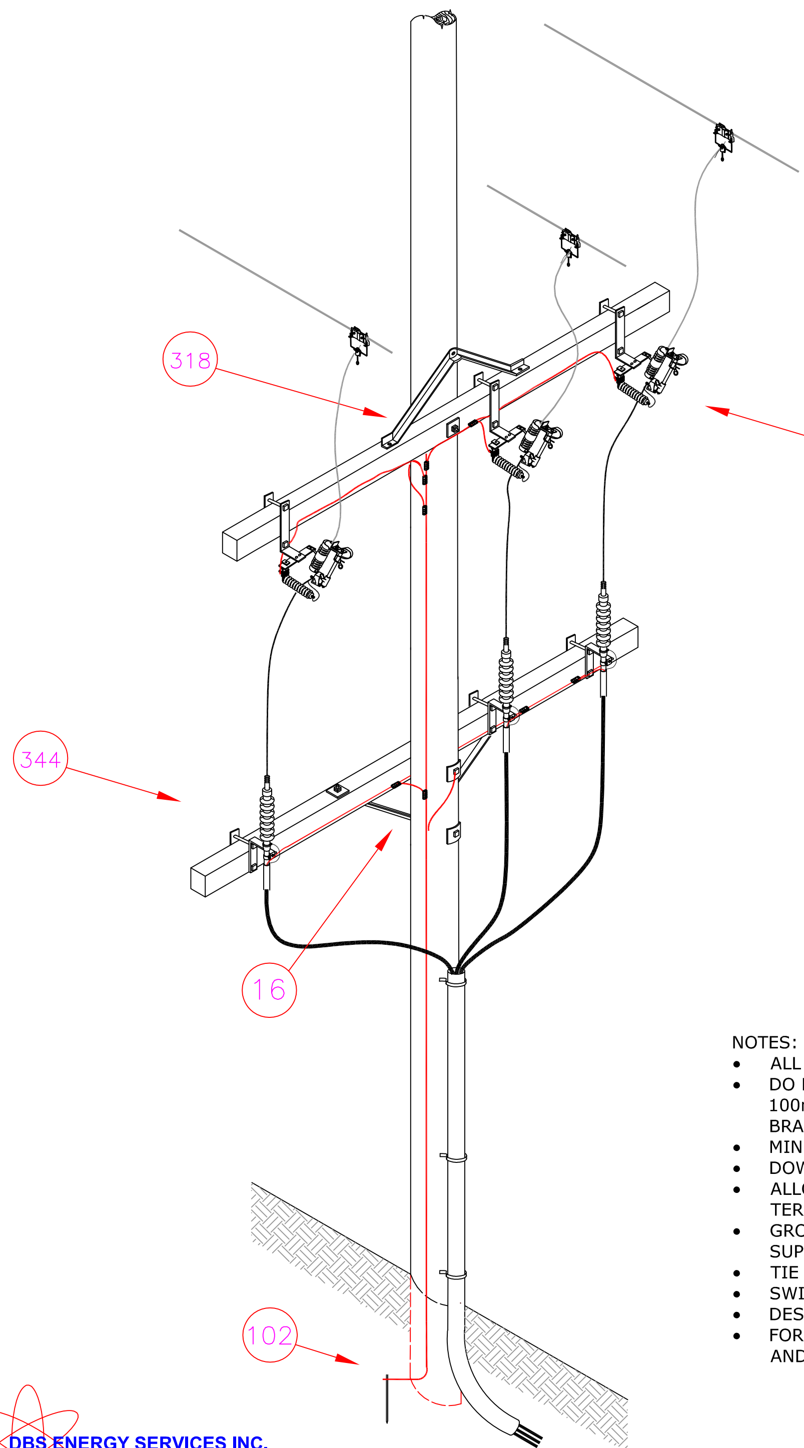
REVISIONS

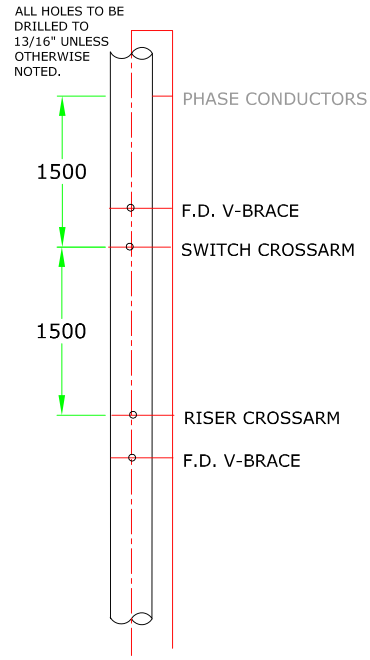
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-05	REMOVE CLIENT SPECIFIC NOTES	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-16	NEW DRAWING - RELEASE FOR FINAL REVIEW	DBS

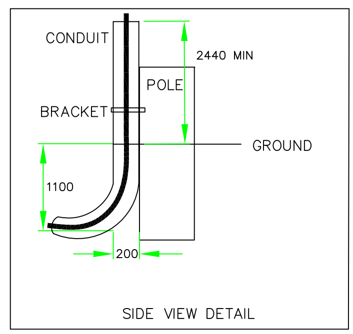
SINGLE POLE DOUBLE DEADEND FLAT WITH DEFLECTION FOR 25kV STRUCTURE TYPE 3382

NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3382	R2







NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- DO NOT GROUND THE CABLE SUPPORT BRACKET. MAINTAIN A MINIMUM OF 100mm CLEARANCE BETWEEN THE GROUND LEAD AND THE CABLE SUPPORT BRACKET
- MINIMUM CABLE BENDING RADIUS DURING INSTALLATION IS 400mm
- DOWNLEAD TO BE PLACED UNDER CONDUIT STRAPS
- ALLOW SUFFICIENT SLACK IN CABLES AT THE BASE OF POLE TO ALLOW FOR TERMINATION FAILURE
- GROUNDING CONDUCTOR MUST BE CONTINUOUS FROM TERMINATOR SUPPORT BRACKET TO GROUND RODS
- TIE CONCENTRIC NEUTRAL TO DOWNLEAD
- SWITCH NUMBERING TO BE ADDED
- DESIGNER TO SPECIFY AND DETERMINE FUSE SIZING
- FOR OHSW UNDERBUILT STRUCTURES DISCONTINUE THE POLE DOWNLEAD AND OHSW BONDING ABOVE THE EQUIPMENT LEVEL

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

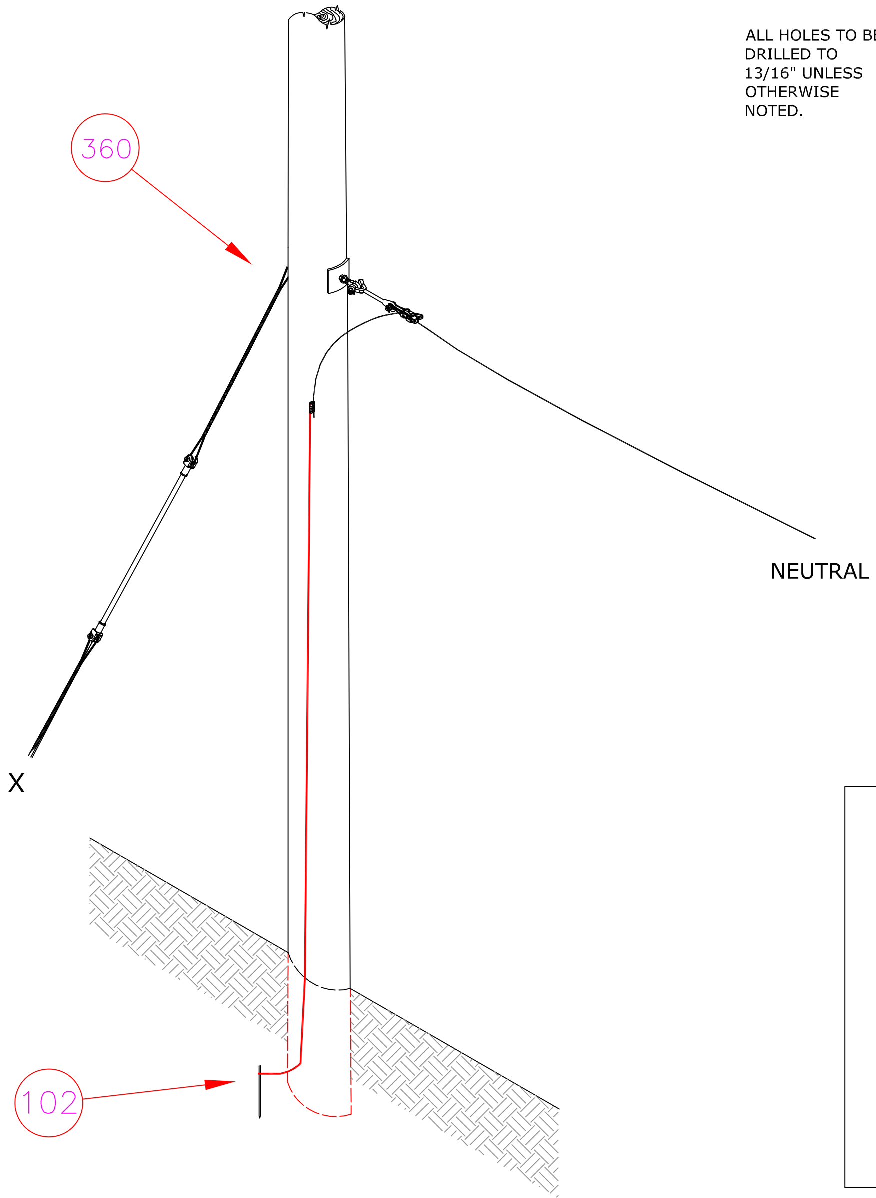
REVISIONS

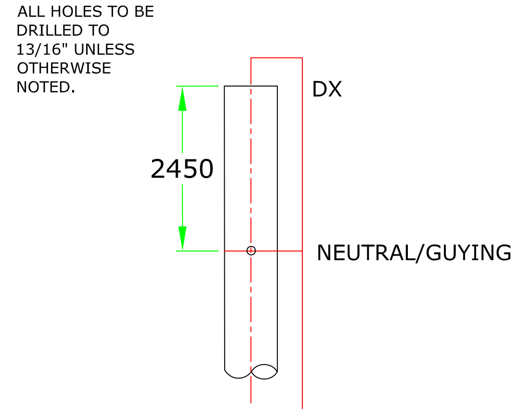
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-08	EDIT GROUNDING ASSEMBLY NUMBER	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-20	NEW DRAWING - RELEASED FOR FINAL REVIEW	DBS

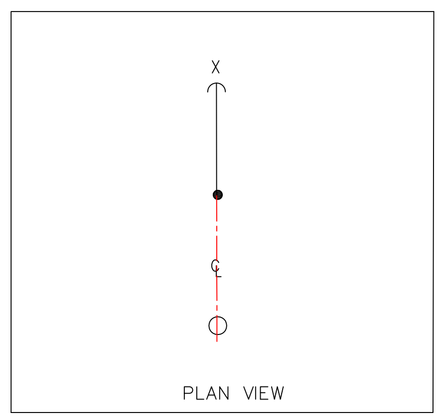
3 PHASE RISER POLE UNDERGROUND DIP FOR LIGHT CABLE STRUCTURE TYPE 3903

NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3903	R2







NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- MAX SLACKSPAN APPROX 30m
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

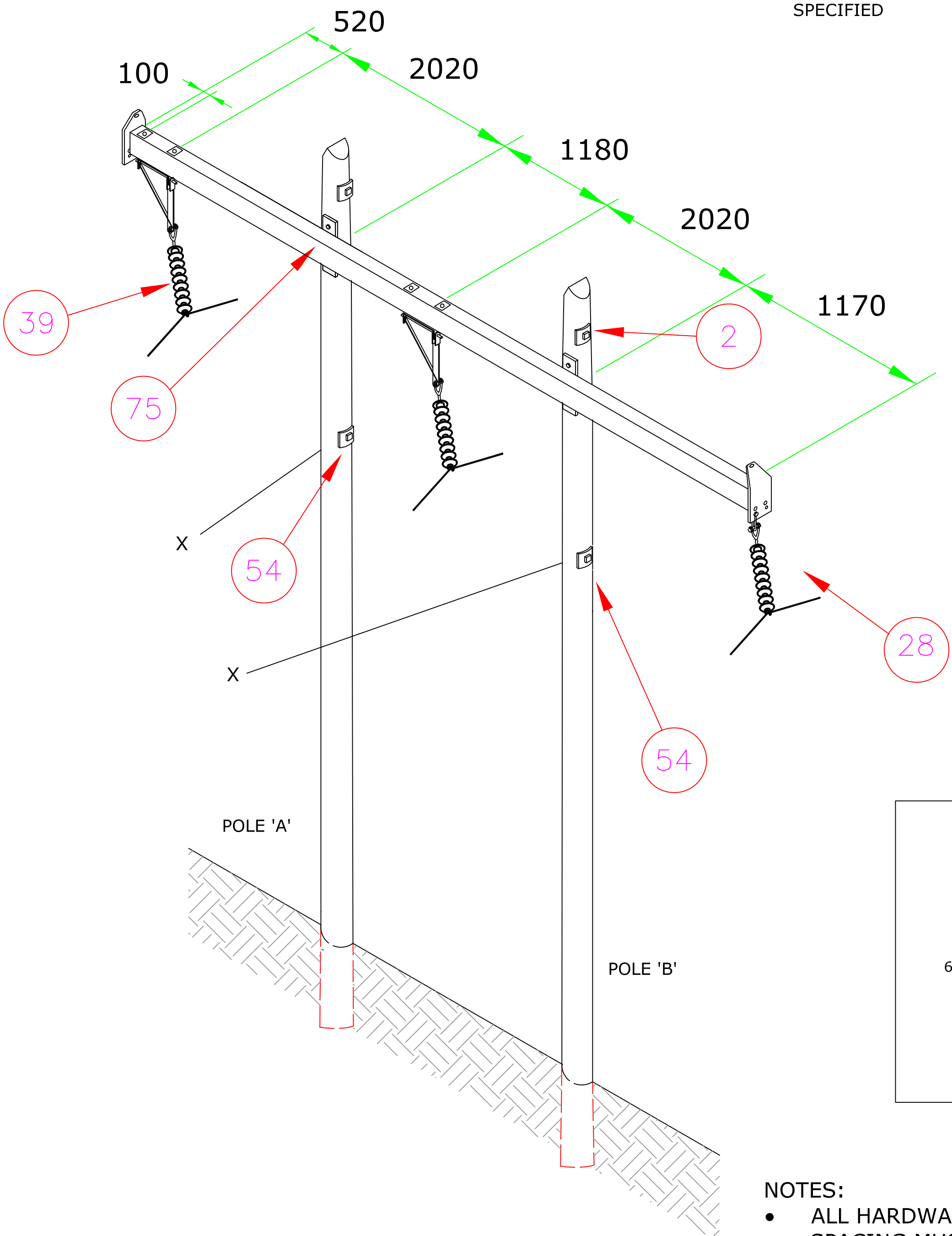
MIDGARD CONSULTING INC

REVISIONS

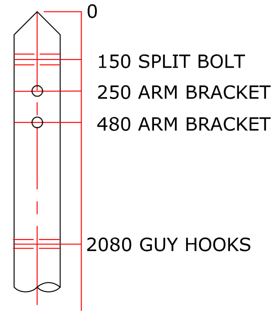
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R2	AM	13-02-08	EDIT GROUNDING ASSEMBLY, DRILL DETAIL	DBS
R1	AM	09-01-05	DISCLAIMER NOTE, RELEASED FOR PACKAGE	DBS
R0	AM	08-10-20	NEW DRAWING - RELEASED FOR FINAL REVIEW	DBS

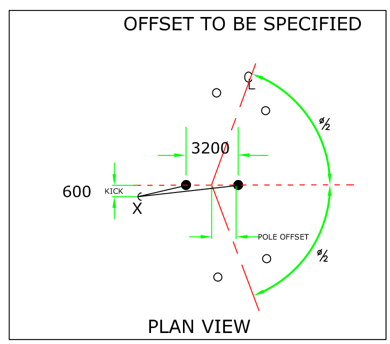
SYSTEM NEUTRAL WIRE STRUCTURE DEADEND
DISTRIBUTION
STRUCTURE TYPE 3914

NT ENERGY	DRAWING NUMBER:	REV:
	D15-SD-3914	R2



ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE SPECIFIED





NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR LOCATION TO BE KICKED BY DESIGNER TO ENSURE GUY WIRE CLEARS POLE
- POLE OFFSET TO BE DETERMINED BY DESIGNER
- ANCHOR TO BE KICKED OPPOSITE OF LONGER SPAN

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

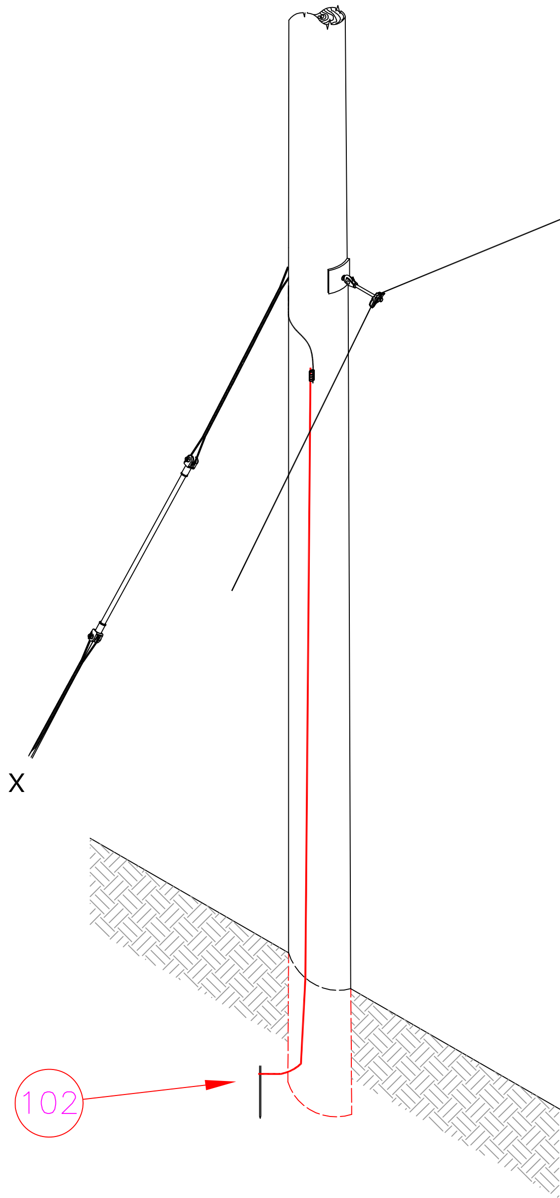
REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R0	AM	13-01-29	NEW DRAWING	DBS

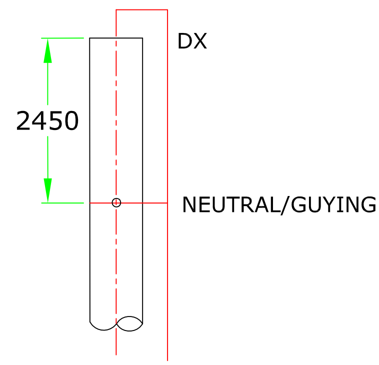
TWO POLE 72kV LIGHT ANGLE H-FRAME FOR ANGLES LESS THAN 15° TYPICALLY STRUCTURE TYPE 4211

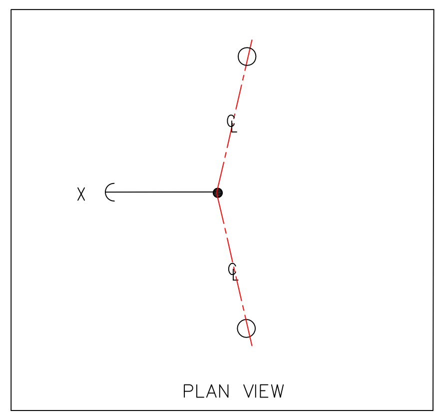
NT ENERGY

DRAWING No.	REV.
T15-SD-4211	R0



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

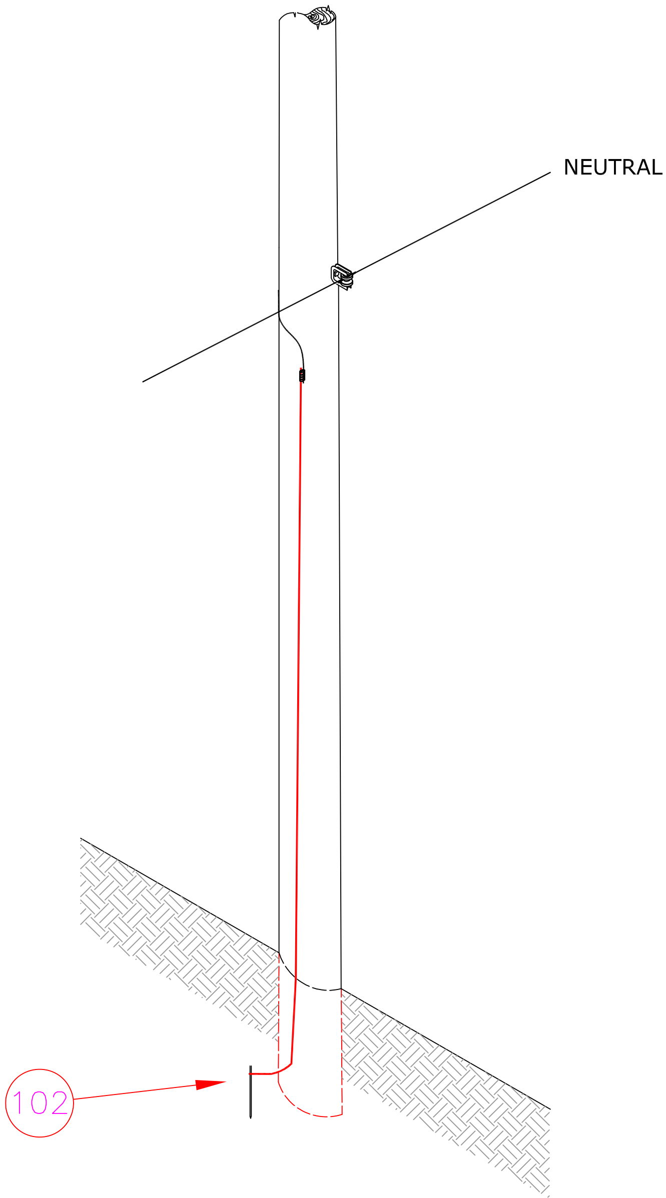
MIDGARD CONSULTING INC

REVISIONS

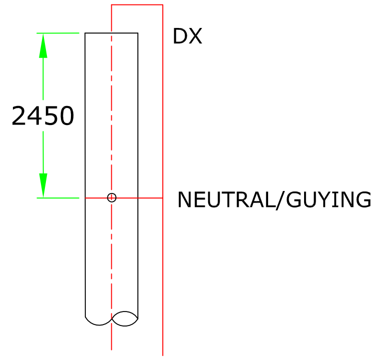
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R0	AM	13-02-08	NEW DRAWING	DBS

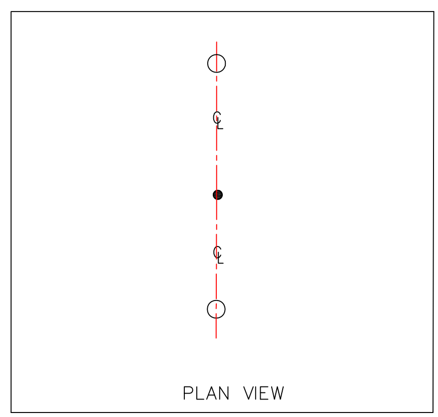
SYSTEM NEUTRAL WIRE STRUCTURE ANGLE
DISTRIBUTION
STRUCTURE TYPE 3916

	DRAWING NUMBER:	REV:
NT ENERGY	D15-SD-3916	R0



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:

- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- GUYING AND ANCHOR TO BE DETERMINED BY DESIGNER

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

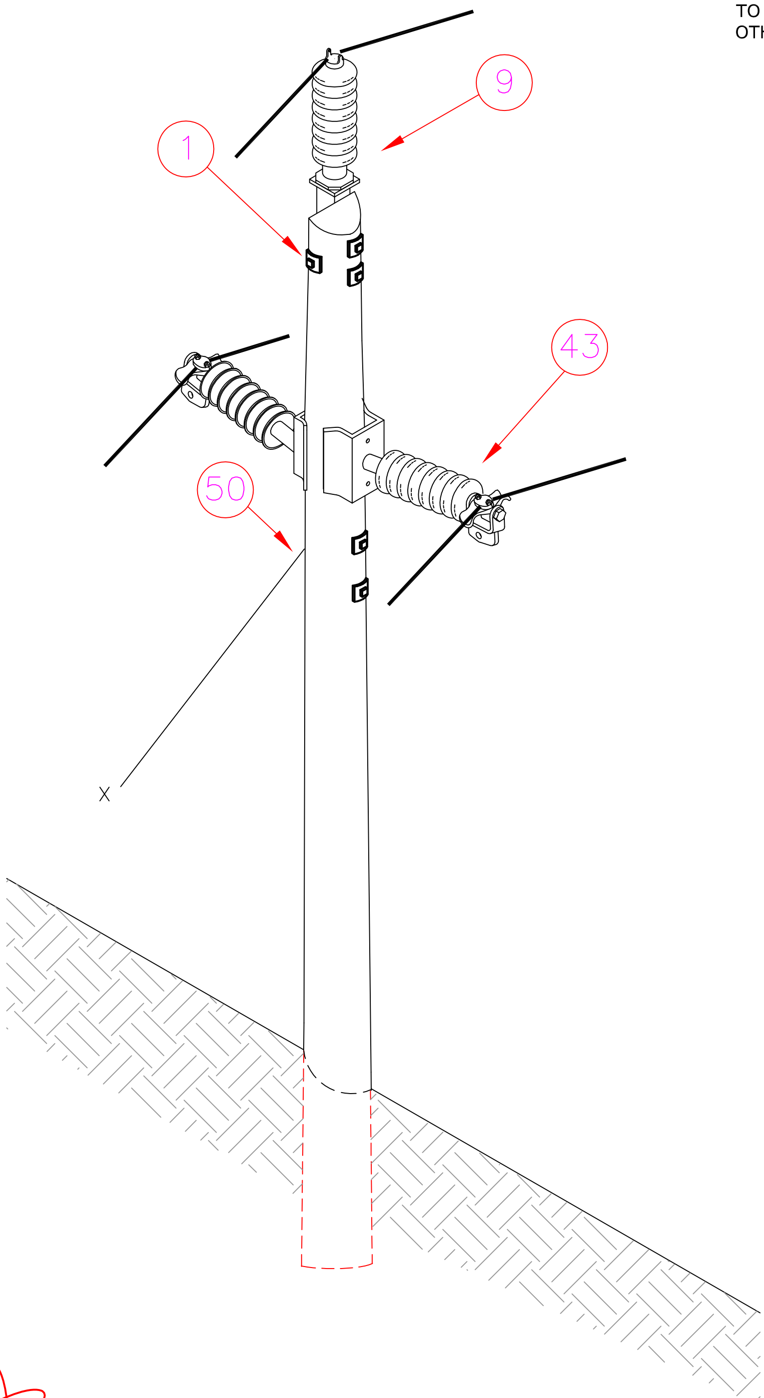
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R0	AM	13-02-08	NEW DRAWING	DBS

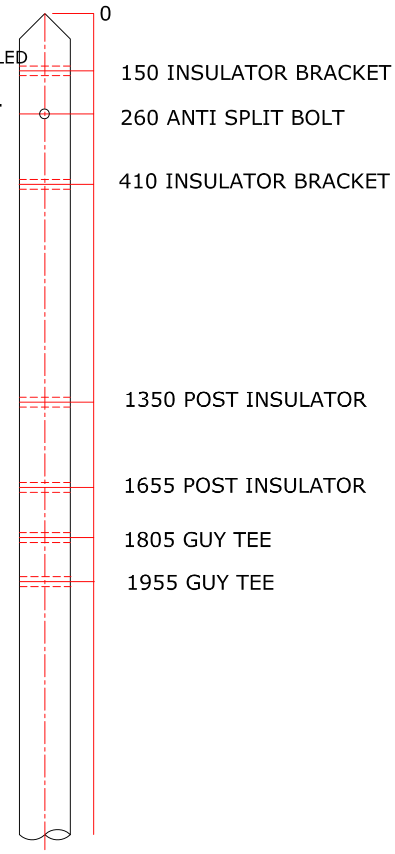
SYSTEM NEUTRAL WIRE STRUCTURE TANGENT DISTRIBUTION
STRUCTURE TYPE 3918

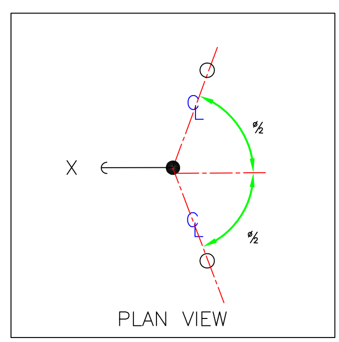
NT ENERGY

DRAWING NUMBER:	REV:
D15-SD-3918	R0



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE SPECIFIED.





NOTES:
1. ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
2. ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
3. FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR AND BRACKET STRENGTHS
4. DESIGNER TO VERIFY PHASE CLEARANCES FOR MAX SPAN LENGTHS

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

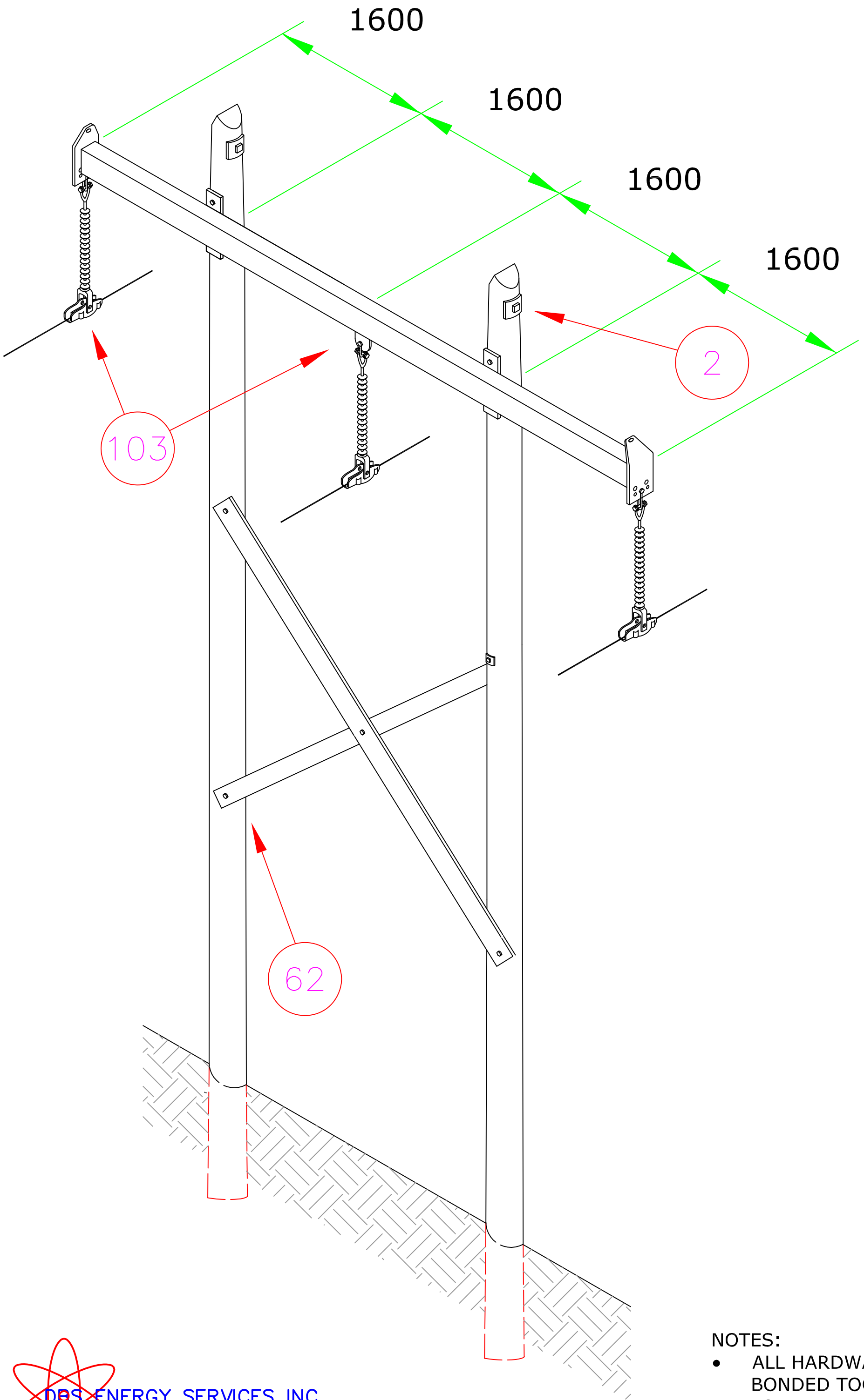
REVISIONS

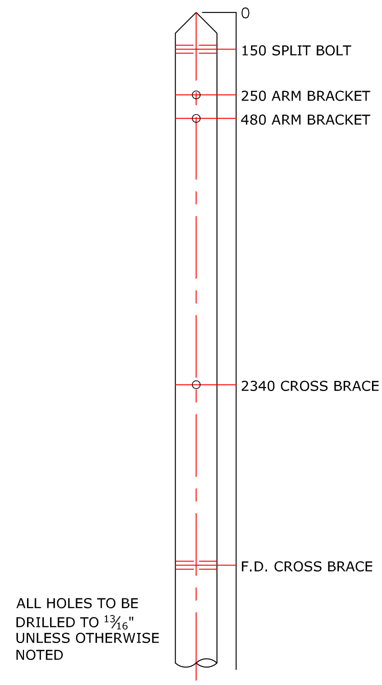
No.	BY	DATE	DESCRIPTION	APP.
R1	AM	12-11-01	REMOVE GROUND, BONDING, DOWNLEAD	DBS
R0	AM	12-06-06	NEW DRAWING	DBS

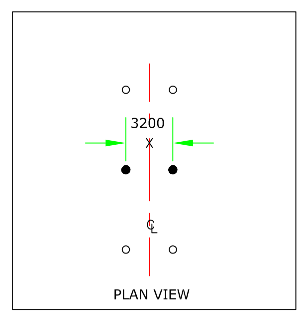
72kV SINGLE POLE LIGHT ANGLE
DELTA HORIZONTAL AND VERTICAL POSTS
STRUCTURE TYPE 4276

NT ENERGY

DRAWING No.	REV.
T15-SD-4276	R1







NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE CAPACITY USE DOUBLE SWAY BRACING FOR POLES ABOVE 80'
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

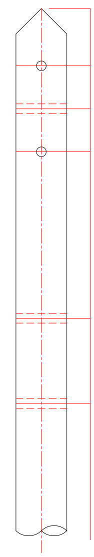
No.	BY	DATE	DESCRIPTION	APP.
R0	AM	13-01-29	NEW DRAWING	DBS

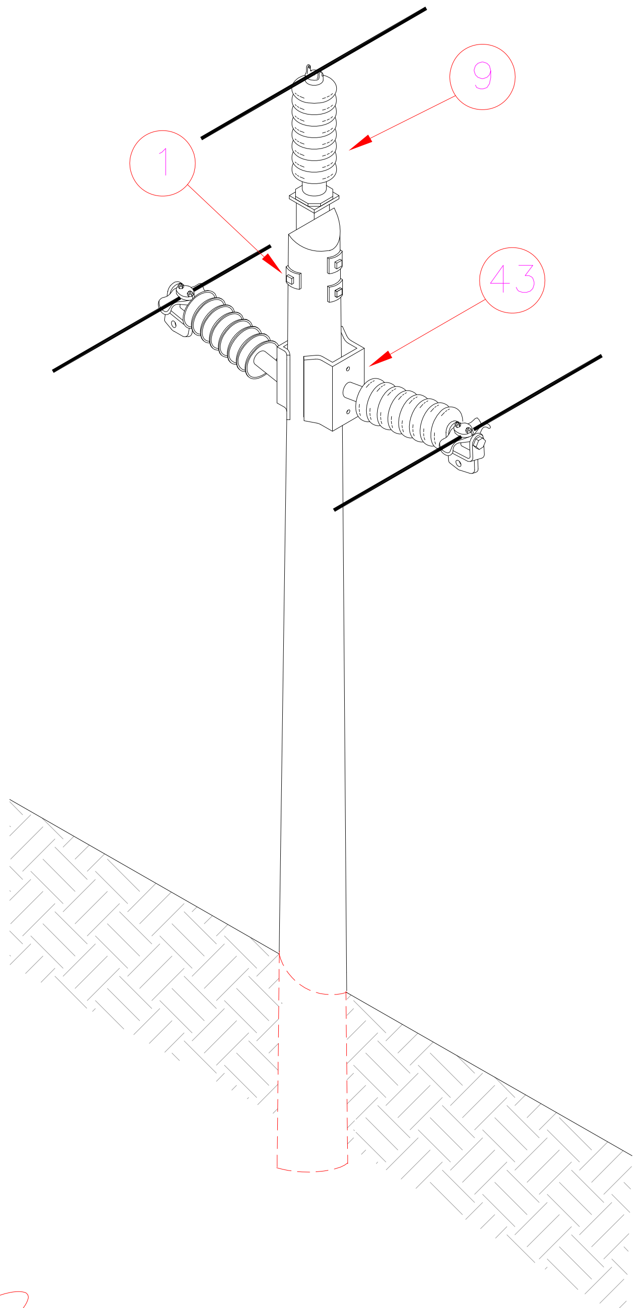
72kV TANGENT H-FRAME WITH WOOD CROSS BRACING AND STEEL ARM STRUCTURE TYPE 4123

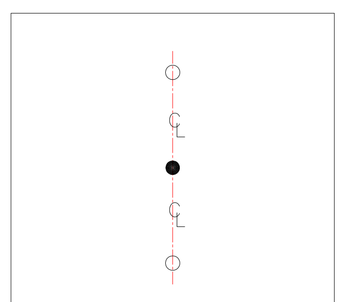
NT ENERGY

DRAWING No.	REV.
T15-SD-4123	R0

ALL HOLES TO BE
DRILLED TO 13/16"
UNLESS OTHERWISE
SPECIFIED.






PLAN VIEW

NOTES:
- ALL DIMENSIONS IN mm UNLESS OTHERWISE SHOWN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR AND BRACKET STRENGTHS
- DESIGNER TO VERIFY PHASE CLEARANCES FOR MAX SPAN LENGTHS

DBS ENERGY SERVICES INC.

MIDGARD
CONSULTING INC

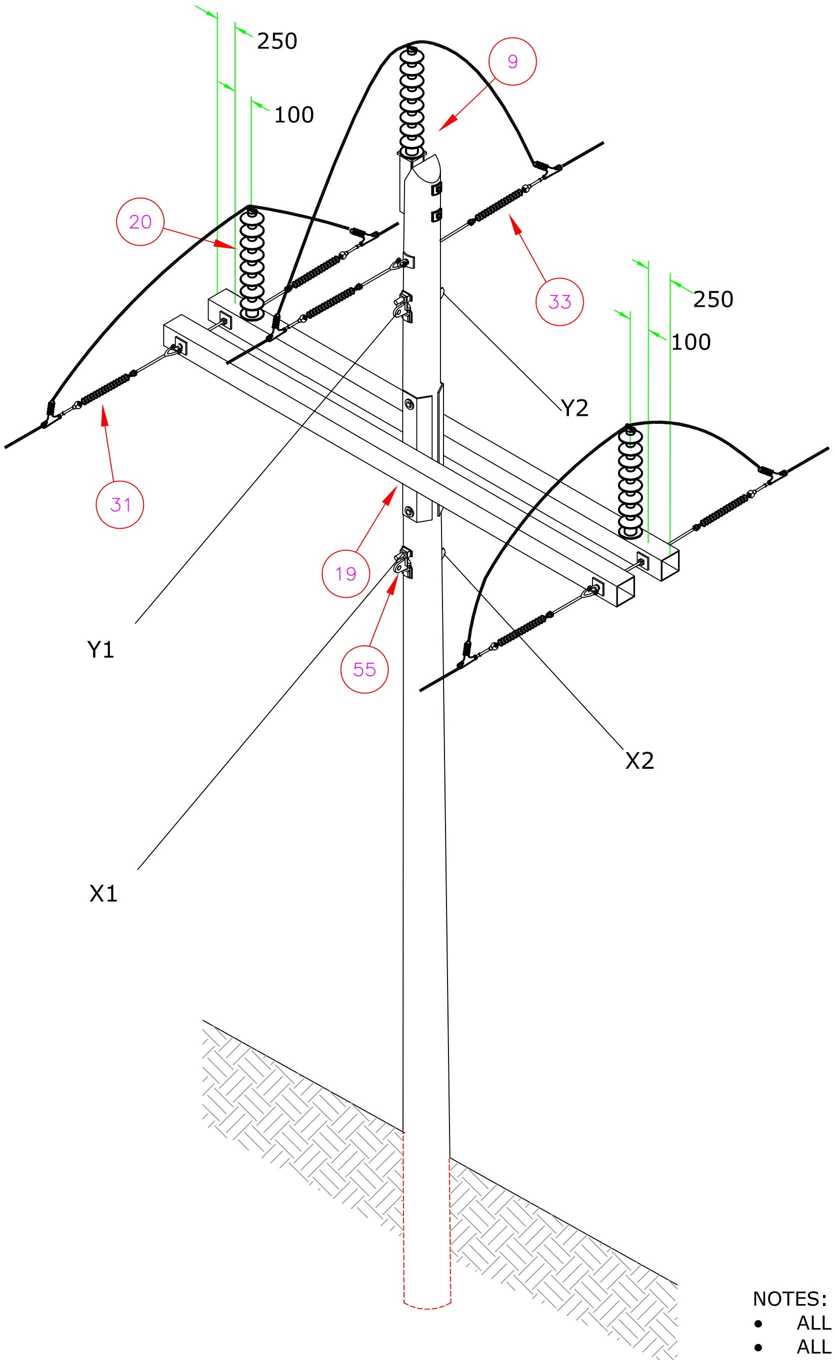
REVISIONS

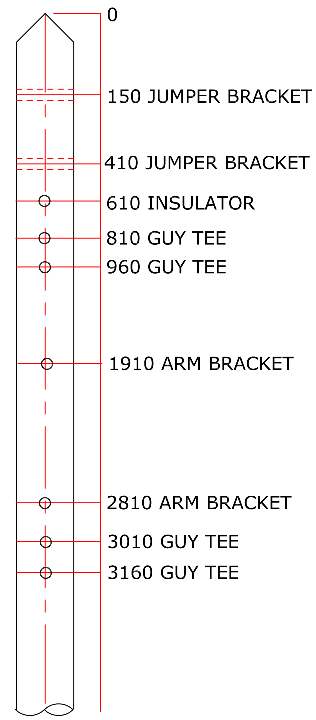
No.	BY	DATE	DESCRIPTION	APP.
R4	AM	12-11-01	REMOVE BONDING AND GROUNDING	DBS
R3	AM	12-06-06	UPDATE STR DWG COMPONENTS	JWT
R2	AM	10-03-08	UPDATE STR DWG	JWT
R1	AM	07-04-11	UPDATE ASS., STR DETAILS, GRND. DRILL	DBS
R0	RDK	02-09	NEW DRAWING	DBS

SINGLE POLE 72kV TANGENT
DELTA - HORIZONTAL AND VERTICAL POSTS
STRUCTURE TYPE 4176

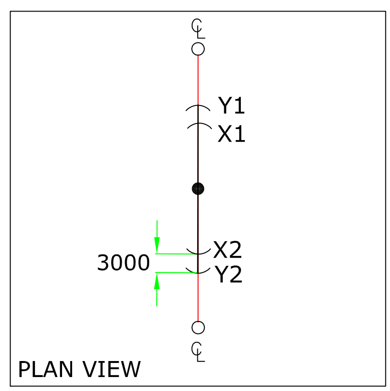
NT ENERGY

DRAWING No.	REV.
T15-SD-4176	R4





ALL HOLES DRILLED TO 13/16"



NOTES:

- ALL DIMENSIONS IN mm UNLESS OTHERWISE SHOWN
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)
- ANCHOR KICKS MAY BE REQUIRED, TO BE SPECIFIED BY DESIGNER IN THE STRUCTURE LIST

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

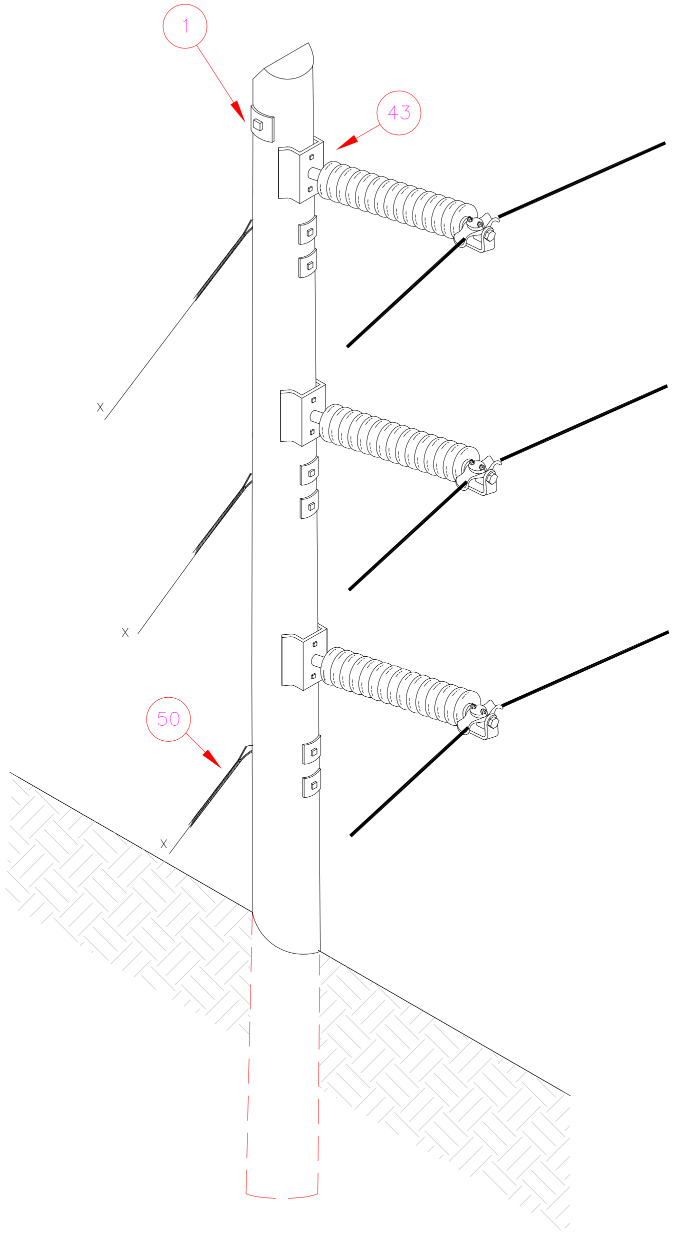
REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R2	AM	13–01–28	REMOVE GROUNDING, BONDING, DOWNLEAD	DBS
R1	AM	12–06–08	UPDATE DRILLING, PARTS, ADD NOTES	DBS
R0	AM	07–01–04	NEW DRAWING	DBS

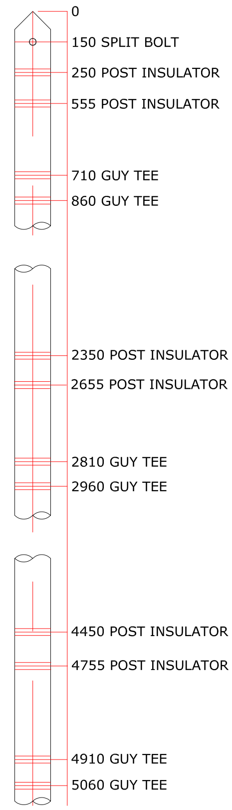
SINGLE POLE 72kV INLINE DDE WITH STEEL ARMS - DELTA CONFIGURATION STRUCTURE TYPE 4302

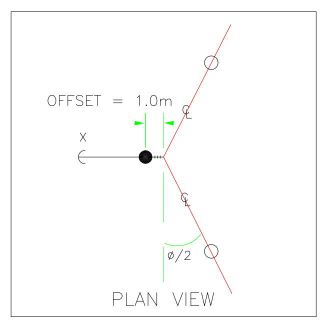
NT ENERGY

DRAWING No.	REV.
T15-SD-4302	R2



ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.





DBS ENERGY SERVICES INC.

NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- FOR MAX TRANSVERSE AND VERTICAL CAPACITY CONFIRM INSULATOR STRENGTHS
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED

MIDGARD CONSULTING INC

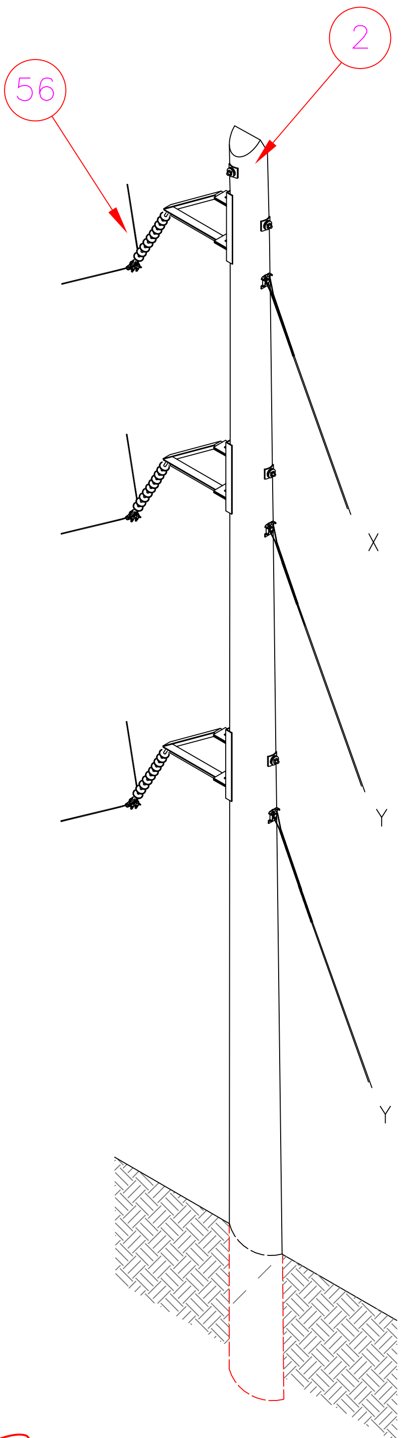
REVISIONS

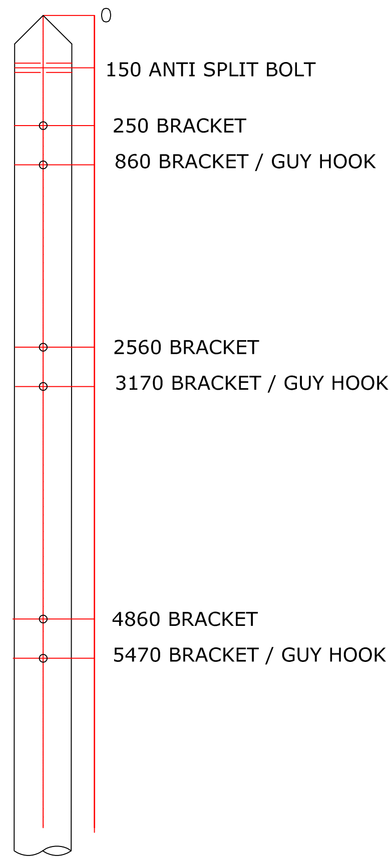
No.	BY	DATE	DESCRIPTION	APP.
R4	AM	12-11-01	REMOVE BONDING AND GROUNDING	DBS
R3	AM	12-10-05	UPDATE DRILLING DETAILS	DBS
R2	JWT	08-06-23	GUYING ASSEMBLY AND DIMENSIONS	JWT
R1	AM	06-11-02	GRND DETAIL, ASS., DRILL DETAIL, DLEAD	DBS
R0	DBS	06-02-23	NEW DRAWING	DBS

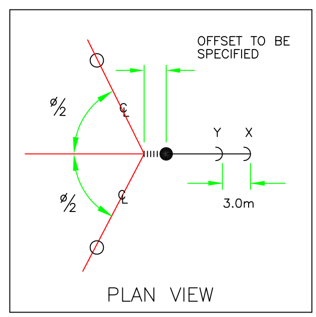
SINGLE POLE 72kV VERTICAL LIGHT ANGLE WITH HORIZONTAL POST INSULATORS FOR TYPICAL DEFLECTION <15°

NT ENERGY

DRAWING No.	REV.
T15-SD-4208	R4







NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- DESIGNER TO SPECIFY OFFSET
- DESIGNER TO CHECK FINAL INSULATOR POSITIONS AND CLEARANCES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

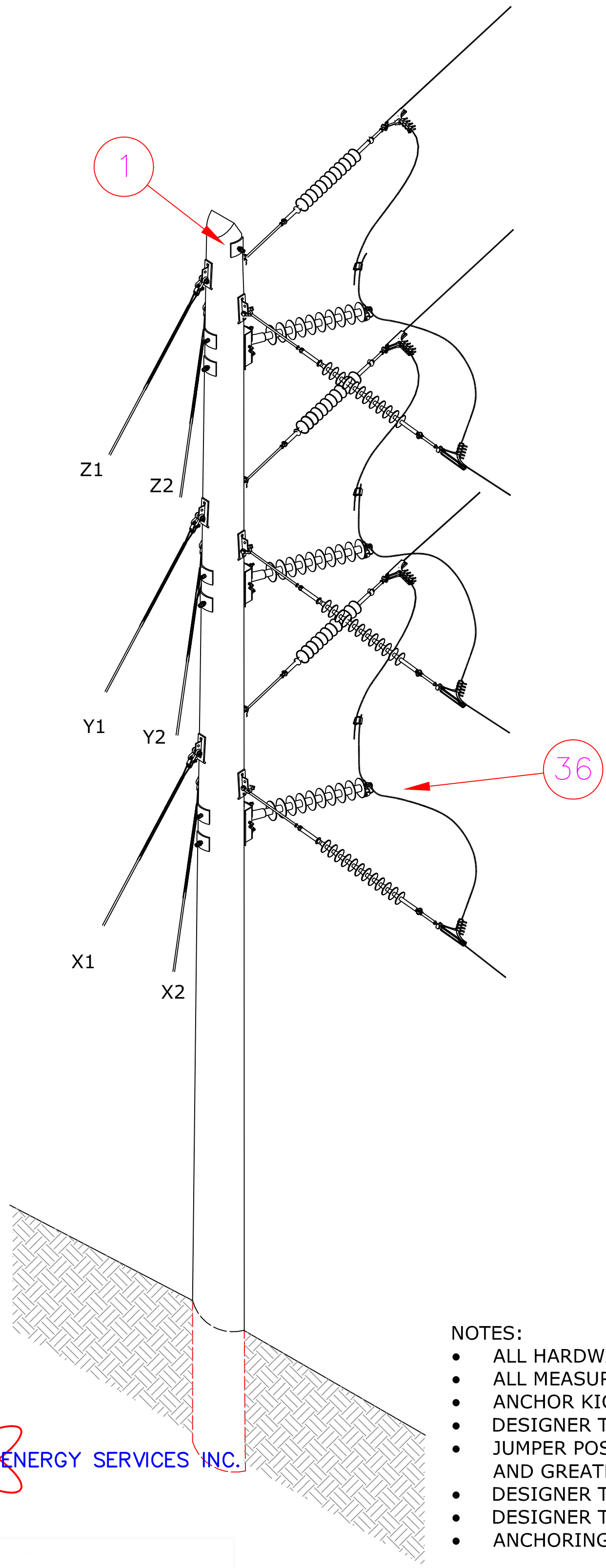
No.	BY	DATE	DESCRIPTION	APP.
R1	AM	13-01-28	REMOVE GROUNDING, BONDING, UPDATE DWG	DBS
R0	AM	06-11-10	NEW DRAWING	DBS

72kV SINGLE POLE VERTICAL
MEDIUM ANGLE STRUCTURE
TYPICAL 10° - 25° DEFLECTION

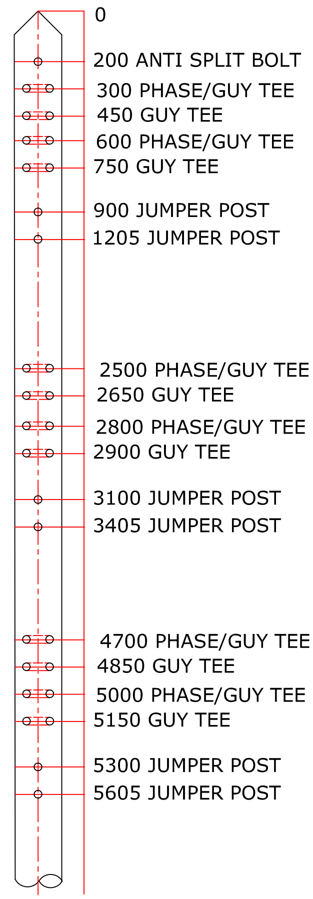
NT ENERGY

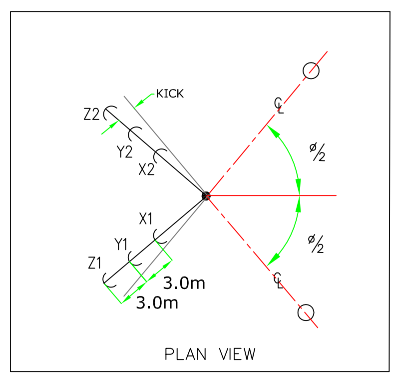
DRAWING No. T15-SD-4210

REV. R1



ALL HOLES TO BE DRILLED TO 13/16" UNLESS OTHERWISE NOTED.





NOTES:
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR KICKS SHOULD BE USED ON DEFLECTIONS < 60°
- DESIGNER TO SPECIFY ANCHOR KICKS (TO BE SPECIFIED IN STRUCTURE LIST)
- JUMPER POSTS REQUIRED FOR LINE DEFLECTIONS < 60° (NOT REQUIRED FOR 60° AND GREATER DEFLECTIONS)
- DESIGNER TO CHECK PHASE AND GUY CLEARANCES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

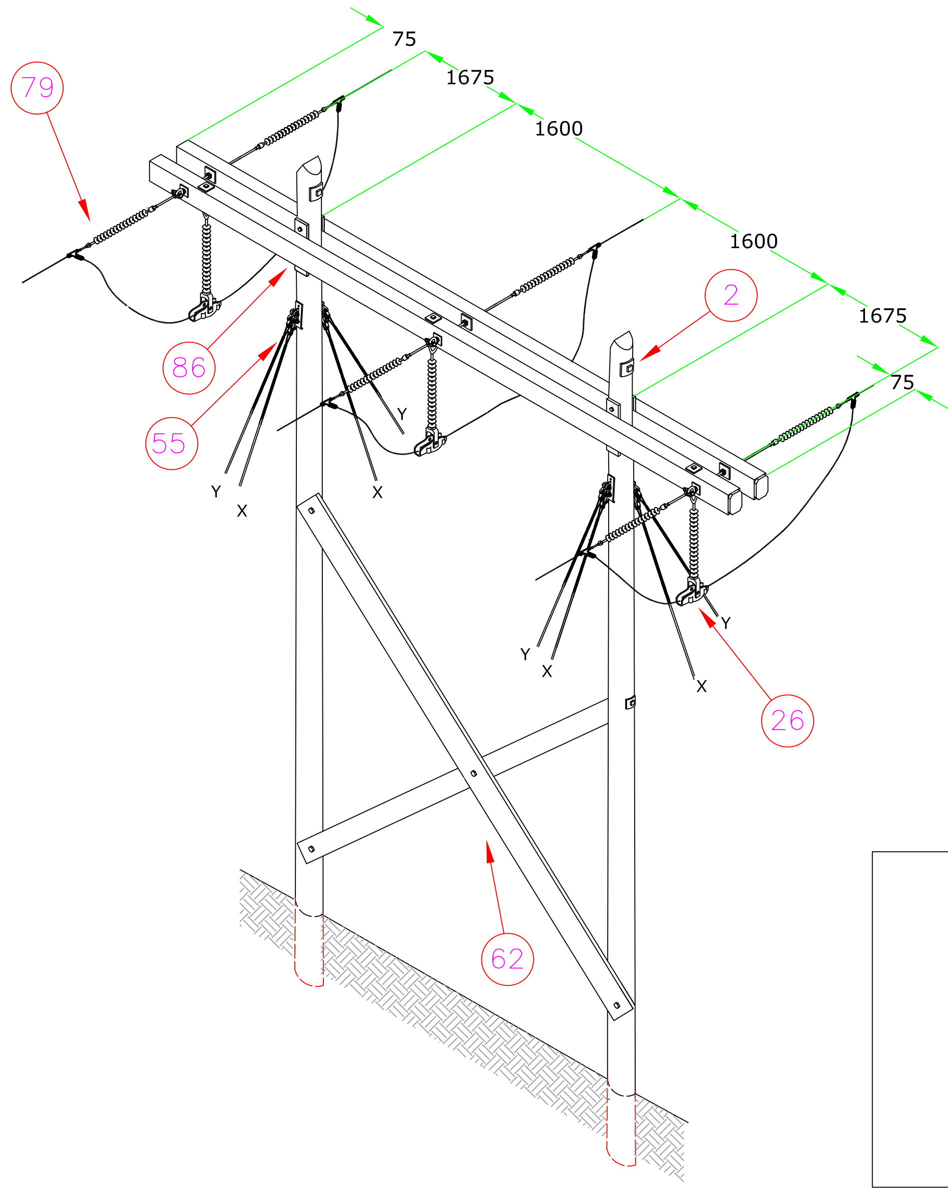
No.	BY	DATE	DESCRIPTION	APP.
R3	AM	13-01-28	REMOVE BONDING, CORRECT DRILLING	DBS
R2	AM	12-10-05	UPDATE DRILL DETAIL	DBS
R1	AM	06-11-02	UPDATE ASS., DRILL DETAIL, PLAN, NOTES	DBS
R0	DBS	06-02-24	NEW DRAWING	DBS

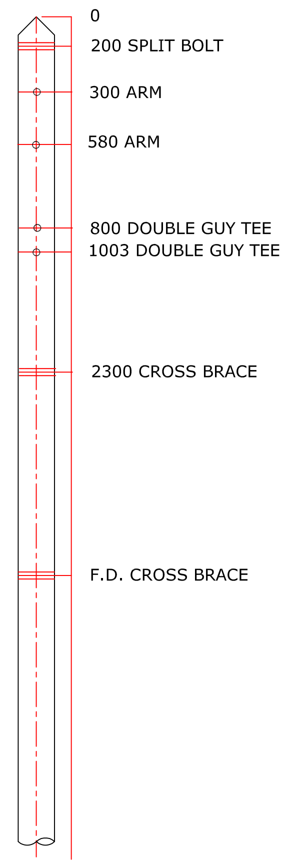
72kV SINGLE POLE VERTICAL DDE
HEAVY DEFLECTION WITH JUMPER POSTS
STRUCTURE TYPE 4310

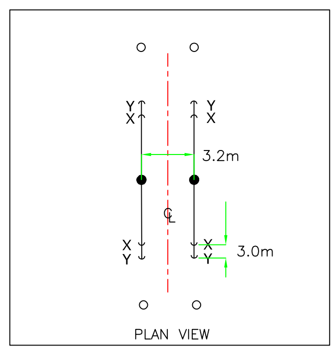
NT ENERGY

DRAWING No.	REV.
T15-SD-4310	R3

ALL HOLES TO BE DRILLED 13/16" UNLESS OTHERWISE NOTED.







NOTES:

- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- FOR MAX STRUCTURAL CAPACITY USE DOUBLE SWAY BRACING FOR POLES OVER 75' TALL
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

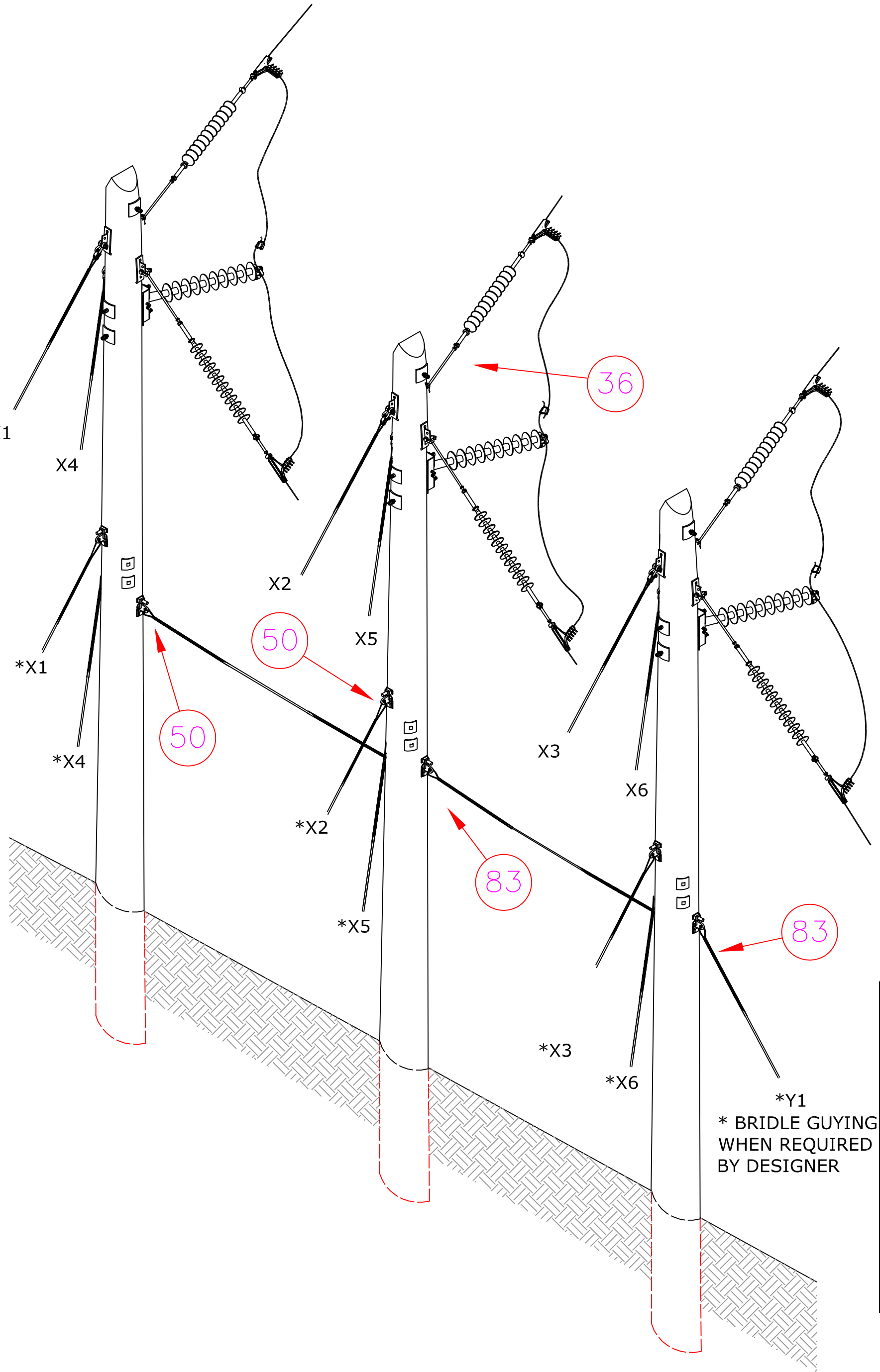
MIDGARD CONSULTING INC

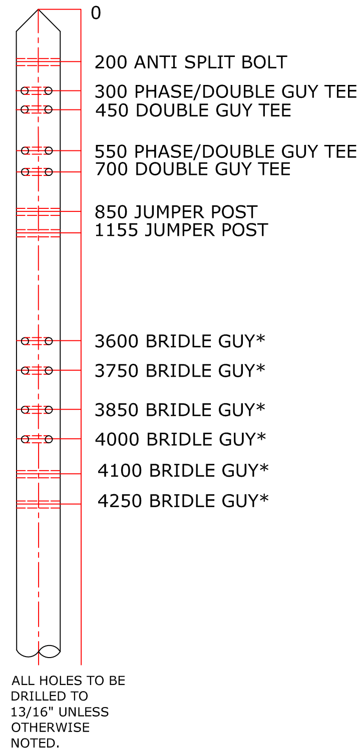
REVISIONS

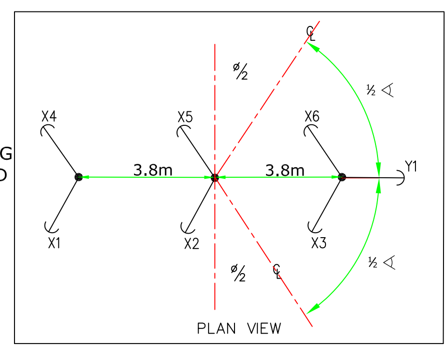
No.	BY	DATE	DESCRIPTION	APP.
R0	AM	13-01-28	NEW DRAWING	DBS

72kV DOUBLE DEADEND H-FRAME INLINE WITH DOUBLE STEEL ARMS STRUCTURE TYPE 4326

	DRAWING No.	REV.
NT ENERGY	T15-SD-4326	R0







NOTES:
- ALL HARDWARE WITH 150mm OR LESS SPACING MUST BE BONDED TOGETHER
- ALL MEASUREMENTS IN mm UNLESS OTHERWISE NOTED
- ANCHOR KICKS MAY BE REQUIRED, TO BE SPECIFIED BY DESIGNER IN STRUCTURE LIST
- JUMPER POSTS REQUIRED FOR LINE DEFLECTIONS < 60° (NOT REQUIRED FOR 60° AND GREATER DEFLECTIONS)
- POLE SPACING MAY BE CHANGED BY DESIGNER TO ADJUST FOR DEFLECTIONS AND PHASE SPACING
- BRIDLE GUYING REQUIREMENT TO BE DETERMINED BY DESIGNER
- DESIGNER TO CHECK GUYING CLEARANCES TO PHASES
- DESIGNER TO CONFIRM ALL DRILLING DETAILS AGAINST MATERIALS USED
- ANCHORING REQUIRED TO BE CONFIRMED AND SPECIFIED BY DESIGNER (SEE STRUCTURE LIST)

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

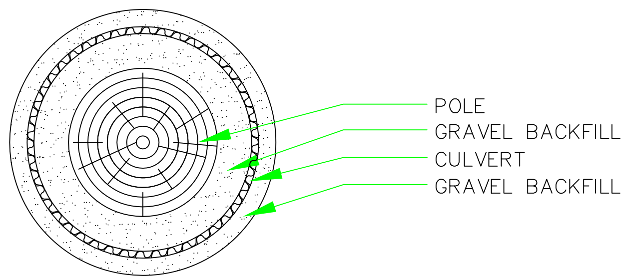
REVISIONS

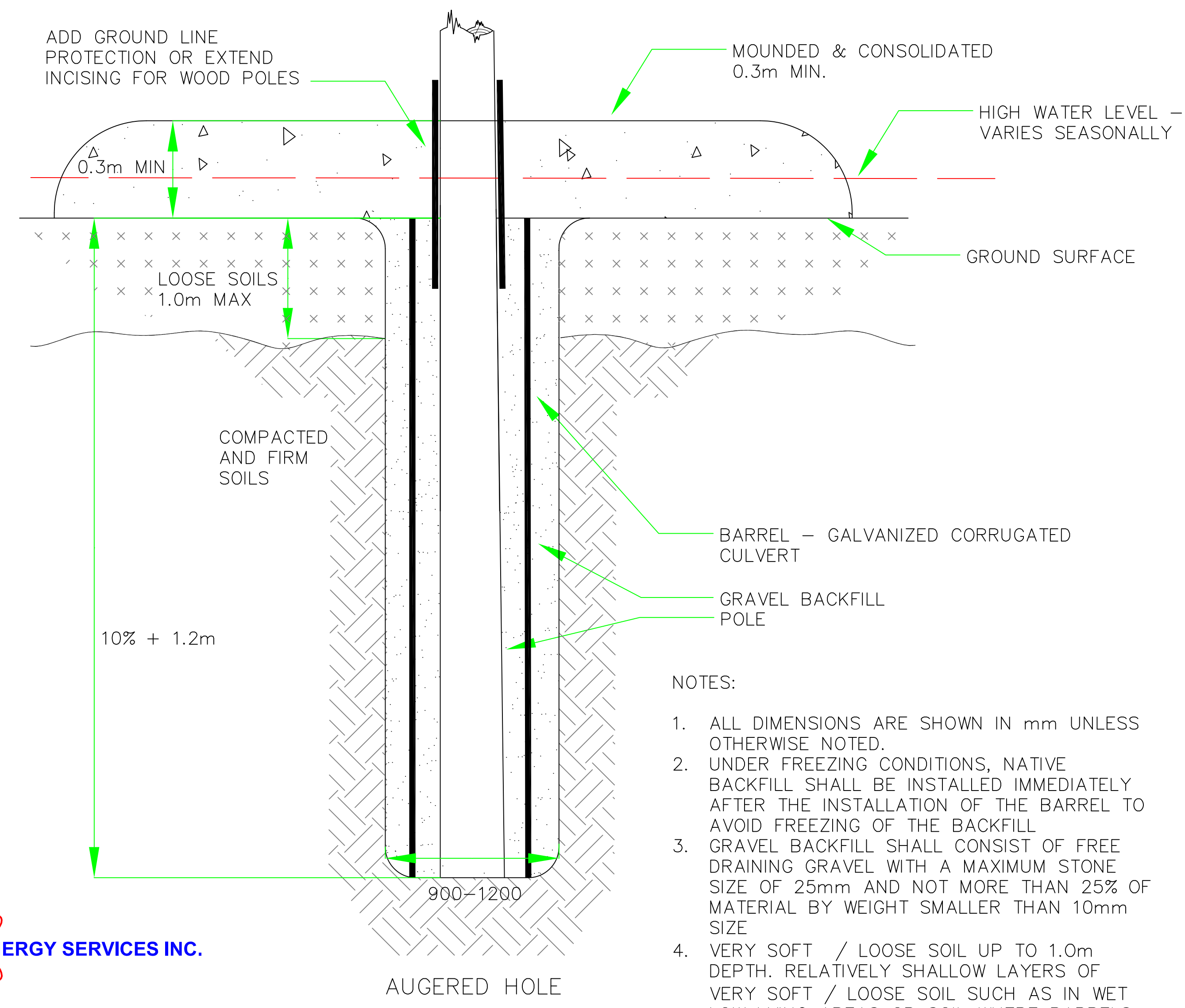
R4	AM	13-01-28	REMOVE GROUNDING, BONDING, UPDATE STR	DBS
R3	AM	10-30-07	ADD JUMPER POST, UPDATE DWG	DBS
R2	AM	06-11-02	GRND DETAIL, DRILL DETAIL, ASSEMBLIES	DBS
R1	DBS	06-04-12	ADDED GROUNDING AND BONDING	DBS
R0	DBS	05-04-11	NEW DRAWING	DBS
No.	BY	DATE	DESCRIPTION	APP.

3 POLE DDE WITH DEFLECTION FOR 72kV
SUSPENSION WITH JUMPER SUPPORT
AND BRIDLE GUYING OPTION
STRUCTURE TYPE 4334

NT ENERGY

DRAWING No.	REV.
T15-SD-4334	R4





NOTES:

1. ALL DIMENSIONS ARE SHOWN IN mm UNLESS OTHERWISE NOTED.
2. UNDER FREEZING CONDITIONS, NATIVE BACKFILL SHALL BE INSTALLED IMMEDIATELY AFTER THE INSTALLATION OF THE BARREL TO AVOID FREEZING OF THE BACKFILL
3. GRAVEL BACKFILL SHALL CONSIST OF FREE DRAINING GRAVEL WITH A MAXIMUM STONE SIZE OF 25mm AND NOT MORE THAN 25% OF MATERIAL BY WEIGHT SMALLER THAN 10mm SIZE
4. VERY SOFT / LOOSE SOIL UP TO 1.0m DEPTH. RELATIVELY SHALLOW LAYERS OF VERY SOFT / LOOSE SOIL SUCH AS IN WET LOW LYING AREAS OR SOIL WHERE BARRELS ARE REQUIRED TO PREVENT CAVING
5. MOUNDED BACKFILL SHALL BE 300mm ABOVE THE GROUND LINE OR HIGHEST WATER LEVEL – WHICH EVER IS THE HIGHER IN ELEVATION

DBS ENERGY SERVICES INC.

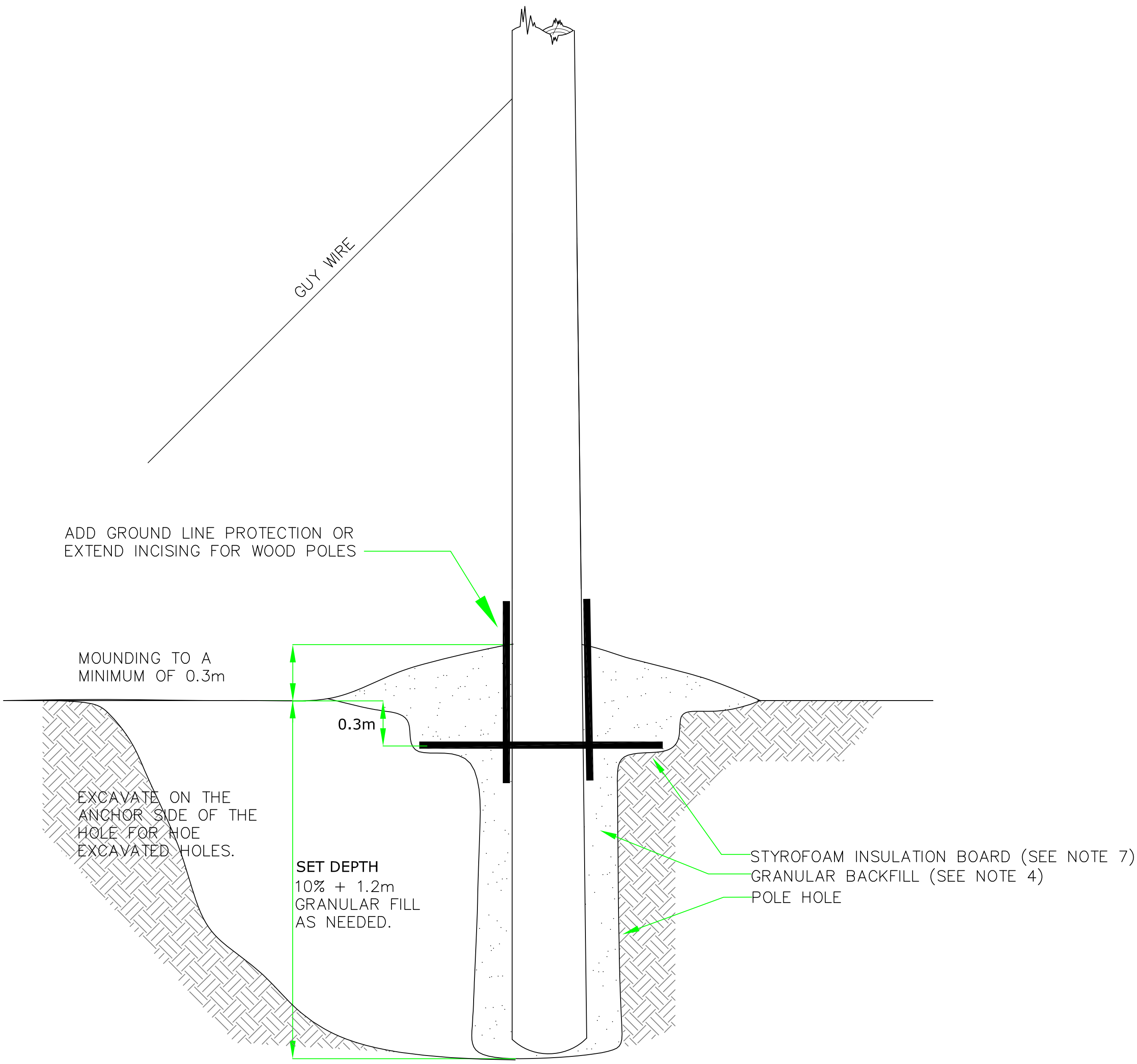
MIDGARD CONSULTING INC

REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	10-10-05	UPDATE FROM DRAFT	DBS
R0	AM	10-04-23	NEW DRAWING	DBS

SHALLOW DEPTH VERY SOFT / LOOSE SOIL
EXTRA EMBEDMENT AND BARREL REQUIREMENTS
DRAWING # 9940

	DRAWING NUMBER:	REV:
NT ENERGY	T15-SD-9940	R1



NOTES:

1. ALL DIMENSIONS ARE IN m UNLESS OTHERWISE NOTED
2. ALL BACKFILL SHALL CONSIST OF GRANULAR MINERAL SOILS, SHALL BE PLACED IN MAXIMUM 250mm LIFTS AND COMPACTED BETWEEN LIFTS WITH A MINIMUM OF 2 AGGRESSIVE PASSES OF ACCEPTABLE TAMPING.
3. OTHER POLES SHOULD BE EMBEDDED 10% OF THEIR HEIGHT +1.2m
4. IN AREAS WHERE PERMAFROST ICE LENSES ARE ENCOUNTERED A 50mm THICK SHEET OF STYROFOAM INSULATION BOARD SHOULD BE INSTALLED ACROSS THE EXCAVATED AREA AT THE 0.5m DEPTH TO REDUCE THAWING OF THE PERMAFROST LAYERS

DBS ENERGY SERVICES INC.

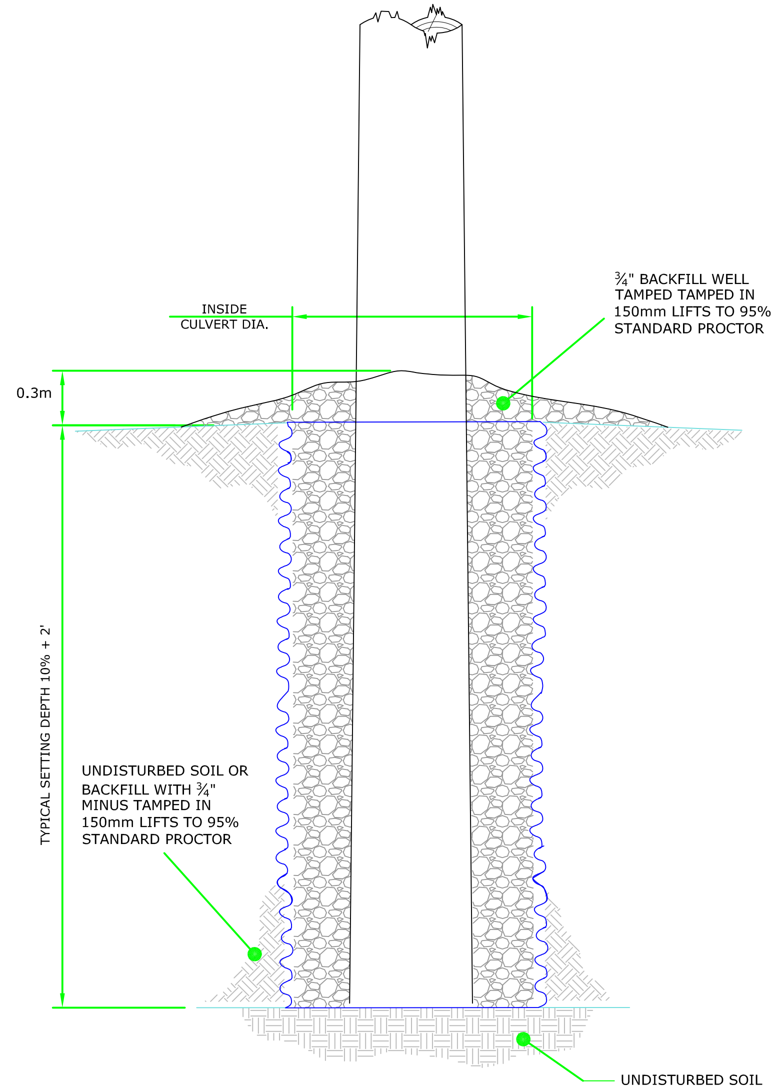
MIDGARD
CONSULTING INC

REVISIONS

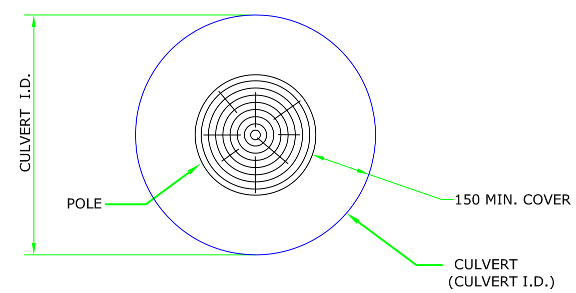
NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	10-10-05	UPDATE FROM DRAFT	DBS
R0	AM	10-04-22	NEW DRAWING	DBS

ANCHORED STRUCTURE FOUNDATIONS IN
WET MINERAL SOIL
DRAWING # 9948

	DRAWING NUMBER:	REV:
NT ENERGY	T15-SD-9948	R1



TYPICAL CULVERT SET



TOP VIEW DETAIL

NOTES:

1. DEPENDING ON SETTING METHODS AND INSTALLATION; WITH USE OF AN EXCAVATOR, BACKFILL HOLE WITH 150mm LIFTS OF ¾" MINUS TO 95% STANDARD PROCTOR DENSITY. IF THE HOLE IS AUGERED WITH "TEXOMA" OR VACUUM TRUCK, THE CULVERT MAY REQUIRE SHORING OF THE EXCAVATION SITE; AND THEN THE VOIDS TO THE OUTSIDE OF CULVERT SHALL BE UNIFORMLY FILLED WITH FINE, FLOWABLE GROUT MIXTURE WHILE VIBRATING THE CULVERT.
2. BASE OF THE FOUNDATION SHALL BE SET ON UNDISTURBED SOIL; IF NOT POSSIBLE AT THE TIME OF CONSTRUCTION, CONSULTATION WITH THE ENGINEER IS REQUIRED.
3. ANY ADDITIONAL EXCAVATION BACKFILLING REQUIREMENTS SHALL BE DONE USING ¾" MINUS AND BACKFILLED WITH 150mm LIFTS @ 95% S.P.

MIDGARD CONSULTING INC

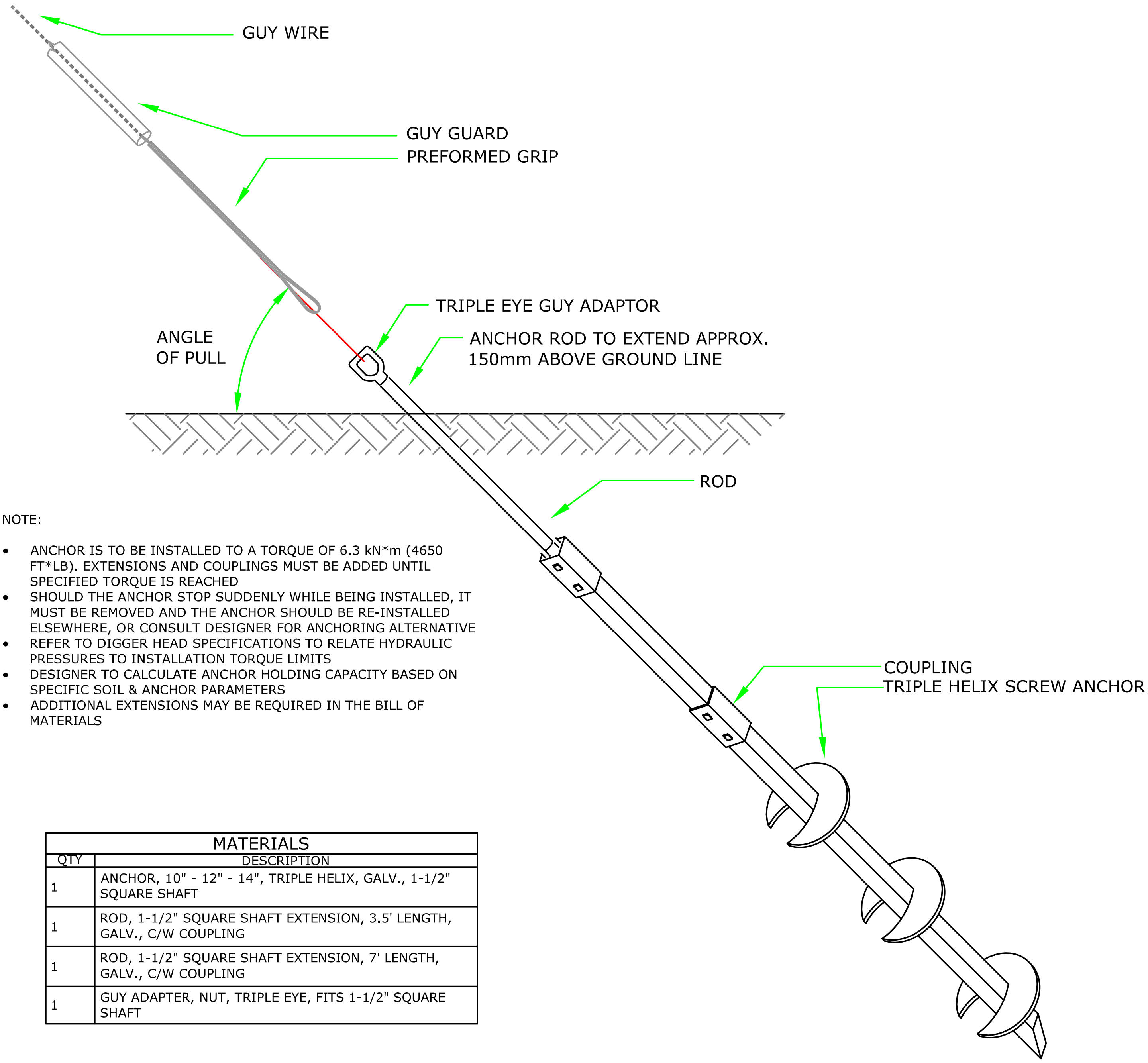
DBS ENERGY SERVICES INC.

REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	13-01-28	UPDATE NOTES AND CULVERT DESCRIPTION	DBS
R0	AM	10-06-21	NEW DRAWING	DBS

TYPICAL CULVERT SET
FOR TX STRUCTURES
STRUCTURE TYPE 9993

NT ENERGY	DRAWING NUMBER:	REV:
	T15-SD-9993	R1



NOTE:

- ANCHOR IS TO BE INSTALLED TO A TORQUE OF 6.3 kN*m (4650 FT*LB). EXTENSIONS AND COUPLINGS MUST BE ADDED UNTIL SPECIFIED TORQUE IS REACHED
- SHOULD THE ANCHOR STOP SUDDENLY WHILE BEING INSTALLED, IT MUST BE REMOVED AND THE ANCHOR SHOULD BE RE-INSTALLED ELSEWHERE, OR CONSULT DESIGNER FOR ANCHORING ALTERNATIVE
- REFER TO DIGGER HEAD SPECIFICATIONS TO RELATE HYDRAULIC PRESSURES TO INSTALLATION TORQUE LIMITS
- DESIGNER TO CALCULATE ANCHOR HOLDING CAPACITY BASED ON SPECIFIC SOIL & ANCHOR PARAMETERS
- ADDITIONAL EXTENSIONS MAY BE REQUIRED IN THE BILL OF MATERIALS

MATERIALS	
QTY	DESCRIPTION
1	ANCHOR, 10" - 12" - 14", TRIPLE HELIX, GALV., 1-1/2" SQUARE SHAFT
1	ROD, 1-1/2" SQUARE SHAFT EXTENSION, 3.5' LENGTH, GALV., C/W COUPLING
1	ROD, 1-1/2" SQUARE SHAFT EXTENSION, 7' LENGTH, GALV., C/W COUPLING
1	GUY ADAPTER, NUT, TRIPLE EYE, FITS 1-1/2" SQUARE SHAFT

DBS ENERGY SERVICES INC.

MIDGARD
CONSULTING INC

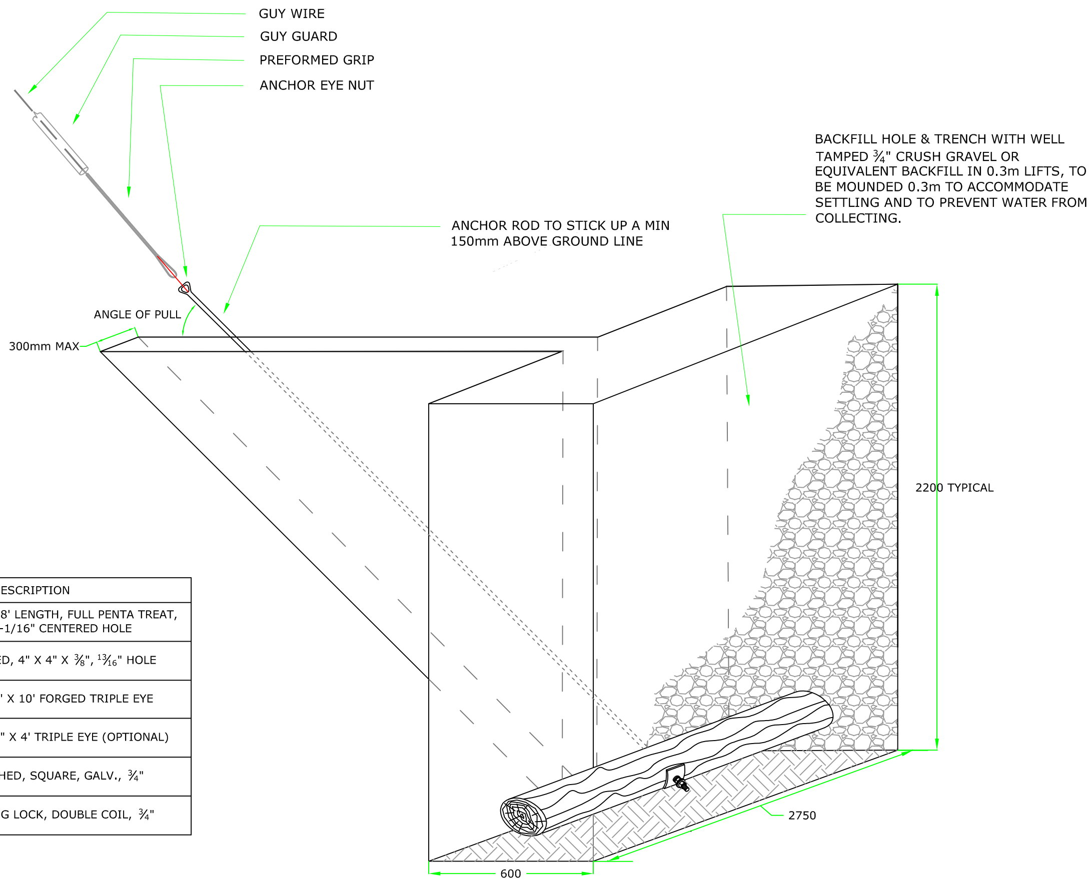
REVISIONS

NO.	BY:	DATE:	DESCRIPTION:	APPROVED:
R1	AM	06-04-15	UPDATE DRAWING AND BOM	DBS
R0	SDM	06-03-10	NEW DRAWING	DBS

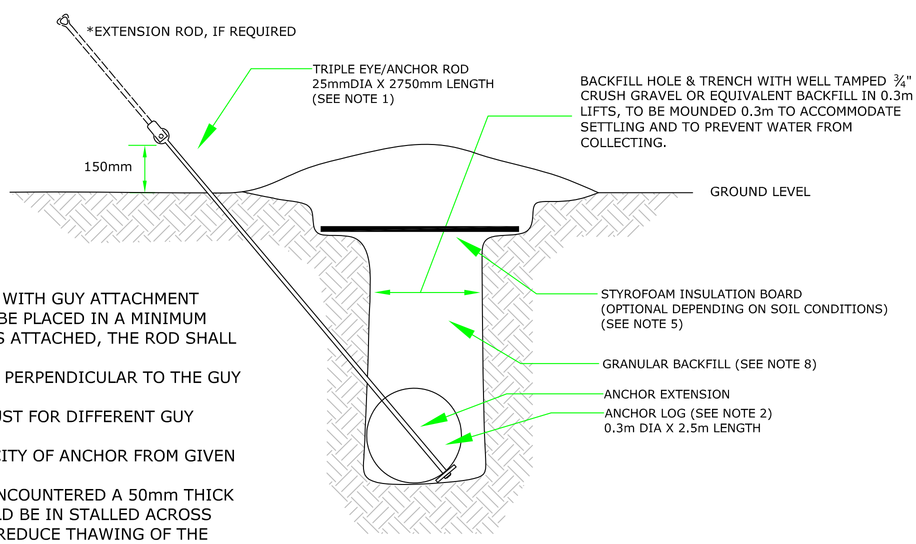
TYPE SS TRIPLE HELIX ANCHOR
ANCHOR DRAWING # 9923

NT ENERGY

DRAWING NUMBER:	REV:
T15-SD-9923	R1



ITEM	QTY	DESCRIPTION
E090203	1	ANCHOR LOG, 14" X 8' LENGTH, FULL PENTA TREAT, WITH ONE 1-1/16" CENTERED HOLE
E142304	1	WASHER, CURVED, 4" X 4" X ⅜", 13⁄16" HOLE
E171112	1	ROD ANCHOR, 1" X 10' FORGED TRIPLE EYE
E170707	1	EXTENSION ROD, 1" X 4' TRIPLE EYE (OPTIONAL)
E141106	2	NUT, UNFINISHED, SQUARE, GALV., ¾"
E142603	1	WASHER, SPRING LOCK, DOUBLE COIL, ¾"



NOTE:

1. ANCHOR ROD SHALL BE ALIGNED IN DIRECT LINE WITH GUY ATTACHMENT POINT ON THE POLE. (+/-3 DEGREES) AND SHALL BE PLACED IN A MINIMUM SLOTTED TRENCH. WHERE MORE THAN ONE GUY IS ATTACHED, THE ROD SHALL BE ALIGNED WITH THE CENTER GUY.
2. ANCHOR LOG SHALL BE PLACED HORIZONTAL AND PERPENDICULAR TO THE GUY DIRECTION
3. ADJUST DEPTH BASED ON GUY ANGLE. FIELD ADJUST FOR DIFFERENT GUY ANGLES.
4. DESIGNER IS TO CALCULATE MAX HOLDING CAPACITY OF ANCHOR FROM GIVEN SOIL CONDITIONS & ANCHOR PARAMETERS
5. IN AREAS WHERE PERMAFROST ICE LENSES ARE ENCOUNTERED A 50mm THICK SHEET OF STYROFOAM INSULATION BOARD SHOULD BE IN STALLED ACROSS THE EXCAVATED AREA AT ABOUT 0.5m DEPTH TO REDUCE THAWING OF THE POLE AND ANCHOR AREAS
6. BACKFILL HOLE AND & TRENCH WITH WELL TAMPED, ACCEPTABLE, NATIVE SOIL OR GRAVEL, IN 0.3m LIFTS
7. MOUND BACKFILL A MINIMUM OF 0.3m TO ACCOMMODATE SETTLING AND TO PREVENT WATER FROM COLLECTING
8. ALL BACKFILL SHALL CONSIST OF GRANULAR MINERAL SOILS; SHALL BE PLACED IN 250mm LIFTS AND COMPACTED BETWEEN LIFTS WITH A MINIMUM OF 2 PASSES OF A MECHANICAL TAMPER
9. USE SOIL SAFETY FACTORS OF A MINIMUM 2.0 UNLESS SOIL TESTS ARE AVAILABLE
10. DESIGNER TO CONFIRM SOIL EXPECTATIONS IN FIELD
11. MACHINE DIG HOLE OR DIG BY HAND.

DBS ENERGY SERVICES INC.

MIDGARD CONSULTING INC

REVISIONS

No.	BY	DATE	DESCRIPTION	APP.
R1	AM	10-10-05	UPDATE FROM DRAFT	
R0	AM	10-06-15	NEW DRAWING	DBS

LOG ANCHOR
ANCHOR DRAWING # 9949

NT ENERGY

DRAWING No.	REV.
T15-SD-9949	R1