

Network Standard

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Title:

Design of Underground Industrial and Commercial Areas

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4	16/09/2024	Conversion to new format and addition of protection requirements	Matthew Cupples	Murray Chandler
5	23/10/2024	Addition of single core cables for 100A services and 300AL4 for over 200 A services.	Matthew Cupples	Jacob Bayley
6	25/02/2026	Update to cable constants to be aligned with AS/NZS 3008.1.1:2025	Matthew Cupples	Evan Riddell

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Scope

This Network Standard sets the minimum design requirements in underground industrial and commercial areas.

Reference Documents

All work covered in this document shall conform to all relevant Legislation, Standards, Codes of Practice and Network Standards.

Ausgrid Documents

NS001 Glossary of Terms

NS113 Site Selection and Construction Design Requirements for Chamber Substations

NS114 Electrical Design and Construction Standards for Chamber Type Substations

NS117 Design and Construction Standards for Kiosk Type Substations

NS119 Public Lighting Design and Construction

NS130 Laying Underground Cables up to and including 11kV

NS141 Site Selection and Preparation for Kiosk Substations

NS143 Easements, Leases and Rights of Way

NS195 High Voltage Customer Connections (HVCs)

NS224 Low Voltage Suburban Commercial and Industrial Underground Distribution Utilising Pillars

NS290 Selection of Distribution Substations

Other Standards and Documents

Service and Installation Rules of New South Wales

Clause Standard Requirements**1 Methods of supply**

1.1 The method of supply shall be determined by Ausgrid and selected from one of the following options:

- Service from the existing low voltage system
- Direct distributor (an exclusive supply line to a customer's connection point from a distribution substation remote from the customer's premises)
- Customer substation
- High voltage supply

2 Initial load and route length limitations**2.1 Assessment of maximum demand**

2.1.1 The estimated maximum demand shall be calculated in accordance with AS/NZS 3000, based on average industrial and commercial maximum demand statistics.

2.1.2 Medium and heavy industrial areas require full details of connected load before an assessment of demand can be made. Only uniformly distributed loads such as lighting and air-conditioning can be assessed using the area usage method.

2.1.3 Individual customer development

2.1.3.1 Where a full list of connected loads is not initially available, a nominated load density value in VA per square metre for floor area shall be used in accordance with AS/NZS 3000.

2.1.3.2 The maximum demand shall include the size and timing of the expectations of future expansion of the installation.

2.1.4 Subdivision development

2.1.4.1 The final maximum load details for each lot in the subdivision shall be determined based on:

- the known load details for each lot in the subdivision; or
- for uniformly distributed loads, an estimate based on the floor area for each lot following the method in AS/NZS 3000; or
- for non-uniformly distributed loads, an estimate based on the likely connected loads, or a per lot maximum demand based on expected use and experience from previous developments; or
- Ausgrid's nomination of a minimum load per lot.

2.1.4.2 Future requests that exceed the initial allocation may result in further contestable work. The subdivision design shall show the designed load allocated for each lot.

2.1.4.3 An allowance for future load growth shall be made by following:

- Fully air-conditioned, modern offices; 15-20%;
- Commercial premises where computer equipment not installed initially; 20-25%;
- Shopping centres and zoned light/medium industrial premises; 25%; or
- an estimate based on expected end use and experience from similar developments.

- 2.1.4.4 All designed distribution centres shall be installed at the time of initial development of the subdivision.
- 2.1.4.5 Appropriate property easements shall be established for distribution centres, and suitable conduits shall be installed, on development lots.
- 2.2 **Maximum low voltage distributor loading**
- 2.2.1 The nominal rating of each distributor will be advised by Ausgrid. Distributors to the network from kiosk and chamber type substations commonly have nominal ratings of 400 amps, except for older type kiosks in the Newcastle-Hunter area, which have nominal distributor ratings of 350 amps.
- 2.2.2 The initial electrical loading for a distributor shall not exceed 75% of its nominal rating, to provide a reasonable margin for load growth and paralleling requirements.
- 2.2.3 The load to be connected to a distribution centre shall be balanced across the distributors and their respective phases.
- 2.3 **Voltage drop**
- 2.3.1 The designed maximum voltage drop along a low voltage distributor shall not exceed 9 volts phase-to-earth at the extremities when the distributor is loaded to its nominal rating, as indicated in Clause 2.2. Voltage drop calculations shall use known lot load details where available. Where lot loads are unknown, they shall be equally apportioned to each proposed lot along the distributor.
- 2.3.2 The designed maximum voltage drop along a direct distributor shall not exceed 11.5 volts phase-to-earth at the extremities when the distributor is loaded to the rating of the fuse installed.
- 2.3.3 The voltage drop in the service mains shall be determined in accordance with the Service and Installation Rules of NSW.
- 2.3.4 Where an existing non-compliance is identified, the designer shall inform Ausgrid. The new connection shall not worsen the voltage drop for existing non-complying sites.
- 2.3.5 Voltage drop constants for distributors and streetlighting cables at 50 Hz and 90° C conductor temperature are given in Table 1.

Table 1 – Voltage drop constants for distributor and streetlighting cables

Underground Cable	Voltage Drop Constants for Balanced Loading over Three Phases (mV/amp-metre)	
	Phase / Earth ¹	Phase / Phase
415V 16 CU4 XQ Z	1.472	2.550
415V 240 AL4 XQ Z / SAC	0.175	0.303
415V 300 AL4 XQ Z / SAC	0.145	0.252
415V 240 CU4 XQ Z	0.118	0.205
415V 185 CU1 XQ Z / COM#COL (4 cables) or 415V 185 CU1 XQ Z (4 cables)	0.162	0.281
415V 300 CU1 XQ Z (4 cables)	0.125	0.217
415V 500 CU1 XQ Z (4 cables)	0.108	0.188

¹ Use this column for calculation of the designed maximum voltage drop in a low voltage distributor.

2.4 Protection of low voltage underground networks

- 2.4.1 All LV networks shall be protected by current limiting HRC fuses at the distribution substation. The fuse size and type shall be selected in accordance with NS114 or NS117, depending on the substation type.
- 2.4.2 The maximum rating fuse to be used on the underground network or distributor shall be 400A and all fuses shall have fast operating characteristics.
- 2.4.3 There are limitations on the length of network distributors for protection reasons. At the extremities of network distributors, the bolted phase to neutral fault current shall be greater than the 10 second fuse current as per Table 2.
- 2.4.4 Where multiple cables per phase are used, the design shall be referred to Ausgrid for individual assessment.

Table 2 – Fuse operating fault level

Fuse Size (Amps)	Fault Level (A) for 10s Operating Time	
	Fuse Type	
	J	T
100	350	443
200	800	1000
250	971	1222
315	1152	1533
400	1521	2154

¹ Unless specifically calculated, the fuse 10 second current is to be taken from this table. This represents typical characteristics for fuses used on Ausgrid's network. Site specific fuse characteristics may be used in lieu this table, refer to Ausgrid for specific fuse sizes and fuse time current characteristics.

² The cable loop impedance of a LV distributor is defined as the total impedance, measured from a Distribution Centre to the network extremity, of a phase conductor plus the return neutral.

³ The maximum distributor length requirements for protection reasons does not consider voltage drop.

2.5 **Route length limitations on low voltage circuits due to fault clearance criteria**

- 2.5.1 The total route lengths for electrical connections such as direct distributors, consumer mains or a combination of direct distributors and consumer mains from distribution substations shall not exceed the distances shown in Table 3 when measured from the distribution substation LV fuses or CB to the customer's LV Service Protection Device (SPD).
- 2.5.2 For multi-transformer substations where distribution substation transformers are operated in parallel, increased distributor lengths may be permitted after consultation with Ausgrid.
- 2.5.3 The route length shall be negotiated with Ausgrid for customer switchboards rated at 800A or greater that do not have an SPD set in accordance with Clause 2.5.5.3 of AS/NZS 3000:2018.

Table 3 – Maximum route length of LV circuits (in metres) at distribution substations for direct distributors and consumer mains

Cable Size	≥185mm ² Cu and <300mm ² Cu ≥240mm ² Al to <500mm ² Al				≥300mm ² Cu to <500mm ² Cu ≥500mm ² Al				≥500mm ² Cu			
	1	2	3	4	1	2	3	4	1	2	3	4
400A Fuse	380 ¹				520				650			
630A Fuse		230				330			230			
800A Fuse			260 ²			240				310 ³		
1000A Fuse			210			190	290			260	390	
1200A Fuse				220			220	300		190	320	
1600A Fuse								180			170	220
>2000A CB/ Relay								100				130

¹ Direct distributor cables only.

² 800A panels cannot accommodate 3 cables per phase; this distance is for 800A fuses installed in higher-rated panels.

³ 800A panels cannot accommodate 500mm² cables; this distance is for 800A fuses installed in higher-rated panels.

3 Distribution substations

3.1 Types and ratings

3.1.1 Substation options available and conditions of use are detailed in NS290.

3.1.2 K-type kiosks and single transformer high voltage circuit-breaker controlled substations shall be restricted to installations for single industrial customers or single commercial customers.

3.1.3 Shopping centres shall be considered to be a multiple customer for the purposes of clause 3.1.2, and shall not be supplied by K-type kiosks.

3.2 Industrial and commercial subdivisions

3.2.1 Where maximum demand information is available at the time of subdivision development, and the required substation sites can be determined during the early stages of development, these sites shall be shown on the subdivision survey plan as unencumbered, obstruction free sites.

3.2.2 The substations shall be sited close to the load centre to fully utilise the substation capacity.

3.2.3 For developments in greenfield areas (subdivisions bordered by other undeveloped land), the Designer shall include options for extensions and connections to future developments.

3.3 Industrial and commercial individual customers

3.3.1 Substations shall be sited on off-street locations on the development lot for all applications from a single applicant or developer (eg a factory, a commercial building, a parcel containing multiple residential or industrial units, or a community title development).

4 High voltage feeders

4.1 Design and arrangement

- 4.1.1 At least one high voltage cable shall be laid through every street of the development to facilitate supply to future substations. The high voltage cable shall loop in and out of cul-de-sacs so as not to form an open point. Each high voltage cable shall be installed with a spare conduit for high voltage use.
- 4.1.2 For an anticipated demand of over 6MVA, a second High Voltage cable from a separate feeder shall be laid through the development.

4.2 Cables and ratings

- 4.2.1 Ausgrid shall specify the cable to be used on each project from the options in Table 4. When connecting to existing radial 11kV networks, the cable size is selected to match the existing cables, provided a minimum size of 400AL3/185CU is used.
- 4.2.2 300mm² copper cables shall be used as feeder cables in the Sydney CBD pit and duct system.

Table 4 - High voltage cables

Conductor type	Cross Sectional Area (mm ²)	Cable Description	General Application
Aluminium	500	11kV 500 AL3 polymeric cable	Feeder cable - urban areas
Aluminium	400	11kV 400 AL3 polymeric cable	Feeder cable - urban areas
Copper	500	11kV 500 CU3 polymeric cable	Where mutual heating is an issue i.e. exiting out of a zone substation or in a long / deep underbore
Copper	300	11kV 300 CU3 PILC cable	Feeder cable -Existing City pit and duct where 300 Triplex does not physically fit
Copper	300	11kV 300 CU1 polymeric cable	Feeder tails
Copper	300	11kV 300 CU1 polymeric triplex cable	Feeder cable – New city pit and duct Feeder tails
Copper	185	11kV 185 CU1 polymeric cable	Feeder tails
Copper	185	11kV 185 CU1 polymeric triplex cable	Feeder tails
Copper	70	11kV 70 CU1 polymeric cable	Cable risers and tees into distribution substations in Sydney CBD area

5 Low voltage distributors

5.1 Design and arrangement

- 5.1.1 Low voltage distributor cables shall be direct-buried, provided the industrial development is a closed-off site without access to the public, unless a crossing (e.g. driveway, easement, roadway, rail) is required, where cables shall be installed in conduits (ducts).
- 5.1.2 Cables shall be looped into and out of distribution pillars.
- 5.1.3 The first pillar from a substation on each distributor shall be a link pillar to allow for isolation of the distributor. (Note: This does not apply to direct distributors.)
- 5.1.4 Each distribution cable shall be terminated into the link module on the side of the module at which the cable enters the pillar, with the pillar in its final position.
- 5.1.5 Adjacent pillars shall be supplied by the same distributor, except for link pillars used as interconnectors.
- 5.1.6 Distribution pillars at the extremities of a low voltage distributor shall have links installed to allow for paralleling with adjacent distribution centres.
- 5.1.7 Pillars shall be installed adjacent to the lot boundaries and positioned in accordance with NS130.
- 5.1.8 Two spare conduits shall be installed on both sides of each roadway for low voltage use.
- 5.1.9 Roadway crossings consisting of a minimum of four conduits, complying with the Table of Conduit Specifications as detailed in NS130, shall be laid approximately every 75 metres and aligned with the nearest pillar.
- 5.1.10 Services up to 200A shall be terminated into the distribution pillars (refer to NS224). Services exceeding 200A and up to 400A, shall be supplied direct from the distribution substation, or after consultation with Ausgrid supplied from the distribution pillars. Services above 400A shall be supplied direct from the distribution substation.
- 5.1.11 Alternate supply to LV distributors shall be provided from adjacent distribution centres where practicable.
- 5.1.12 Dedicated customer substations (i.e. those with Consumer Mains), shall have an additional distributor connected to the LV street network.
- 5.1.13 Every opportunity shall be taken to establish loop feeds where loop roadways exist (i.e. interconnection between distributors from the same distribution centre or between different branches of the same distributor). Extension of distributors beyond that necessary to provide a paralleling path will not normally be required unless specified otherwise by Ausgrid.

5.2 Cables and ratings

5.2.1 Cables for low voltage network distributors and direct distributors shall be selected from the options in Table 5.

5.2.2 For direct distributors that exceed the ratings in Table 5, two cables shall be installed and operated in parallel.

Table 5 - Low voltage distributor cables

Cross Sectional Area (mm ²)	Cable Description	General Application	Summer Cyclic Cable Rating- Amps	
			Duct Laid	Direct Laid
240	415V 240 AL4 XQ Z / SAC	(a) Network distributor cable outside Sydney CBD. (b) Direct distributor.	355 ¹	440
300	415V 300 AL4 XQ Z / SAC	(a) Network distributor cable outside Sydney CBD. (b) Direct distributor.	400	495
185	415V 185 CU1 XQ Z / COM# COL (4 cables) ²	(a) Network distributor cable within or outside Sydney CBD. (b) Direct distributor.	420	520
	415V 185 CU1 XQ Z (4 cables)	(a) Network distributor cable outside Sydney CBD. (b) Direct distributor.	420	520
240	415V 240 CU4 XQ Z	Network distributor cable outside Sydney CBD – special cases	460	565
300	415V 300 CU1 XQ Z (4 cables)	Direct distributor.	540	665
500	415V 500 CU1 XQ Z (4 cables)	Direct distributor.	710	875

¹ This cable can only be used if it has been approved for duct installation. Approval does not need to be sought if the cable is being duct laid for the purpose of crossing a driveway, an easement or a road which is less than 20m subject to the designer undertaking a load assessment as part of their design to ensure that the crossing does not limit the normal rating of the distributor.

² This cable is not UV stable and not suitable for outdoor use i.e. UGOH

³ Cable ratings are based on a soil thermal resistivity of 1.2 Km/W with no other cables in the trench. Refer to NS272.

5.3 Distribution pillars

5.3.1 Pillars for use in industrial and commercial areas of Ausgrid's network shall be selected from those detailed in NS224, which contains the electrical configurations available.

6 Service mains

6.1 Cables and ratings

6.1.1 All underground service cables shall be three-phase, except for builders' services and special small services, which may be single-phase.

6.1.2 Service cable specifications shall be selected from the options in Table 6.

Table 6 - Low voltage service cables

Rating Amps	Cross-sectional area (mm ²)	Cable Description
100	16 or 25	Circular, stranded, copper conductor, single-core, two-core or four-core.
200	50 or 70 ¹	Circular, stranded, copper conductor, single-core or four-core.
>200A	185	Circular, stranded, copper conductor, single-core.
	240 or 300	90 degree sector shaped, solid, aluminium conductor, multicore ² .

¹ 70mm² must be compacted conductor.

² Not suitable for use as a service cable in pillars – refer to NS224.

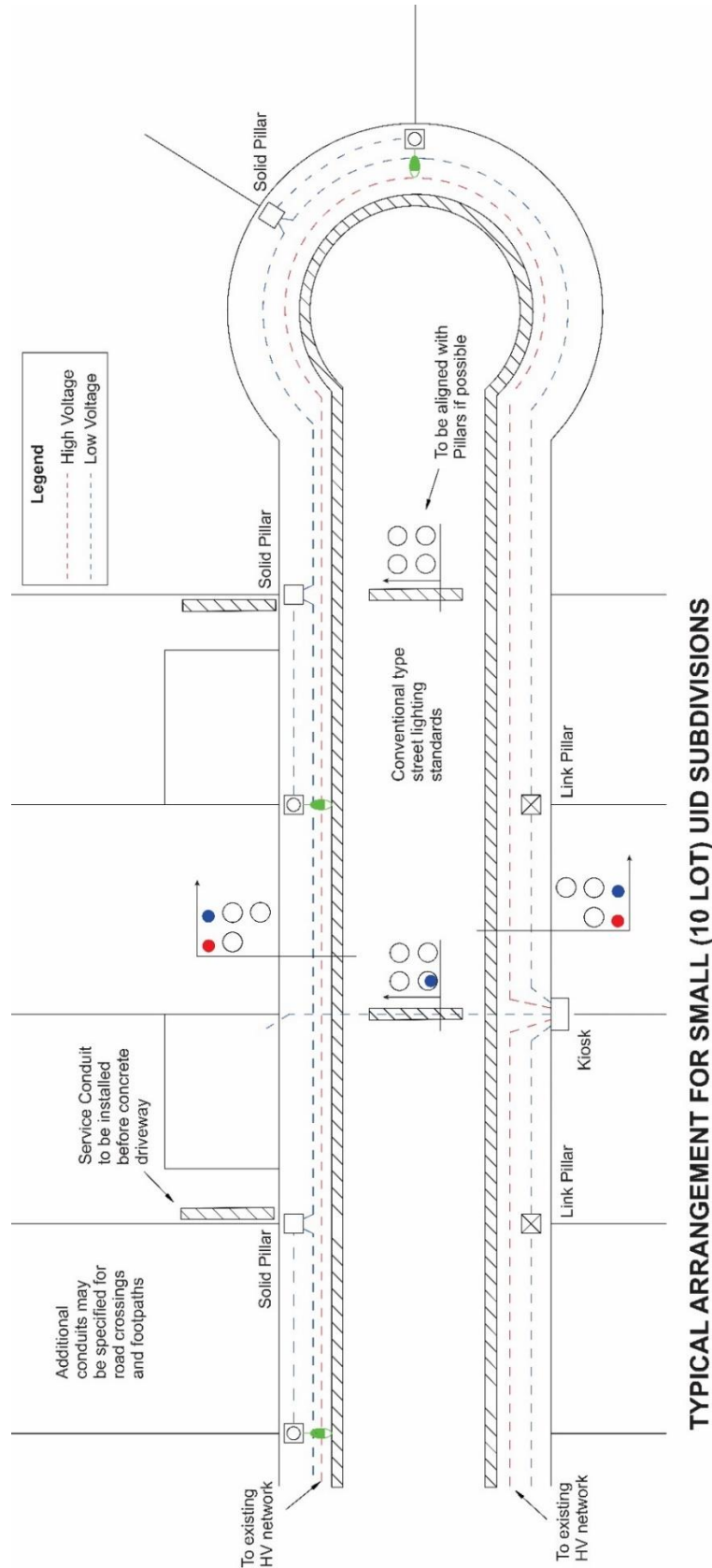
6.1.3 Any intermediate service ratings (based on the assessed demand of the installation) shall use the next largest service rating/cable available. The 50mm² cable may also be used for a 100 amp service to satisfy voltage drop requirements.

Annexure A: Fuse Sensitivity Calculator

The fuse sensitivity calculator is stored externally to this standard.

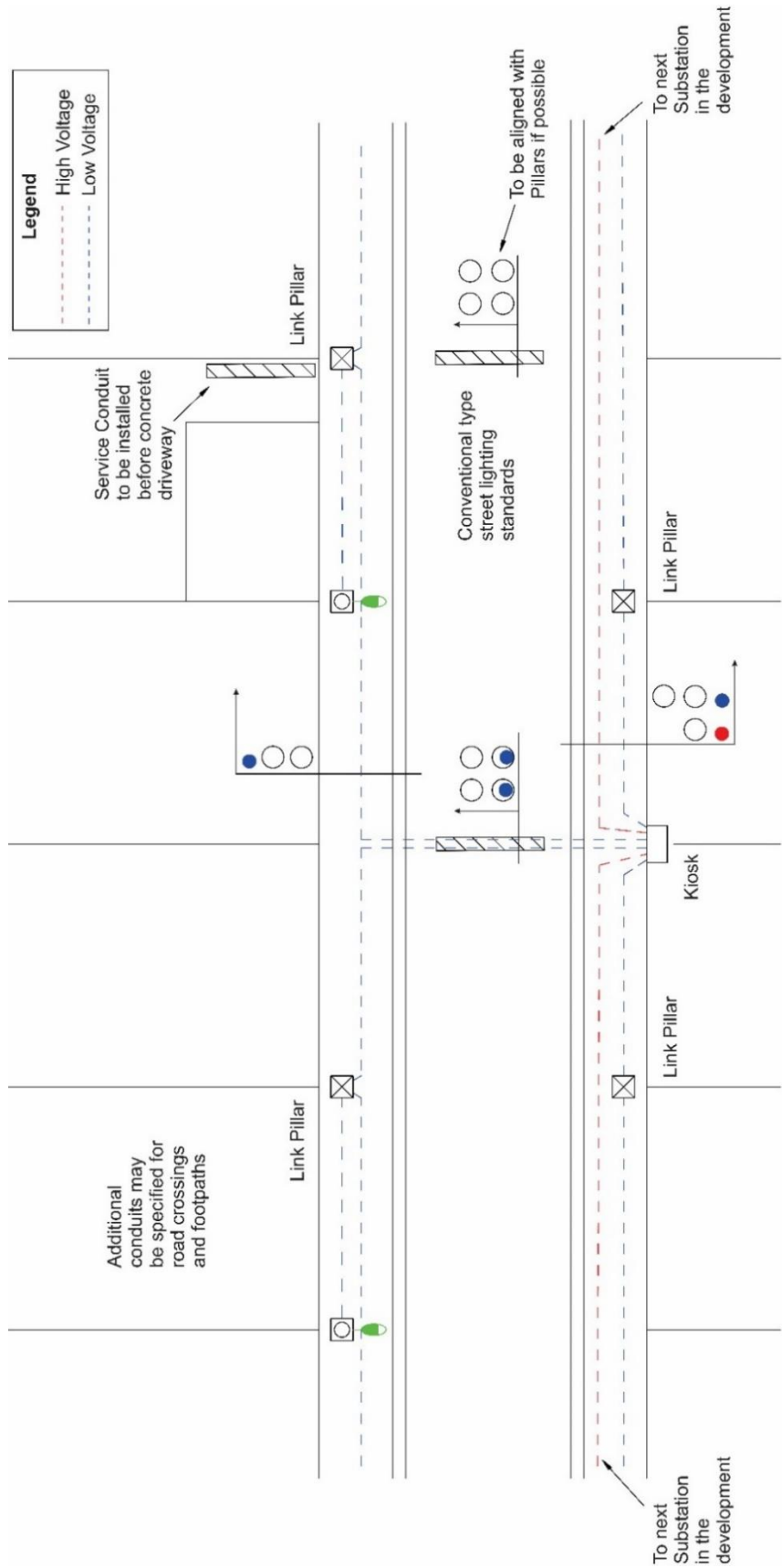
Annexure B: Typical subdivision layout

The following layouts are typically used in the absence of load details.



TYPICAL ARRANGEMENT FOR SMALL (10 LOT) UID SUBDIVISIONS

Figure 1 - Typical subdivision layout



TYPICAL ARRANGEMENT FOR LARGE UID SUBDIVISIONS

Figure 2 - Typical Arrangement for Large UID Subdivisions