

THE CITY OF EDMONTON

**PROJECT AGREEMENT
VALLEY LINE WEST LRT**

Schedule 5 – D&C Performance Requirements

Part 6: Systems

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PART 6: SYSTEMS

SECTION 6-1 – RAIL SYSTEMS

6-1.1 INTRODUCTION

- A. Provide the following Rail Systems, facilities and all associated infrastructure required for the operation and control of the Infrastructure, each specified and described in detail in this Section 6-1 *[Rail Systems]* which include:
1. Train Control System to provide positive Train separation;
 2. Train Routing and Priority System to provide automatic Train routing and Transit Signal Priority to optimize Run Times;
 3. Systems Duct Bank to provide mechanical protection and access for electrical, communication and signalling cable;
 4. Wayside Equipment and associated Wayside Equipment Enclosures;
 5. Fibre Optic Backbone Communication Transmission System (CTS) to provide high capacity communications infrastructure;
 6. main Data Centre and back-up Data Centre(s), as required, to encompass data collection, processing, storage and networking functions;
 7. electrical systems and all associated infrastructure required to energize and protect the System and all associated distributed loads, except Traction Power loads;
 8. mechanical systems and all associated infrastructure required to provide the HVAC, plumbing and other mechanical requirements for the spaces in Stops and Stations and other Building Structures;
 9. CCTV System to provide security and operational Closed-Circuit Television surveillance;
 10. radio systems and infrastructure to provide wireless voice and data communications for operational, emergency and security purposes;
 11. telephone systems to provide landline voice communications for operational purposes, and for the convenience and safety of passengers;
 12. Building SCADA system to centrally monitor and control conditions within the Transportation and Building Structures;
 13. Security, access control and intruder alarm system to protect critical System facilities;
 14. Network Management System to centrally monitor all CTS networked devices;
 15. Infrastructure required to support the Ticket Vending Machines and other fare collection/validation infrastructure which are to be supplied and installed by the City;
 16. Infrastructure required to support the installation of the advertising signs and screens which are to be supplied and installed by the City;
 17. Public Address and Variable Message Sign systems to provide fire command post announcements, automated Train arrival announcements and centrally controlled passenger announcements;

18. wire, cable and other infrastructure required to provide connectivity of Equipment;
 19. Infrastructure required to support the installation of Wi-Fi systems to be supplied and installed by the City;
 20. Master Clock system to synchronize all time-based event logging and reporting systems;
 21. electric vehicle charging stations to provide power to charge electric road vehicles; and
 22. Infrastructure required to support the installation of automated teller machines within the WEM Station.
- B. All Wayside Equipment installed on the Trackway shall be able to operate without damage while being submerged in water.

6-1.2 APPLICABLE CODES STANDARDS AND REGULATIONS

- A. Without limiting Section 1-1.7 [*Reference Documents*] of this Schedule and except as otherwise specified herein, the Rail Systems and all associated infrastructure shall comply with the following codes, standards and regulations, to the extent applicable:
1. Valley Line West LRT Facilities Design and Construction Standards;
 2. NBCAE, provided that any electrical facilities, infrastructure and systems that are not subject to the NBCAE shall comply with Section 6-5 [*Transportation Electrical Service Plan*] of this Schedule;
 3. National Fire Code Alberta Edition;
 4. ASHRAE Handbooks (HVAC Applications, Fundamentals, HVAC Systems and Equipment);
 5. ASPE Handbooks (Volumes 1-4);
 6. ANSI/BICSI 002;
 7. ANSI/ICEA S-87-640-2006 Standard for Optical Fiber Outside Plant Communications Cable;
 8. AREMA C&S Manual;
 9. ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality;
 10. ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential Buildings;
 11. ASHRAE 55 – Thermal Environmental Conditions for Human Occupancy;
 12. BSS 7239 – Test Method for Toxic Gas Generation by Materials on Combustion
 13. Canadian Electrical Code Part I;
 14. Canadian Electrical Code Part II;
 15. Canadian Electrical Code Part III;
 16. CGSB 24.3 – Identification of Piping Systems;
 17. CAN/CSA Z462 Workplace Electrical Safety Standard;
 18. CENELEC Standards;

19. CSA B149.1 – Natural Gas and Propane Installation Code;
20. IEEE 802.3at Power over Ethernet Standard;
21. IEC 1024-1 Protection of Structures Against Lightning, Part 1 - General Principles;
22. IEC 61663-1 Lightning Protection - Telecommunication Lines, Part 1 Fibre Optic Installations;
23. IEC 61663-2 Lightning Protection - Telecommunication Lines, Part 2 Lines Using Metallic Conductors;
24. International Railway Industry Standards;
25. National Plumbing Code;
26. NFPA-10 Standard for Portable Fire Extinguishers;
27. NFPA 13 Standard for the Installation of Sprinkler Systems;
28. NFPA 14 Standard for the Installation of Standpipe, Private Hydrants, and Hose Systems;
29. NFPA-76 Standard for the Fire Protection of Telecommunications Facilities;
30. NFPA-130 Standard for Fixed Guideway Transit and Passenger Rail Systems;
31. Telcordia Technologies, Inc - GR-20-CORE;
32. Telcordia Technologies, Inc - GR-326-CORE;
33. Telcordia Technologies, Inc - GR-449-CORE;
34. Telcordia Technologies, Inc - GR-771-CORE;
35. Telcordia Technologies, Inc - GR-2866-CORE;
36. Telcordia Technologies, Inc - GR-3120-CORE;
37. Transport Canada Grade Crossings Standards; and
38. United States Department of Agriculture Rural Utilities Service (RUS) 7 CFR 1755.900 (PE-90).

6-1.3 TRAIN CONTROL SYSTEM (TCS)

- A. The TCS shall enable full bi-directional Train operations throughout the track alignment. Protect Conflicting Moves by providing locking in accordance with AREMA C&S Manual Part 2.4.5, 2.2.11, and 2.2.15, *Recommended Functional/Operating Guidelines for Traffic Control Systems*, including route locking and traffic locking by means of an arrangement of Block Signals, wheel counters, mass detectors, Track Circuits, Vital Controllers, power operated switch machines (POSM), Switch Position Indicators (SPI), relays or other Vital equipment.
- B. The Infrastructure shall be principally designed for Line-of-Sight operation. Notwithstanding the previous sentence, provide a TCS to maintain positive Train separation at all of the following locations:
 1. sections of the Mainline Track for which the distance between the Driver and any potential Track Occupancy is less than the Sighting Distance as determined by the Valley Line LRT Stage 2 Sightline Study;

2. Yard Track entries/exits to Gerry Wright Parcel B; and
 3. Yard Track entries/exits and lead Track to the Lewis Farms Storage Facility.
- C. Not Used
- D. Design the TCS to provide sequential track circuit clearing.
- E. Integrate the TCS for Valley Line LRT Stage 2 with the TCS provided for Valley Line LRT Stage 1:
1. to prevent operational deadlocking between NorQuest Stop and the Churchill Stop in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule; and
 2. to provide integrated and protected operation for the Gerry Wright OMF.
- F. If the TCS uses:
1. a Block Signal, each Block Signal shall:
 - a. be of Vital design;
 - b. display a horizontal lunar bar aspect, as its default state, to convey an LRT-Stop indication;
 - c. display a vertical lunar bar aspect to convey an LRT-Proceed indication. A vertical lunar bar aspect shall not be displayed unless the Block it governs is free of any Track Occupancy;
 - d. be equipped with luminaires that comply with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment;
 - e. have sighting and conspicuity such that the Block Signal, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the Block Signal, by a person having normal 6/6m vision, under all weather and lighting conditions;
 - f. be equipped with day/night ambient lighting compensation; and
 - g. where applicable, provide a third LRT Traffic Signal head above the “LRT Proceed” aspect to display an ‘R’ aspect to convey acknowledgment of receipt of the Driver initiated Train routing request by the Traffic Controller.
 2. a wheel counter to detect the presence of a Train within a Block, each wheel counter shall comply with AREMA C&S Manual Part 3.1.16, *Recommended Functional/Operating Guidelines for Wayside Based Train Detection Systems Not Based on Track Circuits Used to Activate Highway-Rail Grade Crossing Warning Systems*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for the wheel counters;
 3. a mass detector, of Vital design, to detect the presence of a Train within a Block, each mass detector shall be a BBR ZEUS-100 WSK system;
 4. a Track Circuit to detect the presence of a Train within a Block, each Track Circuit shall:
 - a. be of Vital design;
 - b. be designed to operate with characteristic ballast resistance as low as two (2) Ω per 300 m;

- c. be designed to operate safely under the maximum allowable rail to rail shunt resistance applied by the Stage 1 LRV; and
 - d. notwithstanding the requirement of Section 6-1.3F.4.c [*Train Control System (TCS)*] of this Schedule, comply with AREMA C&S Manual Part 8.2.1, *Recommended Design Criteria and Functional Guidelines for Audio Frequency Track Circuits*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for audio frequency Track Circuit equipment;
5. a Vital Controller (VC), each VC shall:
- a. be of Vital design;
 - b. be a service proven model and version with a minimum of 100,000 hours of relevant revenue service;
 - c. be designed and manufactured in accordance with a product safety plan that describes all of the safety aspects of the product, including procedures for its development, installation, implementation, operation, maintenance, repair, inspection, testing and modification, and includes analyses supporting any safety claims;
 - d. react in a safe manner to all failure modes, such that it assumes a predetermined restricted state for each failure mode, and will not continue to operate if it fails any system integrity test;
 - e. have electrically isolated Vital outputs and inputs, with Vital outputs, inputs and interfaces conforming to AREMA C&S Manual Part 1.5.15, *Recommended Practice for Electrical Interfaces Between Signal, Train Control and Grade Crossing Equipment*, or equivalent International Railway Industry Standard or CENELEC standard(s), applicable to the country of origin for the VC;
 - f. provide a local control facility which can be operated either locally or remotely via IP;
 - i. provide a local control panel (LCP) at the Lewis Farms Storage Facility for remote operation;
 - g. have built-in diagnostic capabilities to periodically confirm operation of processors, memory, I/O and other elements critical to the Vital integrity of the VC in accordance with the product safety plan;
 - h. be provided with tools for testing, simulation, monitoring, and display of application software;
 - i. be provided with a configuration management control plan designed to ensure that the VC configuration, including the hardware components and software version, is documented and maintained through its life cycle;
 - j. be equipped such that erasable portions of memory have physical or electrical protection to prevent unauthorized and accidental changes;
 - k. be equipped with sealed, locked, or otherwise tamper-resistant, modules for all portions of memory containing Vital software or firmware routines;
 - l. communicate with adjacent VCs to exchange Vital Block information wherever Trains may run in opposing directions within the same Block;
 - m. interface in a non-Vital manner with the TRPS;

- n. generate alarms to the ICS and LCP to advise of critical events such as ground faults, operational violations such as switch run-throughs, equipment board failures, and module failures;
 - o. include a data and activity event logging subsystem, with a logging storage capacity of at least 28 days. The logging storage shall be capable of being interrogated remotely by the ICS. All logs shall be time stamped, with time synchronized by the Master Clock system;
 - p. be compliant with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class C (*Wayside Equipment Enclosures*) equipment; and
 - q. provide restrictive signal violation functionality at each signal with a visual indicator to the Driver located past the respective signal but prior to the governed interlocking;
 - i. Provide the same visual warning to any Train performing a conflicting movement to the Train that violated the respective signal.
6. a power operated switch machine (POSM), each POSM shall:
- a. be of Vital design;
 - b. be compliant with AREMA C&S Manual Part 12.2.1, *Recommended Design Criteria and Functional Guidelines for Lockable Electric Motor Switch Operating Mechanism*, or the equivalent International Railway Industry Standard or CENELEC standard(s) applicable to the country of origin for mainline switch machines;
 - c. comply with the environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment;
 - d. be a service proven model and version with a minimum of 100,000 hours of in-street light rail revenue service in the Edmonton climatic conditions described in Section 1-2.1.10 [*Edmonton Climatic Requirements*] of this Schedule;
 - e. be equipped with a switch heater and drainage suitable to prevent ice and snow from building up and immobilizing the switch points or switch rod;
 - f. have electric detection of point or tongue positions;
 - g. allow reversal of machine in mid-stroke or at any point between end positions;
 - h. be provided with a plastic laminated or plastic encased internal-wiring diagram;
 - i. be trailable, meaning that the construction allows for a planned run-through of the switch from the trailing end by a Train operating at Restricted Speed, without damage to the switch mechanism;
 - j. not provide correspondence indication after having been trailed, until the switch is called for and moves to the originally requested position;
 - k. have the internal movement of the locking and throw bars achieved hydraulically, or by an electric motor that is mechanically engaged to the bars;

- l. provide for manual cranking operation of the switches by a single person, using a crank handle in case of failure of power operation capability. Insertion of the hand crank shall automatically inhibit motor power and if applicable, switch correspondence;
 - m. be designed to prevent collection of water within housings;
 - n. be provided with removable covers or other protection for the ends of lock rods and operating rods, where they extend beyond the switch mechanisms;
 - o. be equipped with an SPI;
 - p. be provided with detector locking; and
 - q. be provided with a lockable 120 V 20A AC GFI duplex receptacle;
7. each switch heater shall:
- a. have sufficient thermal rating and capacity with appropriate controls to operate successfully and be effective in the Edmonton climatic conditions described in Section 1-2.1.10 [*Edmonton Climatic Requirements*] of this Schedule;
 - b. be equipped with rail temperature and precipitation sensors allowing for automatic operation;
 - c. be equipped to permit local control for maintenance and troubleshooting;
 - d. be equipped with remote control via SCADA from the LCP or ICS;
 - e. report the status of the switch heater for each switch to the LCP and OCC;
 - f. report the failure of the switch heater status to correspond to the command status to the LCP and OCC; and
 - g. not generate noise that exceeds criteria outlined in Section 1-2.1.5 [*Noise Control*] of this Schedule;
8. each Switch Position Indicator shall:
- a. be of Vital design;
 - b. be mounted on a low mast near the switch points, as close to the point of switch as possible;
 - c. inform the Driver of an approaching Train of the position in which the switch is currently locked, by means of a visual indication;
 - d. have sighting and conspicuity such that the SPI, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the SPI, by a person having normal 6/6m vision, under all weather and lighting conditions; and
 - e. comply with the environmental requirements of AREMA C&S Manual Part 11.5.1, Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment, for Class B (Wayside Outdoors) equipment; and
9. a relay, which is integral to safety of the TCS, each relay shall comply with the requirements of AREMA C&S Manual Part 6.2, *Recommended Plug-in Vital Relays*.

- G. Provide a detailed description of the TCS, track signal plans, and the operational description and rationale for the TCS elements at the first and second Interim Design submission and Final Design submission, (the “**TCS Design Package**”).
1. The TCS Design Package shall include block diagrams, drawings, and schematics to support the narrative and a description of how locking will be implemented to protect two (2) opposing or flanking Trains that are in contention to occupy the same specified limits of Track at the same time.
- H. Prepare and submit to the City an interface control document describing the electrical and functional interface requirements of the Train Control System for the ICS integration, (an “**ICS Interface Control Document**”) with each of the second Interim Design and Final Design submission as described in Appendix 4B [*Project Specific Submission Requirements*].

6-1.3.1 Not Used

6-1.3.2 Yard Control System

- A. This Section 6-1.3.2 [*Yard Control System*] sets out the Design and Construction requirements for the Yard Control System required in the Maintenance and Storage Facilities.
- B. Provide a Yard Control System in the Gerry Wright OMF Parcel B and the Lewis Farms Storage Facility;
1. the Yard Control System for Gerry Wright OMF Parcel B shall be integrated and contiguous with the Gerry Wright OMF Stage 1 Yard Control System in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- C. The Yard Control System shall be designed and constructed to provide control of all Train routing for all Yard Tracks located within each Maintenance and Storage Facility.
- D. Provide all information and support required to allow the Yard Control System to be integrated with the ICS by the Operator.
- E. The Yard Control System shall be implemented with the following field devices, each in accordance with the Design and construction requirements set out in Section 6-1.3F [*Train Control System (TCS)*] of this Schedule:
1. Block Signals;
 2. wheel counters, mass detectors, or Track Circuits;
 3. power operated switch machines;
 4. switch heaters; and
 5. Switch Position Indicators of make and model BBR MAX - W1, W2, and W3 to match the signalling system used in Valley Line LRT Stage 1.
- F. Remote control of the Yard Control System shall be performed from a single workstation in accordance with the *Operability and Maintainability Parameters*;
1. the Yard Control System workstation in Gerry Wright OMF Building A, provided by Other Contractors, shall be modified to incorporate the Yard Control System for Gerry Wright OMF Part B; and

2. provide a separate Yard Control System workstation at the Lewis Farms Storage Facility.

6-1.4 TRAIN ROUTING AND PRIORITY SYSTEM (TRPS)

- A. The TRPS is an arrangement of special purpose Vital and non-Vital computing devices, logic controllers, LRV on-board GPS receivers, wireless transceivers, transponders, display panels, control units, wayside transponders, loops, antennas, data radios, interrogators or other special purpose modules which together comprise a system for initiating:
 1. TSP sequences for execution by the Traffic Controllers; and
 2. Train routing commands for conditional execution by the TCS.
- B. The TRPS shall provide bi-directional Train operation.
- C. Provide redundant train control management at the [REDACTED] for uninterrupted Valley Line LRT operations in the event of loss of functionality or connectivity to the Valley Line LRT Stage 1 central signalling server or the [REDACTED]:
 1. transfer between the redundant central signalling servers shall be automatic and without manual intervention;
 2. submit the conditions for automatic transfer to the City for Acceptance; and
 3. provide an alarm indication in the event of transfer of operation between the redundant central signalling servers.
- D. Integrate the TRPS for the Valley Line LRT Stage 2 with the TRPS provided for the Valley Line LRT Stage 1 to prevent operational deadlocking between NorQuest Stop and the Churchill Stop in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- E. The TRPS shall:
 1. initiate Transit Signal Priority in accordance with Section 6-4.5 [*Transit Signal Priority*] of this Schedule;
 2. initiate field automatic Train routing;
 3. enable Driver initiated Train routing;
 4. enable ICS and LCP initiated Train routing;
 5. provide Train position field reporting with sufficient data accuracy to support operational availability and adherence to the Operability and Maintainability Parameters;
 6. provide TCS field equipment status reporting to the ICS and LCP; and
 7. provide Train onboard TCS equipment status reporting.
- F. The TRPS shall be compatible with the following Train to wayside communication components installed on the Valley Line LRT Stage 1:
 1. wayside coupling coil, FRED-1062;
 2. platform detection loop, FRED-1070;
 3. loop adjustment module, FRED-1072;

4. frequency decoder unit, FRED-1030; and
 5. wayside evaluation unit.
- G. Integrate the Wayside TRPS with the Stage 1 LRV TRPSs and Stage 2 LRV TRPSs, in accordance with Part 7 [*LRV Integration Requirements*] of this Schedule;
1. perform an integration test on the TRPS to prove the functionality as described in Section 6-1.4 [*Train Routing and Priority System (TRPS)*] of this Schedule; and
 2. prepare and submit an integration plan for the integration of Wayside TRPS with the Stage 1 LRV TRPSs and Stage 2 LRV TRPSs with each of the first Interim Design and Final Design submissions for the Signalling System as described in Appendix 4B [*Project Specific Submission Requirements*], detailing step by step operations and integration testing to prove functionality of the TRPS, the ("**TRPS Integration Plan**").
- H. All elements of the TRPS which are equipped with a CPU and on-board memory shall include data and activity event logging capability, with a logging storage capacity of at least 28 days which is capable of being interrogated remotely. All logs shall be time stamped, with time synchronized by the Master Clock system.
- I. The TRPS may communicate to one or more VC(s) via non-Vital communication link, or non-Vital discrete I/O.
- J. TRPS wayside equipment shall comply with the temperature and vibration environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class B (*Wayside Outdoors*) equipment.
- K. TRPS equipment housed within signal cabinets, signal rooms or other Wayside Equipment Enclosures shall comply with the temperature and vibration environmental requirements for all signal components as defined in AREMA C&S Manual Part 11.5.1, *Recommended Environmental Requirements for Electrical and Electronic Railroad Signal System Equipment*, for Class C (*Wayside Equipment Enclosures*) equipment.
- L. Prepare and submit a detailed description including narratives, drawings, block diagrams and schematics of the TRPS, and the operational principles for executing priority requests at Traffic Signals including how the TRPS enables bi-directional operation with each of the first and second Interim Design submissions and the Final Design submission for the Signalling System as described in Appendix 4B [*Project Specific Submission Requirements*], (the "**TRPS Design Report**").

6-1.5 SYSTEMS DUCT BANK AND ASSOCIATED INFRASTRUCTURE

- A. The Systems Duct Bank provides mechanical protection and access for City Conduit cables and for all electrical, CTS and signalling cables required to meet the requirements of this Schedule and the Operability and Maintainability Parameters.
- B. Provide the Systems Duct Bank to accommodate cabling based on the fill factors defined in Section 6-1.21 [*Wire and Cable*] of this Schedule for the following systems and facilities including:
1. signaling;
 2. CTS;
 3. UPS;

4. electrical distribution power;
 5. City Conduits (4); and
 6. spare (10% per type with a minimum two (2) per type per duct bank).
- C. Provide at least four (4) segregated and continuous 103 mm PVC conduits within the Systems Duct Bank from 102 Street Stop to Lewis Farms Storage Facility Building City Communication Room, for exclusive use by the City (the "**City Conduits**").
 - D. Integrate the Valley Line LRT Stage 2 Systems Duct Bank with the Systems Duct Bank deployed in Valley Line LRT Stage 1 at the west end of the 102 Street Stop in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
 - E. Provide all components of underground reinforced concrete encased duct banks that are CSA and/or ULC approved listed and labelled.
 - F. Provide smooth wall 103 mm PVC conduit for internal ducts that are cast in place concrete forming;
 1. galvanized rigid steel shall be used as a stub when transitioning from the concrete encased PVC conduit. The transition shall occur 100mm below the finished grade.
 - G. All other conduit shall be HDPE material.
 - H. Join duct lengths together with a manufacturer approved coupling to provide a sound and watertight joint.
 - I. Provide the Systems Duct Bank extending continuously along the full length of the Valley Line LRT Stage 2 below grade, except where it is required to be concealed within the Elevated Guideways excluding the Stony Plain Road Bridge, in accordance with Section 2-9 [*Support System*] of this Schedule.
 - J. Provide underground secondary conduit connections sufficient to accommodate project needs from the Systems Duct Bank to all Data Centres, Utility Complexes, Stations, Stops, the WEM Transit Centre, Lewis Farms Park and Ride, and the Traffic Controllers located at the intersections listed in **Table 6-4.3-1** [*Traffic Intersections*] of this Schedule.
 - K. Provide two (2) 103 mm PVC underground Local Conduit connections from the nearest Systems Duct Bank Access Vault to the Jasper Place Transit Centre communications room at a location accepted by the City.
 - L. Provide sufficient conduit between the Gerry Wright OMF Building A and the Gerry Wright OMF Building B to accommodate Project Requirements of this Schedule.
 - M. Provide four (4) 103mm Local Conduit connections from the Lewis Farms Transit Centre electrical and mechanical room to the City Communication Room at the Lewis Farms Storage Facility.
 - N. Maintain a physical separation of at least 1m between the Systems Duct Bank and the Traction Power Duct Bank.
 - O. Provide appropriate fittings in the Systems Duct Bank, designed to accommodate all movements and prevent damage to the Systems Duct Bank, and the associated conduit, at any locations where rotations, horizontal displacements or vertical displacements may occur.

- P. In accordance with Section 2-14 [*Landscape Architecture*] of this Schedule, locate the Systems Duct Bank away from the tree line to prevent tree root intrusion from both existing and new trees of the Systems Duct Bank where Street Trees are provided.
- Q. Segregate electrical, CTS and signalling cables in separate conduits along the full length of the Systems Duct Bank;
1. prepare and submit System Cabling Separation Guidelines with the first Interim Design for the Duct Bank as described in Appendix 4B [*Project Specific Submission Requirements*] to manage EMC crosstalk between cable groups and within each group the (“**System Cabling Separation Guidelines**”).
- R. Provide Systems Duct Banks that are:
1. installed to have an even slope in one direction of not less than 76mm in 30m to provide drainage. Ducts shall be sloped to drain towards an Access Vault;
 2. provided with a continuous length of yellow marking tape buried approximately halfway between the installation and grade level;
 3. subducted if the installed cable fill ratio is less than 30%; and
 4. provided with a continuous length of a metallic conductor to use as a tracer for future locates;
 - a. provide access to metallic conductor at each access vault.
- S. Provide each conduit within the Systems Duct Bank:
1. laid with a spacing of 200 mm centre to centre, both horizontally and vertically. Spacers shall be plastic. Wooden spacers shall not be used;
 2. swept and mandrelled after installation to ensure a clean and non-obstructed installation. No cable shall be installed prior to successful completion of these inspections;
 3. with one (1) nylon pull rope extending between opposing access points to the conduit;
 4. with bushings at all open conduit ends to protect cables;
 5. labelled such that each conduit is uniquely identifiable at each end;
 6. terminated with bell fittings at each end;
 7. with caps on all unused conduits;
 8. installed such that water will not accumulate in any section of the conduit; and
 9. installed no less than a minimum depth of 0.6 m below grade.
- T. Provide Access Vaults for the Systems Duct Bank:
1. at each Station and Stop;
 2. at each end of all Elevated Guideways;
 3. at each Utility Complex;
 4. adjacent to the Lewis Farms Storage Facility Building wall; and

5. adjacent to Gerry Wright OMF Building B wall.
- U. Provide Access Vaults for the Systems Duct bank with the following attributes:
1. made of precast reinforced waterproof concrete;
 2. able to withstand all loading from external factors in each installed location;
 3. have minimum dimensions of 3100 mm x 1700 mm x 2250 mm or as demonstrated to accommodate cable bend radii and cable slack;
 4. located at a maximum 200 m spacing;
 5. located at each Traffic Controller location as provided in compliance with Section 6-4.3 [*Traffic Signal Equipment*] of this Schedule;
 6. installed with protective collars for conduits entering and exiting Access Vaults with no exposed sharp or metallic parts that might damage the cables;
 7. provided with a clear a legible identification label consistent with labeling convention used on Valley Line LRT Stage 1;
 8. placed within the LRT right-of-way or within Utility Complex compound;
 9. with sufficient 103 mm knockouts on each wall for incoming conduits;
 - a. a minimum of four (4) 103mm knockouts on each wall shall be provided;
 10. with round manhole covers in accordance with *EPCOR Drainage Design and Construction Standards, Volume 3: Drainage (August 2020)*;;
 11. with lockable covers suitable for operation in all environmental conditions;
 12. with covers in accordance with AASHTO M306;
 13. free of sharp edges, and provided with a center hatch which does not conflict with ladder rungs;
 14. with racking on all four (4) inside walls for cable dressing and suspension;
 15. provided with a drainage system to prevent accumulation of standing water;
 16. include space and mountings for outdoor-rated fibre splice enclosures and cable slack for segregated splicing of the City Fibre cable;
 17. include at least four (4) unused 103 mm knockouts on each wall of the Access Vaults for the City's exclusive use; and
 18. include racking on all four (4) inside walls for cable dressing and suspension of all cables to be housed. Designate one wall racking for City's exclusive use.
- V. Provide pull boxes, where required on local conduit runs, with the following attributes:
1. able to withstand all loading from external factors in each installed location;
 2. minimum dimensions 610 mm (width) x 610 mm (depth) x 610 mm (height) or as demonstrated to accommodate conduit entry, cable pulling, and cable installation bend radii;

3. located at a maximum 200 m spacing;
 4. located at transition points, access points, curves or other logical locations to facilitate pulling and access requirements;
 5. installed with protective collars for conduits entering and exiting pull boxes with no exposed sharp or metallic parts that might damage the cables;
 6. with a clear a legible identification label consistent with labeling convention used on Valley Line LRT Stage 1;
 7. provide covers lockable by concealed padlock; and
 8. provide covers in accordance with AASHTO M306.
- W. Accommodate the City Conduits within all Systems Duct Bank pull boxes.
- X. Provide a 50mm PVC conduit between the Traffic Controller and all future ISD equipment locations as indicated on the Accepted Final Design in accordance with Section 6-4.3.3 [*Intersection Safety Device (ISD)*] of this Schedule, for the City's exclusive use.
- Y. Provide 103 mm PVC conduits between the nearest Systems Duct Bank Access Vault and each:
1. Traffic Controller located at the intersections listed in Table 6-4.3-1 [*Traffic Intersections*], Table 6-4.3-2 [*Pedestrian Activated Signal Locations*] and Table 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule in accordance with Section 6-4.3 [*Traffic Signal Equipment*] of this Schedule – minimum two (2), with one (1) being for the City's exclusive use;
 2. Stop or Station – minimum two (2), with one (1) being for the City's exclusive use;
 3. Utility Complex – minimum five (5), with four (4) being for the City's exclusive use; terminating in the communications room for City's exclusive use; and
 4. WEM Transit Centre – minimum three (3), with two (2) being for the City's exclusive use; and terminating in the WEM Station communications room.

All conduits designated as for City's exclusive use in this section are deemed to be Local Conduits (the "**Local Conduits**").

- Z. Promptly following installation and inspection of the Local Conduits, and associated Access Vaults, at the locations specified in Section 6-1.5T [*Systems Duct Bank and Associated Infrastructure*] of this Schedule, provide notice to the City and provide the City with access to the conduits allocated to the City and associated Access Vaults in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- AA. Provide a Manufacturer Warranty for the Systems Duct Banks, Access Vaults and pull boxes for a minimum of ten (10) years.
- BB. With the first Interim Design submission for the Duct Bank as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the "**First Interim Systems Duct Bank Design Package**"):
1. a detailed description of components to be used in the Systems Duct Bank and associated infrastructure; and

2. preliminary drawings for the duct bank layout to be used in the Systems Duct Bank and associated infrastructure.
- CC. Submit specifications for components to be used in the Systems Duct Bank and associated infrastructure with the second Interim Design submission for the Duct Bank as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Second Interim Systems Duct Bank Design Package**”).
- DD. With the Final Design submission for the Duct Bank as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Systems Duct Bank Design Package**”):
1. updated drawings, specifications, designs and plans for the components to be used in Systems Duct Bank and associated infrastructure; and
 2. shop drawings for all materials and components to be used in Systems Duct Bank and associated infrastructure.

6-1.6 WAYSIDE EQUIPMENT AND WAYSIDE EQUIPMENT ENCLOSURES

- A. Provide Wayside Equipment Enclosures, where required to house Wayside Equipment, that are sized to house the equipment plus 20% spare physical space capacity.
- B. Install electronic Wayside Equipment in Wayside Equipment Enclosures.
- C. Ensure power equipment installed in any Wayside Equipment Enclosure has CSA/ULC compliance ratings.
- D. Provide each electrical load centre with a dedicated surge suppressor in accordance with IEEE C62.41.1 Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits.
- E. Provide a separate Battery Ground Fault detector for each isolated energy source, within a Wayside Equipment Enclosure that contains energy sources for Vital equipment. Provide a scheduled GF detector testing regime within the Maintenance Manuals as described in Section 10 [*Training and Operating Maintenance Manuals*] of Schedule 4 [*Design and Construction Protocols*] that will ensure the GF detector functions properly;
 1. ensure all Battery Ground Fault condition alarms are reported to the ICS.
- F. Provide a communications cabinet within each Utility Complex. Each Utility Complex communications cabinet shall:
 1. be sufficient at a minimum to house all fibre, copper, and communication infrastructure and equipment required for the full operation of the Utility Complex and to provide distribution of infrastructure to the associated Platform communications cabinet;
 2. have a nominal equipment mounting width of 19”;
 3. be a minimum 42 RU (height);
 4. provide access to both front and back of equipment through vented, lockable doors keyed to the same key as those of Valley Line LRT Stage 1; and
 5. provide access to both sides of equipment through removable side panels.
- G. Provide a communications cabinet on each Stop Platform. Each Stop communications cabinet shall:

1. be sufficient at a minimum to house all fibre, copper, and communications infrastructure and equipment required for the full operation of the platform as well as the ETS LAN Cabinet;
 2. provide mounting space for nominal equipment mounting width of 19”;
 3. provide mounting space for DIN rail mountable equipment;
 4. provide access to equipment through lockable doors keyed to the same key as those of Valley Line LRT Stage 1; and
 5. meet the requirements of Section 5-2.6.11.5 [*Systems Cabinets*] of this Schedule.
- H. Provide communications cabinets at the Lewis Farms Park and Ride. Each communications cabinet shall:
1. be located such that all network connected devices (CCTV cameras and BLTs) are within 90m cable distance;
 2. be sufficient at a minimum to house all fibre, copper, and communications infrastructure and equipment required for the full operation of the Park and Ride;
 3. provide mounting space for nominal equipment mounting width of 19”;
 4. provide mounting space for DIN rail mountable equipment;
 5. provide access to equipment through lockable doors keyed to the City’s ABUS key;
 6. be powered from a Level 1 “Emergency” load centre; and
 7. meet the SUI requirements of Section 2-9 [*Support Systems*] of this Schedule and the Design Guide.
- I. Provide a communications cabinet in the communications room of each Station. Each communications cabinet shall:
1. be sufficient at a minimum to house all fibre, copper, and communication infrastructure and equipment required for the full operation of the Station;
 2. have a nominal equipment mounting width of 19”;
 3. be a minimum 42 RU (height);
 4. provide access to both front and back of equipment through vented, lockable doors keyed to the same key as those of Valley Line LRT Stage 1; and
 5. provide access to both sides of equipment through removable side panels.
- J. Provide space in the WEM Station communications room for installation of a future City Cabinet.
- K. Provide an enclosed and locked partition of minimum dimensions 800 mm (width) x 450 mm (depth) x 800 mm (height), (the “**ETS LAN Cabinet**”), within the communications cabinet at each Stop and Station. Each ETS LAN Cabinet shall be supplied with:
1. padlocks, with all keys provided to City; and
 2. two (2) 120 V 20A AC receptacles fed from a Level 1 "Emergency" load centre.

- L. Provide two (2) enclosed data distribution cabinets, of minimum dimensions 800 mm (width) x 1040 mm (depth) x 42RU (height), with security lock, in each Data Centre, Utility Complex communications room and WEM Station communications closet for the City's exclusive use (the "**City Cabinets**"). Each City Cabinet shall include:
1. two (2) 120 V 20A AC receptacles fed from a Level 1 "Emergency" load centre; and
 2. dedicated overhead tray access to the entry panel where the four (4) conduits allocated to the City are terminated.
- M. Provide notice to the City and provide the City with access to the City Cabinets in accordance with Section 1-1.3 [*City Works*] of this Schedule promptly following installation of the City Cabinets and termination and inspection of the overhead cable trays and conduits allocated to the City.
- N. Provide enclosures and cabinets located in outdoor locations that:
1. are designed to operate properly in the extremes of local weather conditions, including heavy winds, rain, hail, snow, ice and outside air temperatures, and relative humidity up to 100 percent, per Section 1-2.1.10 [*Edmonton Climatic Requirements*] of this Schedule;
 2. are equipped with sun shields and convection vents so that maximum internal temperature rise above outdoor ambient air temperature does not exceed 25 °C where enclosures and cabinets are subject to temperature extremes caused by exposure to direct sunlight in ambient temperatures of +40 °C including heat from internal electrical losses;
 3. are equipped to ensure a maximum internal relative humidity of 95% noncondensing;
 4. are equipped with heaters so that maximum internal temperature does not go below +15 °C where the enclosures and cabinets are subject to severe winter conditions and temperatures as low as -40 °C;
 5. include design and construction measures to protect against deterioration due to salt air, condensation, ice, snow, and temperature extremes, including control of fungus growth and metal corrosion;
 6. comply with NEMA 4X and have a stainless-steel finish; and
 7. are lockable with a padlock.
- O. Provide equipment located within enclosures and cabinets in outdoor locations that:
1. are designed and tested for continuous service at +70 °C;
 2. are designed and tested for continuous service at -40 °C; and
 3. are designed to operate properly in relative humidity up to 95%.
- P. Provide equipment and cabinets located in indoor wayside locations that are designed to operate continuously, properly, and safely in a temperature range of 0 °C to +40 °C, at relative humidity ranging up to 95%.
- Q. With the first Interim Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the "**First Interim Wayside Equipment Design Package**):

1. a detail description of components to be used for the Wayside Equipment and Wayside Equipment Enclosures;
 2. preliminary drawings for the placement and layout of the Wayside Equipment and Wayside Equipment Enclosures; and
 3. a qualification test plan for the Wayside Equipment and Wayside Equipment Enclosures.
- R. Submit specifications for components to be used for the Wayside Equipment and Wayside Equipment Enclosures with the second Interim Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*] ,(the “**Second Interim Wayside Equipment Design Package**”).
- S. With the Final Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Wayside Equipment Design Package**”):
1. the qualification test reports for the Wayside Equipment and Wayside Equipment Enclosures; and
 2. updated drawings, specifications, designs and plans for the Wayside Equipment and Wayside Equipment Enclosures.

6-1.7 Fibre Optic Networking

6-1.7.1 Communication Transmission System (CTS)

- A. This Section 6-1.7.1 [*Communication Transmission System (CTS)*] sets out the requirements for the Infrastructure designed to provide high capacity communications for data, voice and video connectivity between all communication devices and within new Data Centres, and includes fibre optic cabling and corresponding cable assemblies, fibre distribution frames, cabinets, splice enclosures, network switches, routers, firewalls, and other devices providing local connectivity to end devices (the “**Communications Transmission System**”).
- B. The CTS provides data transport for the following services, each as further described in this Part 6 [*Systems*] of this Schedule:
1. Train Control System;
 2. Train Routing and Priority System
 3. Integrated Control System (provided by the Operator);
 4. CCTV System;
 5. radio system;
 6. telephones;
 7. Building SCADA;
 8. security and alarm,
 9. Network Management System;
 10. Public Address and Variable Message Signs;
 11. Master Clock; and

12. Traction Power SCADA.
- C. Provide a CTS that is fully compatible with and provides the same functionality and features at a minimum for the Valley Line LRT Stage 2 as the CTS used in the Valley Line LRT Stage 1.
- D. Provide the CTS including but not limited to the following equipment:
1. network equipment;
 2. active optical components ;
 3. passive optical components;
 4. fibre cabling;
 5. structured copper cabling; and
 6. associated patch panels, fibre optic distribution panels (FDP), splice enclosures, and trays.
- E. Provide network equipment consisting of:
1. redundant core network switches, with redundant equipment located in the [REDACTED], the [REDACTED] auxiliary Data Centre and the [REDACTED];
 2. redundant distribution network switches, located in the Utility Complexes, Stations, Lewis Farms Storage Facility Building, and Gerry Wright OMF Building B; and
 3. access network switches, located in the Utility Complexes, Stops, Stations, Gerry Wright OMF Building A, Gerry Wright OMF Building B, the Lewis Farms Storage Facility, and along the ROW for local and field device connectivity.
- F. Provide the CTS as an IP-based network, compliant with IEEE 802.3 standards and protocols, and utilizing commercially available equipment.
- G. Assign the CTS network switch addresses in accordance with an address plan fully compatible with the Valley Line LRT Stage 1 CTS to allow for full integration of the Stage 1 and 2 networks.
- H. Not Used.
- I. Not Used.
- J. Not Used.
- K. Not Used.
- L. Not Used.
- M. Upgrade the CTS deployed in Valley Line LRT Stage 1 as necessary to integrate the CTS for the Valley Line LRT Stage 2.
- N. Integrate the CTS for the Valley Line LRT Stage 2 with the CTS deployed in Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
1. Submit an integration plan for the integration of CTS for the Valley Line LRT Stage 2 with the CTS deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**CTS Integration Plan**”) of how to achieve the integration and

migration of the newly configured CTS system without impact to the Valley Line LRT Stage 1 revenue operations.

- O. Configure the CTS in the Valley Line LRT Stage 2 to use the existing primary and secondary Master Clocks.
- P. Verify the CTS connectivity from all access network switches to the core network switches.
- Q. With the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (“**First Interim CTS Design Package**”):
 - 1. a hardware description for the CTS;
 - 2. a preliminary network design for the CTS; and
 - 3. an overview of the integration of the Valley Line LRT Stage 1 CTS and the Valley Line LRT Stage 2 CTS.
- R. With the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (“**Second Interim CTS Design Package**”):
 - 1. an interface specification for each interface between products and systems; and
 - 2. a cable plan.
- S. Submit updated drawings, specifications, designs and plans for the CTS with the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], (“**Final CTS Design Package**”).

6-1.7.1.1 CTS Fibre Optic Cabling

- A. Design, supply, install, and conduct PICO tests of all fibre cable including:
 - 1. 48 strand SM backbone fibre cable; and
 - 2. secondary ring cables from the distribution network switches in the Utility Complexes to the PoE access network switches at each Stop.
- B. Submit a PICO test plan (the “**CTS Cable PICO Test Plan**”) 90 days prior to implementation of the test plan that shall include:
 - 1. cable tests including insulation, continuity and OTDR tests of terminated cables;
 - 2. cable termination and interconnection verifications; and
 - 3. verification of termination markings and labels.
- C. Provide a fibre optic backbone in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, with two (2) separate fibre optic cable runs in a ring topology using minimum 48 strand SM fibre optic cables from the Churchill Connector Utility Complex to the Lewis Farms Storage Facility Building.
- D. Extend the fibre optic ring deployed in the Valley Line LRT Stage 2 from the Churchill Connector to the Gerry Wright Building OMF Building A and Gerry Wright OMF Building B using four (4) strands from a spare buffer tube from the backbone cable deployed in Valley Line LRT Stage 1.

- E. Deploy one dedicated buffer tube from the fibre optic backbone in Valley Line LRT Stage 2 to provide a redundant unbroken end to end link from the Lewis Farms Storage Facility Building to Churchill Connector Utility Complex.
- F. Extend the redundant end to end link from the Churchill Connector Utility Complex to the [REDACTED] [REDACTED] for dedicated Data Centre to Data Centre link using spare fibre in the spare tube from the backbone cable deployed in Valley Line LRT Stage 1.
- G. Provide a minimum 48 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, between Gerry Wright OMF Building A and Gerry Wright OMF Building B Data Centres.
- H. Provide a minimum 24 strand SM cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from the distribution switch in each Utility Complex to the access switches in the nearest Stop in the same topology as deployed in the Valley Line LRT Stage 1.
- I. Provide a minimum 24 strand SM cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from the new Automatic Vehicle Inspection Station at Gerry Wright OMF access switch location to the distribution switch in the nearest Gerry Wright OMF Building communications room.
- J. Provide an interface from the distribution switch in each Stop and Station to the access switches in the Station using same topology as deployed in the Valley Line LRT Stage 1 using either a 24 strand SM cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule or a high speed Ethernet interface.
- K. Allocate fibre within the backbone as described in Table 6-1.7-1 [*Backbone Fibre Allocation*] of this Schedule.

Table 6-1.7-1: Backbone Fibre Allocation

Backbone fibre allocation		
Tube Number	Core Number	Assignment
1	1-4	Backbone fibre
	5-8	
	9-12	Spare
2	13-16	[REDACTED]
	17-20	
	21-24	
3	25-28	Available for design flexibility
	29-32	
	33-36	
4	39-40	Spare
	41-44	EPCOR SCADA
	45-48	City ETS LAN

- L. Allocate two (2) dedicated fibre pairs within the fibre optic backbone for an EPCOR SCADA connection to monitor the photo voltaic array system in accordance with Section 8-3.6.1 [*Lewis Farms Storage Facility Sustainability Requirements*] of this Schedule.
- M. Allocate two (2) dedicated fibre pairs within the fibre optic backbone for the City's exclusive use for a dedicated ETS IP network. Configure these fibre pairs such that both pairs are extended to and terminate within:

1. the City Cabinets at each Data Centre;
 2. the City Cabinets at each Utility Complex; and
 3. the ETS LAN Cabinet at each Stop and Station.
- N. Promptly following installation, inspection and verification of these fibre pairs, and the ETS LAN Cabinets, provide notice to the City and provide the City with access to the fibre pairs and the ETS LAN Cabinets in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.7.1.2 CAT-6 Cabling

- A. Design, supply, install and conduct PICO tests of all CAT-6 cables.
- B. Use outdoor-rated CAT-6 field cabling from the nearest ruggedized access network switch to end devices.
- C. Do not exceed CAT-6 cable length of 90 m.
- D. If the CAT-6 cable length would be greater than 90 m, provide ruggedized local media converter and 6-strand SM fibre optic cable for connection of end devices.
- E. Provide separate conduit for power and communication cables.
- F. Provide concealed conduits in public areas.
- G. Promptly following installation, inspection and verification of CAT-6 cable at the WEM Transit Centre, provide notice to the City and provide the City with access to the cables and the communications room in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.7.1.3 CTS Equipment

- A. Design, supply, install, and conduct PICO tests of all equipment to verify equipment has not been damaged during the transportation and handling, and has been installed correctly.
- B. Submit a PICO test plan (the “**CTS Equipment PICO Test Plan**”) 90 days prior to implementation of the test plan that details the installation and securing of termination cabinets.
- C. Design the CTS to be able to accommodate all Valley Line LRT Stage 2 data traffic in a redundant bi-directional ring topology represented in Figure 6-1.7.4-2: *Network Architecture*] of this Schedule.
- D. Provide a sub 50 ms recovery time from both ring and network nodal failures for the CTS.
- E. Provide a minimum 10 Gbps primary ring from the core network switches in the Gerry Wright OMF Building A, the Gerry Wright OMF Building B and the Lewis Farms Storage Facility Building Data Centres to the distribution network switches in the Utility Complexes and Stations with sufficient bandwidth to support system needs.
- F. Provide a minimum 1-Gbps secondary ring from the distribution network switches in the Utility Complexes and Stations to PoE access network switches at each Utility Complex, Station or Stop with sufficient bandwidth to support system needs.
- G. Provide network topology represented in Figure 6-1.7.4-2: *Network Architecture*] of this Schedule.
- H. Provide CTS Network switches with the following characteristics:
 1. local switch management;

2. support VLAN configuration;
 3. support security features including port security, dynamic host configuration protocol snooping, user authentication, access control lists, RADIUS authentication to prevent unauthorized users from altering the switch configuration;
 4. dual redundant hot swappable power supplies that allow independent connections to UPS and power feeds;
 5. powered by sufficient UPS backup for an eight (8) hour run time; and
 6. provide a Manufacturer Warranty for the CTS network switches for a minimum of five (5) years.
- I. Provide CTS access switches in each Utility Complex, Stop, Station, the WEM Transit Centre, Gerry Wright OMF Building B, Lewis Farms Storage Facility Building and at the new Automatic Vehicle Inspection Station at the Gerry Wright OMF with the following minimum characteristics:
1. functional characteristics described in Section 6-1.7.1.3H *[CTS Equipment]* of this Schedule;
 2. minimum of two (2) 1 Gbps SFP ports as uplinks;
 3. minimum of two (2) 1 Gbps SFP ports as downlinks;
 4. minimum layer two (2) switching capability;
 5. sufficient 10/100/1000 PoE copper ports to support all local IP end devices and an additional 20% spare quantity;
 6. ruggedized switches to meet environmental conditions for operations and storage for temperature range of a minimum of -40 °C to +70 °C;
 7. fanless, convection cooled;
 8. hardened for vibration, shock, surge, and electrical noise immunity;
 9. provide authentication protocol to prevent unauthorized clients from connecting to the LAN; and
 10. mount access switches and associated equipment in an environmentally controlled bungalow or NEMA 4X cabinet when a communications room is not possible.
- J. Provide CTS distribution switches in each Utility Complex, Station, Gerry Wight OMF Building B and the Lewis Farms Storage Facility Building with the following minimum characteristics:
1. functional characteristics described in Section 6-1.7.1.3H *[CTS Equipment]* of this Schedule;
 2. minimum of two (2) 10 Gbps SFP ports as uplinks;
 3. minimum of four (4) 1 Gbps SFP ports as downlinks;
 4. minimum layer 3 switching capability;
 5. sufficient 10/100/1000 PoE copper ports and SFP to support all access switches and an additional 20% spare quantity;
 6. standard 19-inch rack mountable;
 7. redundant field replaceable fans; and

8. switch aggregation or switch stacking functionality.
- K. Provide CTS core switches in the Gerry Wright OMF Building A, Gerry Wright Building B and the Lewis Farms Storage Facility Building with the following minimum characteristics:
1. functional characteristics described in Section 6-1.7.1.3H [*CTS Equipment*] of this Schedule;
 2. minimum of four (4) 10 Gbps SFP ports as uplinks for backbone connections;
 3. minimum layer 3 switching capability;
 4. standard 19-inch rack mountable;
 5. redundant field replaceable fans;
 6. virtualized switching system used to provide redundancy in network in case of device failure;
 7. local switch management; and
 8. switch aggregation or switch stacking functionality.
- L. Perform integration tests of the CTS including the following:
1. functionality tests to prove the functionality as described in item Sections 6-1.7.1.3I [*CTS Equipment*], 6-1.7.1.3J [*CTS Equipment*], and 6-1.7.1.3K [*CTS Equipment*] of this Schedule.

6-1.7.2 City Fibre

- A. In addition to the fibre optic backbone described in Section 6-1.7.1 [*Communication Transmission System*] of this Schedule, provide the following for the City's exclusive use:
1. one (1) 216 strand SM fibre optic cables in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, throughout the full length of one of the City Conduits from the dedicated City Communication Room in the Lewis Farms Storage Facility Building to Century Place through existing conduit originating in the Churchill Connector Utility Complex;
 2. one (1) 216 strand SM fibre optic cables in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, throughout the full length of one of the City Conduits from the last Access Vault located at the Lewis Farms Stop where the main signalling communications duct bank terminates to Churchill Station communications room #1 through existing conduit originating in the Churchill Connector Utility Complex;
 3. a 72 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from the WEM Transit Centre to the nearest Access Vault via one of the Local Conduits;
 4. a 48 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from every Utility Complex to the nearest Access Vault via one of the Local Conduits;
 5. a 72 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from Jasper Place Transit Centre to the nearest Access Vault via one of the Local Conduits;
 6. a 24 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from Jasper Place Transit Centre to the nearest City Cabinet via one of the Local Conduits and Systems Duct Bank;

7. a 72 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from the City Communication Room within the Lewis Farms Storage Facility to the last Access Vault located at the Lewis Farms Stop on the main signalling communications duct bank;
8. a 48 strand SM fibre optic cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from Lewis Farms Transit Centre to the nearest City Cabinet via one of the Local Conduits and Systems Duct Bank;
9. a 12 strand SM cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from each Traffic Signal Cabinet to the nearest City Cabinet via one of the Local Conduits; and
10. a 12 strand SM cable in accordance Section 6-1.7.3 [*Fibre Optic Cabling*] of this Schedule, from each ETS LAN Cabinet to the City Cabinet in the nearest Utility Complex via one of the Local Conduits

(collectively, the “**City Fibre**”).

- B. Splice all strands such that strands 1-216 in each of the City’s 216 strand fibre cables extend in accordance with a splice schedule to be developed in co-ordination with the City;
 1. a reference splice schedule has been provided in the Disclosed Data and is to be used in developing the final splice schedule.
- C. Provide notice to the City, promptly following determination of all Access Vaults. Following receipt of notice, the City will develop its detailed splice schedule in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- D. Within each shared use Local Conduit between the Traffic Controller locations and the nearest Access Vaults, provide a minimum four (4) strand SM fibre optic cable for City’s exclusive use. Splice these four (4) strands to the City Fibre in the Access Vault in accordance with the splicing schedule developed in accordance with Section 6-1.7.2 [*City Fibre*] of this Schedule.
- E. Clearly label all fibre provided for “City Works” to provide differentiation from those for the CTS.
- F. Within each Data Centre, provide an enclosed 2000 mm height Fibre Distribution Frame, equipped with a secured padlock, immediately adjacent to the City Cabinets described in Section 6-1.5 [*Systems Duct Bank and Associated Infrastructure*] of this Schedule, for the City’s exclusive use (the “**City-FDF**”). Promptly following installation of the City-FDF, provide notice to the City and provide the City with access to the City-FDF in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- G. Allocate two (2) dedicated fibre pairs within the spare City Fibre deployed in the Valley Line LRT Stage 1 for an EPCOR SCADA connection from the Churchill Connector Utility Complex to the Gerry Wright OMF to monitor the photo voltaic array system in accordance with Section 8-2.6.1 [*Gerry Wright OMF Sustainability Requirements*] of this Schedule.

6-1.7.3 Fibre Optic Cable Requirements

- A. Provide fibre optic cable that adheres to fibre optic cable standards listed in Section 6-1.21 [*Wire and Cable*] of this Schedule.
- B. Provide all fibre optic cable with:
 1. an accessible minimum 10 m cable figure-8 slack coil in each Access Vault;
 2. a minimum 5 m cable slack coil secured to the wall at each City-FDF and City Cabinet;

3. continuous cable lengths with the number of splices minimized on each cable path;
 4. splices only in accessible vault locations; and
 5. splice cases mounted on walls within Access Vaults.
- C. Terminate all fibre strands using LC terminations in Corning fibre enclosure modules:
1. 1U: Up to 48 fibre LC, Holds two (2) bulkhead modules or splicing cassettes; and
 2. 2U: Up to 96 fibre LC, Holds four (4)
 3. bulkhead modules or splicing cassettes.
- D. Subject all terminated fibre strands to the following post installation tests and rework installation until tests pass:
1. unidirectional OTDR test at 1310 nm and 1550 nm for SM fibre;
 2. end-to-end bi-directional power meter test at 1310 nm and 1550 nm for SM fibre;
 3. bi-directional Optical Loss Test Set (OLTS) test at 1310 nm and 1550 nm for SM fibre;
 4. optical spectrum analysis using the following criteria:
 - a. range: 1250-1650 nm;
 - b. resolution: +/- 0.033 nm;
 - c. accuracy: +/- 0.015 nm; and
 - d. power accuracy: 0.4 dB;
 5. chromatic dispersion analysis using the following criteria:
 - a. range: 1250 nm – 1650 nm;
 - b. wavelength accuracy: 0.1 nm; and
 - c. dispersion accuracy: 1.6 ps/nm; and
 6. polarization mode dispersion analysis (both 1st and 2nd order) using the following criteria:
 - a. range: 0 – 115 ps; and
 - b. accuracy: +/- (0.020 +/- 2% of PMD).
- E. Determine the following using the results of the tests performed in accordance with Section 6-1.7.3D [*Fibre Optic Cabling*] of this Schedule:
1. span loss (total loss of span from patch panel to patch panel);
 2. optical loss margin, defined as the additional loss that can be added to a fibre optic span without adding additional bit errors or packet loss to any given circuit on the optical multiplexer;
 3. return loss (as measured from a matching connector);
 4. splice loss;

5. termination loss; and
 6. physical distance to all fibre features correlated with actual track positioning.
- F. Utilize the following test data as pass criteria:
1. splices < 0.1 dB loss;
 2. terminations < 0.25 dB loss and > -55 dB return loss (matching);
 3. total loss < calculated span loss or link budget for span components including cable, connectors, splices, patch panels; and
 4. optical loss margin > 10 dB.
- G. Provide all software necessary to interrogate and read the test data native format files.
- H. Provide digital copies of all test data results.
- I. Promptly following successful completion of the tests set out in this Section 6-1.7.3[Fibre Optic Cable Requirements], deliver all test results and software and provide notice to the City and provide the City with access to the terminated fibre strands in accordance with Section 1-1.3 [City Works] of this Schedule.

6-1.7.4 Network Layout

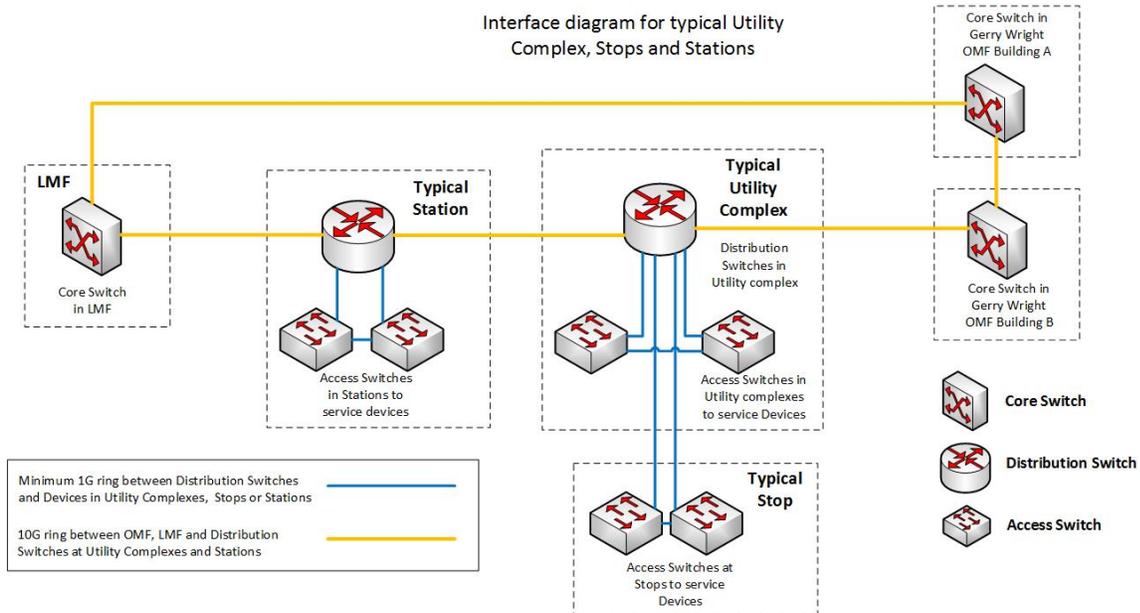


Figure 6-1.7.4-1: Interface Diagram for Typical Utility Complexes, Stops and Stations

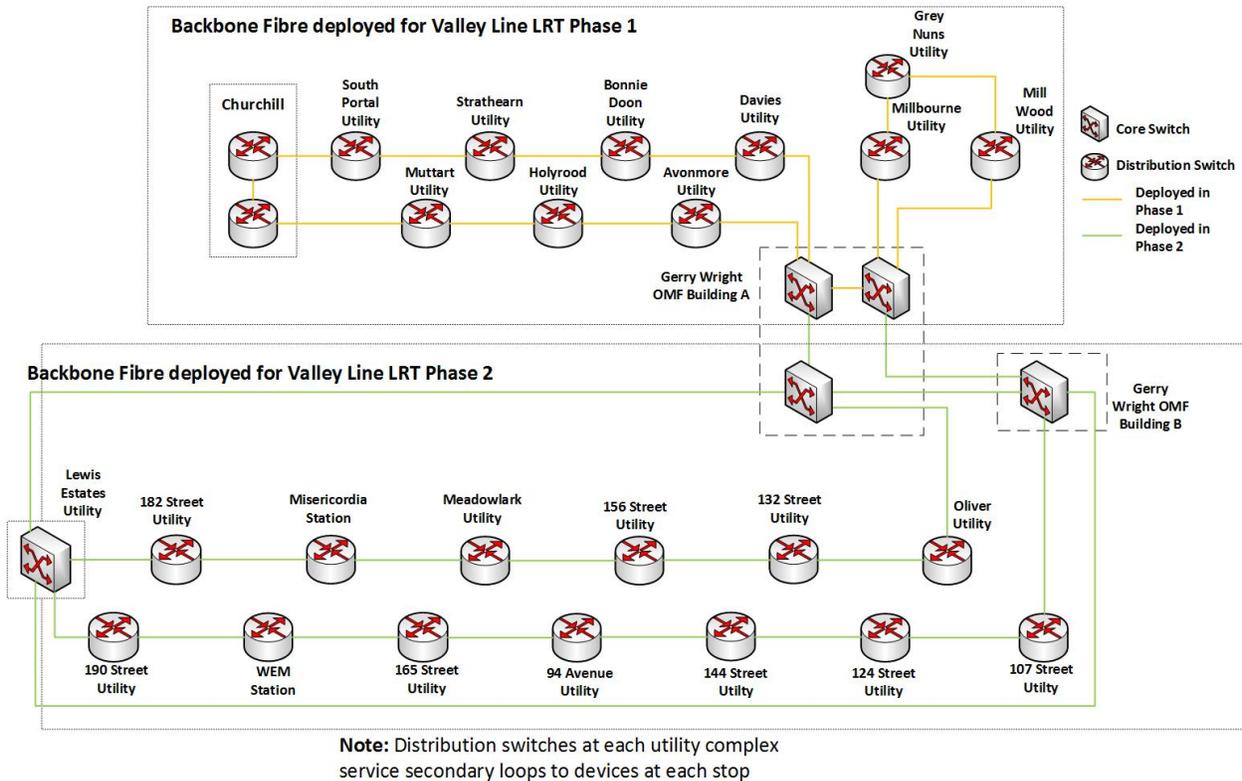


Figure 6-1.7.4-2: Network Architecture

6-1.8 DATA CENTRES

- A. Provide Data Centre space in the [REDACTED] to house Data Centre equipment and provide a minimum 50% expansion capability.
- B. Provide auxiliary Data Centre space in [REDACTED] to house a core network switch and main fibre termination point.
- C. Evaluate the capacity of the existing HVAC and UPS in the main Data Centre in [REDACTED] for sufficiency to support the data centre equipment to be installed as part of Valley Line LRT Stage 2. Where necessary, upgrade HVAC and/or UPS to provide capacity to support all data centre equipment and an additional 20% loading.
- D. Allocate existing space in the main Data Centre in [REDACTED] to accept and accommodate equipment from Valley Line LRT Stage 2.
- E. Provide space in the [REDACTED] to house core switches, distribution switches and access switches.
- F. Provide virtual servers for supporting systems using virtual machine platforms compatible with those of Valley Line LRT Stage 1 or replace all to provide a consistent platform across Valley Line LRT.
- G. Provide additional physical server equipment in [REDACTED] to support the expansion of the Valley Line LRT Stage 1 systems.

- H. Run virtual servers on physical server equipment in the [REDACTED], expanded server equipment in [REDACTED]. Physical servers may only be used instead of virtual servers if permitted by the City, in its discretion.
- I. Provide a data centre architecture that includes disaster recovery through the use of data centre redundancy to protect against component or hardware failure, server or assembly failure, or loss of any Valley Line LRT Data Centre.
- J. Provide configuration of servers that ensures complete functionality in case of failover to redundant server.
- K. Configure all Data Centre equipment to use the existing primary and secondary Master Clocks.
- L. Design and construct all Data Centres in accordance with ANSI/BICSI 002-2014. The Data Centres shall be designed and constructed to Class F3.
- M. Design and construct the auxiliary Data Centre in accordance with ANSI/BICSI 002-2014. The Data Centre shall be designed and constructed to Class F2.
- N. Design and implement the architecture of all Data Centres infrastructure (or equipment) to be modular and easily expandable with no, or minimal, operational downtime.
- O. Commission all Data Centres in accordance with ANSI/BICSI 002-2014.
- P. Commission each element of the Data Centres as standalone subsystems prior to being placed into service.
- Q. Integrate the Data Centre equipment with the Data Centre equipment deployed in Valley Line LRT Stage 1 to achieve redundancy in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule;
1. submit an integration plan for the integration of Data Centre equipment with the data centre equipment deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**Data Centre Integration Plan**”).
- R. Perform integration tests of the Data Centre equipment including functionality tests to prove the functionality as described in item Section 6-1.8 [*Data Centres*] of this Schedule.
- S. Provide a Manufacturer Warranty for Data Centre equipment for a minimum of five (5) years.
- T. With the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim Data Centre Design Package**”):
1. a detail description of components to be used in the Data Centres;
 2. preliminary drawings for the equipment layouts for the Data Centres; and
 3. qualification test plan for the Data Centres.
- U. With the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used in the Data Centres (the “**Second Interim Data Centre Design Package**”).

- V. With the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Data Centre Design Package**”):
 - 1. the qualification test reports for the Data Centres; and
 - 2. updated drawings, specifications, designs and plans for the components to be used in the Data Centres.
- W. Include the electrical and functional interface requirements of the Data Centres for ICS integration in the ICS Interface Control Document.
- X. Design all Data Centres in accordance with ANSI/TIA-942-B.

6-1.9 ELECTRICAL DESIGN AND CONSTRUCTION CRITERIA

6-1.9.1 Introduction

- A. This Section 6-1.9 [*Electrical Design and Construction Criteria*] sets out the electrical Design and Construction requirements for the system and the associated distributed loads, except Traction Power loads.

6-1.9.2 General

- A. All electrical distribution elements shall comply with the *Canadian Electrical Code, Part I, C22.1, and Canadian Electrical Code, Part II, C22.2*. All secondary and service-entrance cables shall also comply with *Canadian Electrical Code, Part II*.
- B. All transformers shall be dry-type.
- C. Provide a minimum 25% spare distribution capacity above the projected electrical loading requirements as at the Expiry Date for all transformers, switchgear and electrical distribution panels.

6-1.9.3 Calculations

- A. Perform short-circuit calculations to determine the Amps interrupting capacity rating of the electrical distribution system, based upon the actual available short-circuit value or per-unit impedance values obtained from the electric Utility Company at the electric service entrance or point of connection.
- B. System device coordination and selectivity shall be based on calculated short-circuit values and used for selection of ratings and settings of protection devices.
- C. Voltage drop calculations along circuits and feeders shall be completed for maximum loads, and, where applicable, under motor starting conditions.
- D. Arc flash hazard calculations shall be completed for equipment that is required to be field marked for arc flash warning per CAN/CSA Z462. Values to be calculated shall include:
 - 1. flash protection boundary in units of centimeter from equipment; and
 - 2. incident energy at 45.72 cm working distance from equipment in units of calories per square centimeter (cal/cm²). The calculated values shall be permanently displayed on equipment arc flash hazard warning labels.
- E. Computations for service, feeder and branch circuit loads shall be based on the nominal system voltage used and applicable demand factors in accordance with the *Canadian Electrical Code*.

6-1.9.4 Electrical Load Classification

A. Electrical loads shall be classified as follows:

1. "Normal" electrical loads can tolerate occasional prolonged interruptions and can, thus, be served by a nonredundant power circuit served from a single electrical utility service feeder, or a single service feeder from a traction power substation. These include any metered loads that are not classified as "Essential" or "Critical" loads which, if de-energized, have no effect on Passenger safety or system operations; or Equipment connected from the normal system load, including:
 - a. normal lighting at Stations and Stops;
 - b. Street Lighting at Lewis Farms Park and Ride Facility and WEM Transit Centre;
 - c. advertising signage at Stations and Stops;
 - d. escalators at Stations;
 - e. space heaters at Stations and Stops;
 - f. ventilation systems (not fire ventilation);
 - g. sanitary drainage pumps;
 - h. typical "Critical" system load equipment, including:
 - i. Station emergency lighting;
 - ii. Emergency signage;
 - iii. Emergency phones (E-Tels) and passenger assist intercoms;
 - iv. ventilation supervisory controller;
 - v. fiber optic system;
 - vi. critical signal systems;
 - vii. TPSS SCADA system;
 - viii. fire alarm system;
 - ix. PA/VMS system;
 - x. CCTV and other security loads; and
 - xi. TVM any other metered load that cannot sustain momentary disruptions; and
 - i. equipment connected from the "Essential" system load including, but not limited to:
 - i. elevators;
 - ii. storm and ground water drainage pumps;
 - iii. fire booster pumps;
 - iv. fire ventilation smoke removal system;

- v. HVAC (when critical systems can fail due to overheating) sump pumps; and
- vi. any other metered load that can sustain momentary disruptions, but which requires redundant and diverse energy sources as determined in accordance with the Safety and Security Certification Program and the RAM Program.

6-1.9.5 Emergency and Standby Sources

- A. Provide standby power sources sized to energize all Critical and Essential electrical loads.
- B. Standby power sources shall be designed such that:
 - 1. Critical loads will not be subjected to prolonged or momentary power interruptions. Critical loads must, therefore, be served by a UPS system;
 - 2. Essential loads can tolerate only momentary interruptions and can, therefore, be served by:
 - a. an off-line UPS
 - b. a redundant power circuit served from two (2) electrical utility service feeders;
 - c. two service feeders from a traction power substation;
 - d. a single feeder from the traction power substation, and an alternative power source such as a permanent generator; and
 - e. a single feeder from electrical utility and an alternative power source such as a permanent generator; and
 - 3. Essential loads shall not experience any interruption exceeding two (2) minutes, or such shorter time as determined by the Safety and Security Certification Program and the RAM Program, upon failure of any main electrical Utility feed.
- C. Where standby power is provided by a second Utility feed, it shall be independently fed from an alternate Utility substation.
- D. Standby power batteries shall not be located within a Pedestrian Priority Zone, unless housed within a Utility Complex that includes a TPSS.
- E. Where standby power is provided by use of a mobile energy source, provide an electrically interlocked external connection point on the outside wall of the applicable electrical room, located within 10 m of a parking stall or Roadway with no parking restrictions to allow access.

6-1.9.6 Stop and Station Services

- A. Provide three (3) phase, 60 Hz, incoming mains for each Stop and Station via a standard meter load or a transformer.
 - 1. Where installation of a transformer is required at a Stop, it shall be located within a vault.
 - 2. Coordinate with the electric Utility Company for supply, installation and maintenance of electrical distribution equipment up to the demarcation point.
 - a. The demarcation point between the electric Utility Company's system and the System shall be as defined in the electric Utility Company's Customer Connection Guide.
- B. At Misericordia Station and WEM Station, provide an electrical room and equip with:

1. revenue class metering;
 2. switchboard;
 3. power distribution panels, including separate Normal, Critical, and Essential load centres;
 4. feeders to all electrical loads;
 5. emergency and transfer equipment as described in Section 6-1.9.5 [*Emergency and Standby Sources*] of this Schedule;
 6. transformers;
 7. elevator and escalator electrical services;
 8. lighting control cabinet; and
 9. Station heating controls.
- C. At Stops, provide one (1) Platform mounted enclosure rated at NEMA 4X when installed, equipped with:
1. revenue class metering;
 2. 600/120V-208V three (3) phase transformer (if required)
 3. 120/208V three (3) phase distribution panel complete with main breaker;
 4. feeders to all “normal” electrical loads;
 5. lighting controls; and
 6. Shelter heating controls.

6-1.9.6.1 Stop and Station Electrical

- A. At all Stops and Stations, provide general-purpose duplex receptacles in accordance with the Room Data Sheets.

6-1.9.6.2 Grounding and Bonding

- A. The electrical distribution systems at Stops and Stations shall be solidly grounded and bonded in accordance with Section 1-2.7 [*Grounding and Bonding*] of this Schedule.
- B. The grounding electrode system shall be supplemented and bonded together with an embedded ground grid on each side of the Tracks at Stations.
- C. All non-current-carrying metal enclosures and all alternating current equipment shall be securely bonded to the grounding system at the applicable Stop or Station.
- D. Each metallic electrical equipment housing shall provide a welded boss for attaching a protective ground connection and shall be sized for expected trip currents.
- E. Any pipe connected to an active cathodic protection system shall not be connected to the grounding system, except where the design of the active cathodic protection system requires that the pipe be grounded.

- F. Feeder circuit grounding conductors shall be:
 - 1. housed in a separate conduit or run alongside the feeder cables; and
 - 2. bonded to electrical equipment along the LRT Corridor, including metallic equipment enclosures.

6-1.9.7 Utility Complex Services

- A. At each Utility Complex, provide within each associated electrical room:
 - 1. electrical load centre panel, energized from a TPSS auxiliary feed in accordance with Section 6-2.3.3 [TPSS] of this Schedule;
 - 2. transformers; and
 - 3. such other electrical distribution equipment as required to support the functionality of the applicable Utility Complex.
- B. External aerial feeder cabling within a Utility Complex is not permitted.

6-1.9.8 Lighting and Receptacle Metered Services

- A. Track lighting, including Yard Track and Lead Track lighting, shall be revenue metered.
- B. Street Lighting in accordance with Section 3-7 [Street Lighting Requirements] and Section 6-6 [Street Lighting System Requirements] of this Schedule except along roadways, Sidewalks and SUPs which are part of the City of Edmonton street light program, shall be revenue metered;
 - 1. For all unmetered Street Lighting, Project Co shall track and submit to the City all load changes during the Construction Period (each, a “**Unmetered Street Lighting Load Change Report**”).
- C. Walkways or pedestrian pathway lighting, bench lighting and any other electrical loads that are part of the project (e.g. receptacles for decorative lighting within Jasper Place Opportunity Area) shall be revenue metered.
- D. Provide power to pedestrian street lights from a flush mounted utility box between landscaped areas, with one (1) box supplying power to two (2) landscape areas.

6-1.9.9 Life Safety

6-1.9.9.1 Electrical Safety Provisions

- A. Ground fault protection of equipment, as defined in the NEC (2014), shall be provided as required by the CEC. Ground fault “annunciation only” shall be provided where is required for equipment or feeders serving Essential electrical loads.
- B. Ground fault protection for personnel, as defined in UL 943, shall be provided on branch circuits that have equipment or outlets for which personnel protection is required by the CEC or Good Industry Practice.

6-1.10 MECHANICAL DESIGN AND CONSTRUCTION CRITERIA

- A. This Section 6-1.10 [Mechanical Design and Construction Criteria] sets out the mechanical Design and Construction requirements for Building Structures.

6-1.10.1 Not Used

6-1.10.2 Not Used

6-1.10.3 HVAC Design Requirements

6-1.10.3.1 General HVAC Design Requirements

- A. Indoor air temperature and relative humidity in all rooms and spaces shall comply with the requirements of NBCAE and ASHRAE standards and shall meet any temperature and humidity requirements set by the manufacturers of equipment situated in such rooms or spaces.

6-1.10.3.2 Stops Specific HVAC Design Requirements

- A. Provide automatic control for the heating system in each Shelter, such that:
 - 1. the heating system becomes activated within 15 seconds of the space becoming occupied and de-activated when the space becomes or remains unoccupied for more than three (3) consecutive minutes;
 - 2. if the heating system has been de-activated, the Shelter shall reach a breath zone temperature of at least 4 °C within five (5) minutes of being activated, with all doors closed, and maintain this minimum temperature while the space remains occupied.
- B. Shelters shall be electrically heated.
- C. Space temperatures in Shelters shall not be higher than 2 °C above July 2.5% outdoor summer design dry bulb ambient temperatures given in the NBCAE.
 - 1. Only passive ventilation of Shelters is allowed.
- D. Indoor environmental design parameters for the Lewis Farms Stop operator washroom shall be in accordance with the Room Data Sheets.
- E. Space temperatures in ETS operator washrooms shall not be higher than 2 °C above July 2.5% outdoor summer design dry bulb ambient temperatures given in the NBCAE.

6-1.10.3.3 Station Specific HVAC Design Requirements

- A. Indoor environmental design parameters for spaces within the WEM Station and Misericordia Station shall be in accordance with the Room Data Sheets.
 - 1. The minimum and maximum temperatures indicated for the WEM Station and Misericordia Station on the Room Data Sheets shall be used for the design of the heating and cooling systems as well as for the purposes of energy modelling.
- B. Space temperatures in heated waiting areas, public washrooms, ETS operator washrooms, janitorial rooms, and mechanical rooms shall not be higher than 2 °C above July 2.5% outdoor summer design dry bulb ambient temperatures given in the NBCAE.
- C. Temperatures in vertical circulation spaces between L2 Mezzanine and L3 Platform levels shall not be lower or higher than the operating temperatures of the escalators as set out in the Valley Line West LRT Facilities Design and Construction Standards.

6-1.10.3.4 Maintenance and Storage Facility Specific HVAC Design Requirements

- A. Indoor environmental design parameters for spaces within the Gerry Wright OMF Building B and Lewis Farms Storage Facility shall be in accordance with the Room Data Sheets.
 - 1. Heating systems within the Gerry Wright OMF Building B and Lewis Farms Storage Facility shall be designed to accommodate the minimum temperatures for the design of heating systems that are indicated on the Room Data Sheets.
 - 2. For the purposes of energy modelling for the Gerry Wright OMF Building B and Lewis Farms Storage Facility, the minimum operational temperatures for energy modelling that are indicated on the Room Data Sheets may be assumed.
 - 3. The maximum temperatures indicated for the Gerry Wright OMF Building B and Lewis Farms Storage Facility on the Room Data Sheets shall be used for the design of the cooling systems as well as for the purposes of energy modelling.

6-1.10.4 Not Used

6-1.10.5 Fire Protection Design Requirements

6-1.10.5.1 General Fire Protection Design Requirements

- A. Wherever the NBCAE requires provision of a fire protection system, such systems shall comply with the requirements of NFPA 130.
- B. At Stops, fire protection shall be provided via hydrant coverage.

6-1.10.5.2 Not Used

6-1.10.5.3 Supply Air Exchange

- A. Provide a stand-alone-supply air and exhaust system and a hydrogen sensor in each room containing batteries designed to vent hydrogen.
- B. The supply air and exhaust system shall provide a minimum of five (5) air-changes per hour in accordance with the requirements of NFPA-76.
- C. Upon sensing 1% or higher concentration of hydrogen in the air, the hydrogen sensor shall:
 - 1. provide an audible alarm;
 - 2. initiate operation of the exhaust air fan system; and
 - 3. report the alarm condition to the Building SCADA system.
- D. The hydrogen sensor shall be capable of sensing within the range of 0.2% to 4% hydrogen concentrations in air.

6-1.10.6 Utility Complex Services

- A. Provide the following at each stand-alone Utility Complex:
 - 1. a non-freeze cold-water spigot with secure access that shall be operational year-round, which shall be serviced by a minimum 20 mm water line; and

2. a floor drain that drains into the sanitary service to prevent accumulation of standing water below the spigot.

6-1.11 CCTV SYSTEM

A. The CCTV System consists of:

1. The Valley Line CCTV System to provide coverage of Stops, Stations, LRVs, the [REDACTED], the [REDACTED], the [REDACTED], the [REDACTED], the [REDACTED], and dedicated intersections along the LRT Corridor, to be integrated into the Valley Line LRT Stage 1 CCTV system.

6-1.11.1 Reference Standards

A. Design, construct and test the Valley Line CCTV system to following codes and standards, but not limited to:

1. American National Standards Institute (ANSI);
2. American Public Transportation Association (APTA);
3. Canadian Electrical Code (CEC);
4. Electrical & Electronics Manufacturers (EEMAC) Standards;
5. Electronic Industry Association – E.I.A.;
6. Telecommunications Industry Association (TIA);
7. IEEE 802 Local and Metropolitan Area Networks;
8. IEEE 802.3at and IEEE 802.3af (PoE and PoE+);
9. ITU H.323 Packet Based Multimedia Communication Systems;
10. Transport Canada;
11. Underwriters Laboratories (ULC) Inc. Standards; and
12. ITU H.323 Packet Based Multimedia Communication Systems.

6-1.11.2 Valley Line CCTV System

6-1.11.2.1 General Surveillance Requirements and Coverage

- A. [REDACTED]
- B. [REDACTED]
- [REDACTED]
- [REDACTED]
- [REDACTED]

- 4. [REDACTED]
- 5. [REDACTED]
- 6. [REDACTED]
- C. [REDACTED]
- D. [REDACTED]
- E. [REDACTED]
- F. [REDACTED]
- 1. [REDACTED]
- G. [REDACTED]
- H. [REDACTED]
- I. [REDACTED]
- J. [REDACTED]
- 1. [REDACTED]
- 2. [REDACTED]
- K. Collect and store all information recorded by the Valley Line CCTV System in compliance with the requirements of Schedule 18 [*Freedom of Information and Privacy Protection*] and all Applicable Laws, including the *Freedom of Information and Protection of Privacy Act* (Alberta).
- L. Submit a comprehensive surveillance study, including horizontal and vertical fields of view for each camera, with the Final Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], of the Valley Line LRT Stage 2 and of each facility referred to in Section 6-1.11.2.1M (the “**Surveillance Study**”);
 - 1. The Surveillance Study shall demonstrate that the Valley Line CCTV System complies with the minimum coverage requirements set out in Sections 6-1.11.2.1M and 6-1.11.2.1N and the design requirements set out in Section 6-1.11.2.1 [*General Surveillance Requirements and Coverage*] of this Schedule.
- M. [REDACTED]
- 1. [REDACTED]

- a. [REDACTED]
 - b. [REDACTED]
 - c. [REDACTED]
2. WEM Station and Misericordia Station with CCTV cameras placed to monitor activity at the following facilities:
- a. emergency telephones;
 - b. escalators, along the escalator path and entry/exit;
 - c. outside of elevators;
 - d. concourse/mezzanine levels with 100% coverage and no blind spots;
 - e. all entrance doors,
 - f. fixed view of each washroom entrance;
 - g. Pedway/walkway/stairwell entrances and exits; and
 - h. 100% coverage of surface parking areas, with activity identifiable to 45m;
3. all public areas at the Lewis Farms Park and Ride, with CCTV cameras placed:
- a. with unobstructed views of BLTs; and
 - b. to provide 100% coverage of the [REDACTED];
4. Utility Complexes, with CCTV cameras placed to monitor activity at the following:
- a. gate entrance to the Utility Complex; and
 - b. door entrances to each TPSS, electrical room, communications room, signal room, and any other rooms in the Utility Complex;
5. [REDACTED] site and [REDACTED]:
- a. depot perimeter;
 - b. stabling area;
 - c. each Train entrance from the mainline to the [REDACTED];
 - d. each road entrance;
 - e. each door monitored by the intrusion system;
 - f. car wash entrance and exit of [REDACTED];
 - g. loading dock(s);

- h. outdoor storage area(s);
 - i. track switch areas;
 - j. track entrances to buildings;
 - k. Traction Power Substation at [REDACTED]; and
 - l. car park;
6. all public waiting areas at the WEM Transit Centre, with CCTV cameras placed:
- a. with views of all TVMs and BLTs;
 - b. provide 100% coverage of the area;
 - c. with views of all Shelters;
 - d. with a fixed view of each washroom entrance; and
 - e. with views of all entrance doors;
7. all Elevated Guideways, with CCTV cameras placed to provide 100% coverage of the LRT Corridor; and
8. the following traffic intersections, with fixed CCTV cameras placed to provide 100% coverage of the intersection including at a minimum all Road Traffic Signals, Grade Crossings and vehicle, bicycle, and pedestrian movements at the intersection, in accordance with Table 6-4.3-1 [*Traffic Intersections*] of this Schedule:
- a. 87 Avenue / Ramp SB AHD;
 - b. 87 Avenue / Ramp NB AHD;
 - c. 87 Avenue / 163 Street;
 - d. 87 Avenue / 159 Street;
 - e. Meadowlark Road / 156 Street;
 - f. 92 Avenue / 156 Street;
 - g. 95 Avenue / 156 Street;
 - h. 99 Avenue / 156 Street;
 - i. 100 Avenue / 156 Street;
 - j. Stony Plain Road / 156 Street;
 - k. Stony Plain Road / 149 Street;
 - l. Stony Plain Road / 142 Street;
 - m. Stony Plain Road / 102 Avenue;
 - n. Stony Plain Road / 139 Street;

- o. Stony Plain Road / 136 Street;
 - p. Stony Plain Road / 134 Street;
 - q. Stony Plain Road / 124 Street;
 - r. 104 Avenue / 116 Street;
 - s. 104 Avenue / 109 Street;
 - t. 104 Avenue / 107 Street;
 - u. 103 Avenue / 107 Street;
 - v. 102 Avenue / 107 Street;
 - w. 102 Avenue / 106 Street; and
 - x. 102 Avenue / 105 Street.
- N. Provide enhanced LRT CCTV Subsystem coverage with thermal cameras and video-analytic tripwires placed to alarm and monitor unauthorized entry or activity:
- 1. at each Train entrance from the mainline to the [REDACTED];
 - 2. at each Train entrance from the mainline to the [REDACTED] F; and
 - 3. to/from the Elevated Guideway Ramps and station platforms at all Elevated Guideways; and
 - a. provide a visual indicator on both tracks with bi-directional running to alert the operator of the Train in the event of unauthorized entry or activity.
- O. Provide the following functionality:
- 1. LRT CCTV Subsystem surveillance coverage as described in Section 6-1.11.2.1M *[General Surveillance Requirements and Coverage]* of this schedule;
 - 2. System Requirements in compliance with Section 6-1.11.2.2 *[System Requirements]* of this Schedule;
 - 3. ability to provide and record images in real time;
 - 4. coverage to ensure doorways are clear of passengers;
 - 5. coverage of all access-controlled doors;
 - 6. digital signature provided for each recorded data file for authentication;
 - 7. mitigate safety and security threats identified in the Safety and Security Certification Program and in accordance with CPTED principles;
 - 8. provide visual evidence for incident and accident forensic investigation;
 - 9. view and record the faces of persons entering and leaving any monitored area;
 - 10. provide video clarity for facial recognition on specific cameras as determined by a Surveillance Study; and

11. provide observance of general activity.

- P. [REDACTED]
 - 1. [REDACTED]
 - 2. [REDACTED]
 - 3. [REDACTED]
 - 4. [REDACTED]
 - 5. [REDACTED]
- Q. [REDACTED]
- R. [REDACTED]
 - 1. [REDACTED]
 - 2. [REDACTED]
 - 3. [REDACTED]
- S. [REDACTED]
- T. [REDACTED]
 - 1. [REDACTED]
 - 2. [REDACTED]

6-1.11.2.2 System Requirements

- A. Provide a head-end platform for the Valley Line CCTV System, comprised of the most recent version of “Genetec Security Center” in use on the Valley Line LRT Stage 1 within six (6) months of Construction Completion.
- B. Provide a Valley Line CCTV System with:
 - 1. camera organization and naming conventions which are consistent with Valley Line LRT Stage 1;
 - 2. harmonization of IP and multicast addressing with those adopted on the Valley Line LRT Stage 1;
 - 3. IP-based cameras in compliance with Section 6-1.11.2.4 [CCTV Camera Requirements] of this Schedule;

4. dedicated application servers which control and manage every aspect of the Valley Line CCTV System, including video archives and corresponding databases;
 5. seamless integration, such that the Valley Line CCTV System operation incurs no disruption, when cameras or workstations are added anywhere on the network, at any time;
 6. support for up to 64 clients (users) simultaneously monitoring and managing live and recorded CCTV feeds deployed throughout the Infrastructure, with no measurable degradation in performance;
 7. support for viewing a minimum 32 live feeds at two (2) megapixel resolution at 10 fps, from multiple servers on the same screen, with digital zoom and tracking;
 8. identical copies of each video file on NAS storage devices, in secure encrypted format, at Gerry Wright OMF Building A and the Lewis Farms Storage Facility Building. Simultaneous transfer of secure encrypted digital video to each location shall be provided using multicast transport at the distribution level;
 9. secure, encrypted, tamper proof, digital, scalable and continuous video recording;
 10. the capacity and functionality to accept secure encrypted at rest video images from Stage 1 LRVs and Stage 2 LRVs located within the either the Gerry Wright OMF and the Lewis Farms Storage Facility Building via the Data Radio System;
 11. selectable image rates up to 60 fps, on a per camera basis and for groups of cameras. Actual image rates shall be selectable by the City;
 12. regular, and on demand, retrieval of recorded video from edge devices where cameras have the capability to store video;
 13. ONVIF protocol and certification;
 14. user configurable alarm reporting to the ETS Transit Security Control Centre, including camera failure alarms; and
 15. video recording and date/time and camera ID watermarks synchronized with the Master Clock system.
- C. Confirm alarm events properly trigger live and record CCTV video actions at the ETS Transit Security Control Centre, as defined within Section 6-1.11.2.2 [*System Requirements*] of this Schedule.
- D. Configure the Valley Line CCTV System, and provide integration with the City's "Genetec Security Center" surveillance system, to provide:
1. display of up to a minimum of 32 live feeds at two (2) megapixel resolution at 10 fps;
 2. two (2) connections from two separate geographic locations to be Accepted by the City;
 - a. at each location provide two 10 gigabit ethernet links in a network link aggregation bundle;
 3. simultaneous display of any combination of cameras;
 4. instant replay capability from any camera;
 5. digital and optical zoom for clear identification;

6. touch screen support;
7. automatic display of live video of TVMs when triggered by TVM contacts;
8. automatic display of live video of BLT on activation of a BLT;
9. retrieval and viewing of any Valley Line CCTV System stored video images;
10. automatic display of live video of exterior door washroom doors when triggered by the washroom emergency phone; and
11. automatic display of the elevator cab live video when triggered by the elevator emergency phone.

Notify the City and provide such assistance as may be reasonably requested by the City to integrate the Valley Line CCTV System with the City's "Genetec Security Centre" surveillance system, in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- E. Provide the Valley Line CCTV System as accessible from the existing security workstations at the ETS Transit Security Control Centre, at highest viewing and control priority of all Valley Line CCTV System workstations, such that viewing and control of any PTZ camera by others is disabled while the camera is under control of the ETS Transit Security Control Centre, until such time as control is relinquished by the ETS Transit Security Control Centre.
- F. Design and account for both the viewing and recording bandwidth requirements.

6-1.11.2.3 Video Storage Requirements

- A. Provide a scalable and modular NAS storage solution that is compatible with the NVR used in the Valley Line LRT Stage 1 that includes a redundant array of independent disks (RAID) at the [REDACTED] and the [REDACTED].
- B. Provide a RAID configuration that is consistent with Valley Line LRT Stage 1.
- C. Provide video storage capacity that is determined based on a 21-day video retention capacity, and archival strategy at maximum frame rates and resolution. All archived video shall be watermarked. Provide locked cabinets to secure storage devices and provide all keys to the City's Representative for their exclusive access.
- D. Expand storage capacity to support retention of all video images on NAS storage devices, including images uploaded from LRVs, for a duration of 21 days, with automatic overwrite of stale images.
- E. Integrate the LRT CCTV Subsystem with the Stage 1 LRV and Stage 2 LRV CCTV Subsystems, in accordance with Part 7 [*LRV Integration Requirements*] of the Schedule.
 1. Perform an integration test on the Stage 1 LRV and Stage 2 LRV CCTV Subsystems to prove the functionality as described in Section 6-1.11.2.3 [*Video Storage Requirements*] of this Schedule.
 2. Submit an integration plan for the integration of the LRT CCTV Subsystem with the Stage 1 LRV and Stage 2 LRV CCTV Subsystems, not less than 90 days before application of the plan, detailing step by step operations and integration testing to prove functionality, the ("**LRV CCTV System Integration Plan**").

6-1.11.2.4 CCTV Camera Requirements

- A. Provide CCTV cameras that:
 1. utilize minimum H.264 encoding;

2. be either stationary or pan tilt zoom, as determined by the Surveillance Study;
 3. be hybrid fibre capable;
 4. connected on UPS-powered device;
 5. provide a minimum two (2) megapixel resolution;
 6. have remote aiming capability for all “fixed” cameras for configuration and setup;
 7. capture colour video of sufficient clarity for facial recognition and video analytics under all controlled lighting conditions;
 8. be tamper proof and inconspicuous by blending in with the interior and exterior finishes;
 9. provide record for incident investigations;
 10. provide video clarity for facial recognition on specific cameras as determined by the Surveillance Study;
 11. have sufficient sensitivity for any possible combination of controlled ambient and interior or exterior lighting levels, including emergency lighting;
 12. have local removable storage for a minimum of five (5) days; and
 - a. designed for the high write activity of the video data;
 13. capability to remotely load video analytic software to the camera itself
- B. Provide a Manufacturer Warranty for CCTV cameras for a minimum of three (3) years.
- C. Provide all equipment that operates with full functionality under all environmental conditions applicable to the location at which they are installed.
- D. Where lighting is uncontrolled and lighting conditions are insufficient to permit image quality required by Section 6-1.11.4A [*CCTV Camera Requirements*] of this Schedule, provide cameras with:
1. infrared illumination;
 2. automatic switch from colour for daytime use, to ultra-sensitive black & white for night time surveillance;
 3. minimum sensitivity of 0.14 lux at F1.4 in colour mode, and 0.01 lux at F1.4 in black & white mode;
 4. sensitivity enhancement of 32x for full colour surveillance in light as low as 0.01 lux; and
 5. built-in digital motion detector.
- E. Interface each LRT CCTV Subsystem CCTV camera to the CTS through the nearest network access switch.
- F. Where distances permit, power LRT CCTV Subsystem CCTV cameras by Power over Ethernet using 60 W (POE). If distances are greater than what standards allow, cameras shall be powered by a 4 strand SM 100W hybrid fibre cable.

6-1.12 RADIO SYSTEMS

6-1.12.1 Not Used

6-1.12.2 Voice Radio System

6-1.12.2.1 Functional Requirements

A. Provide a voice radio system, which satisfies the following functional requirements:

1. provides 99% reliable communication over 95% of the area of the Valley Line LRT Stage 2, including Stations. Acceptable RF coverage shall be defined as a received signal strength of -78 dBm.
2. does not impact the operation of LRVs;
3. includes console access to manage the system;
4. supports the needs of operations staff, the OCC, and maintenance staff as users of the system;
5. provides capacity for a minimum of 500 users;
6. provides uninterrupted coverage and operation of the Voice Radio System in the event of any single point of failure; and
7. is a contiguous single system across the Valley Line LRT

(the “**Voice Radio System**”).

6-1.12.2.2 Extension of Valley Line LRT Stage 1 Voice Radio System

- A. Submit with the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*] an evaluation of the voice radio system for the Valley Line LRT Stage 1 (the “**Valley Line LRT Stage 1 Voice Radio System Evaluation**”) for suitability to extend and meet the operational requirements of the Valley Line LRT Stage 2;
1. if the voice radio system for the Valley Line LRT Stage 1 can be extended and designed to meet the requirements described in Section 6-1.12.2.1 [*Functional Requirements*] of this Schedule, extend the system to cover the entire Valley Line LRT;
 - a. integrate the Voice Radio System with the Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule; or
 2. if the voice radio system for the Valley Line LRT Stage 1 cannot be extended, provide a Voice Radio System for the entire Valley Line LRT that meets the requirements described in Section 6-1.12.2.1 [*Functional Requirements*] of this Schedule, such that;
 - a. loss of Valley Line LRT Stage 1 voice radio system functionality shall not be permitted during the migration to the new Voice Radio System;
 - b. coordinate all migration activities with the Operator;
 - c. provide and install all necessary Voice Radio System equipment on the Stage 1 LRVs; and
 - d. provide all the necessary Voice Radio System equipment for the Stage 2 LRVs to be installed by Other Contractors.

- B. Provide voice recording storage capacity for the Valley Line LRT to allow for access to a minimum of 30 days on line storage and the ability to archive a minimum of one (1) year of voice radio communications as well as the addition of up to 50% end devices for future expansion the Valley Line LRT and in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.

6-1.12.2.3 Other Requirements

- A. Provide locked cabinets for any additional storage devices for the Voice Recording System as specified in Section 6-1.13 [*Telephones*] of this Schedule.
- B. Configure the Voice Radio System to use the existing primary and secondary Master Clocks.
- C. Provide a Manufacturer Warranty for the Voice Radio System for a minimum of five (5) years.
- D. Provide no less than 80 handheld radio devices in accordance with the staffing requirements as described in the Operability and Maintainability Parameters.
- E. Provide a charging facility for handheld radio devices at the Gerry Wright OMF B and Lewis Farms Storage Facility.

6-1.12.2.4 Testing

- A. Perform integration and functionality testing of the Voice Recording System, including:
 - 1. recording of each Wi-Fi voice radio conversation;
 - 2. playback of voice radio recordings; and
 - 3. functionality tests to prove the functionality as described in Section 6-1.12.2.1 [*Functional Requirements*] of this Schedule.

6-1.12.2.5 Submittals

- A. Include the electrical and functional interface requirements of the Voice Radio System for ICS integration in the ICS Interface Control Document.
- B. Submit an integration plan for the Integration of the Voice Radio System for the Valley Line LRT Stage 2 with the voice radio system deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**Voice Radio System Integration Plan**”).
- C. With the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim Voice Radio System Design Package**”):
 - 1. a radio study to confirm the design provides coverage in accordance with Section 6-1.12.2.1 [*Functional Requirements*] of this Schedule;
 - 2. a detailed description of the Voice Radio System;
 - 3. preliminary drawings for the Voice Radio System; and
 - 4. qualification test plan for the Voice Radio System.

- D. With the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for components to be used on the Voice Radio System (the “**Second Interim Voice Radio System Design Package**”).
- E. With the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Voice Radio System Design Package**”):
 1. qualification test reports for the Voice Radio System; and
 2. updated drawings, specifications, designs and plans for the Voice Radio System.

6-1.12.3 Data Radio System

6-1.12.3.1 Functional Requirements

- A. Provide a Data Radio System, which satisfies the following functional requirements:
 1. Meets the same functional and performance requirements as the data radio system of the Valley Line LRT Stage 1;
 2. provides 99% reliable communication over 95% of the area of the vehicle storage areas of the Lewis Farms Storage Facility and Gerry Wright OMF;
 3. does not impact the operation of LRVs;
 4. console access to manage the Data Radio System; and
 5. is a contiguous single system across the Valley Line LRT (the “**Data Radio System**”).

6-1.12.3.2 Extension of Valley Line LRT Stage 1 Data Radio System

- A. Submit with the first Interim Design for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], an evaluation of the data radio system for the Valley Line LRT Stage 1 for suitability to extend and meet the operational requirements of the Valley Line LRT (the “**Valley Line LRT Stage 1 Data Radio System Evaluation**”).
 1. If the data radio system for the Valley Line LRT Stage 1 can be extended and designed to meet the requirements described in Section 6-1.12.3.1 [*Functional Requirements*] of this Schedule, extend the system to cover the Lewis Farms Storage Facility Building and Gerry Wright OMF Building B.
 2. If the data radio system for the Valley Line LRT Stage 1 cannot be extended, provide a Data Radio System for the Lewis Farms Storage Facility Building, Gerry Wright OMF Building A, and Gerry Wright OMF Building B that meets the requirements described in Section 6-1.12.3.1 [*Functional Requirements*] of this Schedule.
 - a. Provide all the necessary Data Radio System equipment for the Stage 1 LRVs and Stage 2 LRVs to be installed by Other Contractors.
- B. Perform and submit a data radio study (“**Data Radio Study**”) to confirm the design provides continuous coverage of functionality throughout the Lewis Farms Storage Facility and Gerry Wright OMF that meets an acceptable signal strength of a minimum of -58 dBm with the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*].

- C. Provide signal coverage using multiple antenna at the edge of the yard to provide interface to multiple vehicles.
- D. Provide data radios to interface with LRVs in the vehicle storage areas of the Lewis Farms Storage Facility and Gerry Wright OMF.
- E. Integrate the Data Radio System with the Valley Line LRT Stage 1 data radio system deployed in Valley Line LRT Stage 1 to achieve redundancy in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.

6-1.12.3.3 Other Requirements

- A. Provide a Manufacturer Warranty for data radios for a minimum of five (5) years.
- B. Configure the Data Radio System to use the existing primary and secondary Master Clocks.

6-1.12.3.4 Testing

- A. Perform integrated functionality tests to prove the functionality of the Data Radio System as described in item Section 6-1.12.3.1 [*Functional Requirements*] of this Schedule.

6-1.12.3.5 Submittals

- A. Include the electrical and functional interface requirements of the Data Radio System for ICS integration in the ICS Interface Control Document.
- B. Submit an integration plan for the integration of the Data Radio System for the Valley Line LRT Stage 2 with the Data Radio System deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**Data Radio System Integration Plan**”).
- C. With the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim Data Radio System Design Package**”):
 1. detailed description of the Data Radio System;
 2. preliminary drawings for the Data Radio System;
 3. qualification test reports for the Data Radio System; and
 4. qualification test plan for the Data Radio System.
- D. With the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used on the Data Radio System (the “**Second Interim Data Radio System Design Package**”).
- E. With the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum the (the “**Final Data Radio System Design Package**”):
 1. updated drawings, specifications, designs and plans for the Data Radio System;
 2. qualification test reports for the Data Radio System; and
 3. updated drawings, specifications, designs and plans for the Data Radio System.

6-1.12.4 Radio System Integration with LRVs

- A. Integrate the wayside Voice Radio System and wayside Data Radio System with the LRV voice radio system and LRV data radio system, in accordance with Part 7 [*LRV Integration Requirements*] of this Schedule.
 - 1. Prepare and submit an integration plan with each the first Interim Design and Final Design submissions for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*] for the integration of wayside Voice Radio System and Data Radio System with the voice radio system and data radio system on the LRVs, at the time of final design of the Voice Radio System and Data Radio System, detailing step by step operations and integration testing to prove functionality, the ("**Radio System Integration Plan**").
 - 2. Perform an integration test on the Voice Radio System and Data Radio System with the LRVs voice radio system and data radio system to prove the functionality as described in Section 6-1.12 [*Radio Systems*] of this Schedule.

6-1.13 TELEPHONE SYSTEM

6-1.13.1 System Specific Reference Standards

- A. Design, construct and test the telephone system in compliance with the latest revisions and applicable sections of the following codes and standards.
 - 1. Americans with Disabilities Act (ADA);
 - a. 28 CFR Part 36, ADA Standards for Accessible Design;
 - 2. American Society of Mechanical Engineering (ASME);
 - a. ASME A17.1a-2002 - Safety Code for Elevators and Escalators;
 - 3. Federal Communications Commission (FCC);
 - a. 47 CFR Part 68 - Connection of Terminal Equipment to the Telephone Network;
 - 4. American National Standards Institute (ANSI);
 - 5. Building Industry Consulting Services International (BICSI);
 - 6. National Fire Protection Association (NFPA);
 - a. NFPA 70 - National Electric Code (NEC);
 - b. NFPA 72 - National Fire Alarm Code;
 - c. NFPA 130 - Standard for Fixed Guideway Transit and Passenger Rail Systems;
 - 7. Telecommunications Industries Association (TIA); and
 - 8. Underwriters Laboratories (UL);
 - a. UL1459 - UL Standard for Safety Telephone Equipment;
 - b. UL/CSA 60960 - Safety of Information Technology Equipment; and
 - c. UL 50, Type 3R - Enclosures for Electrical Equipment.

6-1.13.2 Telephones

- A. Provide telephone system equipment and functionality that are compatible and consistent in design with the telephone system used in the Valley Line LRT Stage 1.
- B. Provide telephone systems required for VoIP voice communications for operational purposes and for the convenience and safety of passengers, including:
 - 1. administrative phones;
 - 2. Emergency Alarm Station phones;
 - 3. blue light telephones;
 - 4. public washroom access phones;
 - 5. washroom emergency phones;
 - 6. elevator emergency phones;
 - 7. entrance access phones;
 - 8. Voice Recording System; and
 - 9. connectivity to the Public telephone network on an emergency and restricted basis.
- C. Provide telephone service for the Valley Line LRT Stage 2 as an extension of the Valley Line LRT Stage 1 telephone service using an extension of the existing VoIP servers.
- D. Provide telephone servers and licensing at the Lewis Farms Storage Facility Building to provide redundancy to the Valley Line LRT Stage 1 telephone system and provide full telephone capacity for Valley Line LRT Stage 2.
- E. Submit an Integration plan for the integration of telephone system with the telephone system deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the "**Telephone System Integration Plan**").
- F. Integrate the telephone servers and licensing at the Lewis Farms Storage Facility Building with the Valley Line LRT Stage 1 telephone system to achieve redundancy in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- G. Expand the Valley Line LRT Stage 1 voice recording storage capacity to allow for access to a minimum of 30 days on line storage and the ability to archive a minimum of twelve (12) years of calls made to the ETS Transit Security Control Centre and the Gerry Wright OMF as well as the addition of up to 50% end devices for future expansion of Valley Line LRT and in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- H. Program each telephone instrument to provide unique on demand information to authorized personnel at the Gerry Wright OMF, Lewis Farms Storage Facility and ETS Transit Security Control Centre that identifies the telephone location and telephone type to indicate that assistance is required.
- I. Perform integration tests for the telephone system that includes equipment integrated from the Valley Line LRT Stage 1 and Valley Line LRT Stage 2 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- J. Configure the telephone system to use the existing primary and secondary Master Clocks.

- K. Demonstrate through Commissioning the following minimum functionality for the Telephone System:
1. operation;
 2. call forwarding;
 3. recording of each telephone;
 4. recording of calls to ETS Transit Security Control Centre;
 5. playback telephone recordings; and
 6. dial access to public switch network.
- L. Not Used.
- M. Interface each telephone not located at the Lewis Farms Park and Ride to the nearest Power over Ethernet (PoE) capable CTS access switch backed by UPS.
- N. Interface each telephone located at the Lewis Farms Park and Ride to the nearest Power over Ethernet (PoE) capable ETS access switch backed by UPS.
- O. Provide telephones and associated equipment rated to operate and provide full functionality under all environmental conditions applicable to the location at which they are installed.
- P. Include the electrical and functional interface requirements of the telephone system for ICS integration in the ICS Interface Control Document.
- Q. With the first Interim Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim Telephone Design Package**”):
1. a detailed description of the telephone system;
 2. preliminary drawings for the telephone system; and
 3. qualification test plan for the telephone system.
- R. With the second Interim Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used on the Telephone System (the “**Second Interim Telephone Design Package**”).
- S. With the Final Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Telephone Design Package**”):
1. the qualification test reports for the telephone system; and
 2. updated drawings, specifications, designs and plans for the telephone system.
- T. Provide administrative telephones in the following locations of Valley Line LRT Stage 2:
1. offices;
 2. reception areas;
 3. work spaces in Gerry Wright OMF Building B and the Lewis Farms Storage Facility Building;

4. electrical, mechanical and utility rooms;
 5. TPSS, communication and signal rooms; and
 6. elevator rooms.
- U. Provide administrative telephones that:
1. are charcoal in colour;
 2. are compatible and equivalent in functionality to the administrative telephones used in the Valley Line LRT Stage 1;
 3. meet the Americans with Disabilities Act (ADA) for hearing aid compatible handset, with hands-free feature, for desktop or wall mount use; and
 4. are capable of internal calling and connecting to external parties through telephone system head-end equipment.
- V. Provide power to administrative telephones via PoE ports on network switches backed by UPS.
- W. Provide Emergency Alarm Stations (EAS) telephones with the functionality of “Blue Light Stations”, as defined in NFPA-130, at:
1. each end of the WEM Station Platform;
 2. each end of the Misericordia Station Platform; and
 3. each end of the 87 Avenue Elevated Guideway.
- X. Provide EAS and enclosures that are the same part numbers as those in Valley Line LRT Stage 1.
1. Mount EAS within a weather resistant enclosure with a hinged door with a latch that is inaccessible to the public;
 2. Provide power to EAS phones via PoE ports on network access switches backed by UPS;
 3. Identify the location of the EAS phone at the operator workstation when the handset is removed from the handset cradle;
 4. Configure the EAS to auto-dial the OMF when the handset is removed and provide visual indication of call status to the operator; and
 5. Provide a Manufacturer Warranty for EAS phones for a minimum of five (5) years.
- Y. Provide Blue Light Telephones (BLT):
1. at each Stop and Station;
 2. at Lewis Farms Park and Ride, the manufacturer and model of which to be specified by the city at the second Interim Design review;
 3. at WEM Transit Centre;
 4. that are consistent with those in Valley Line LRT Stage 1;

5. that are clearly visible, ADA compliant, and hands-free devices, equipped with a distinctive push button;
 6. that are configured to automatically connect through telephone system head-end equipment to the ETS Transit Security Control Centre when activated;
 7. that indicate that the call is in progress but do not provide a dial tone;
 8. that are configured with the CCTV Systems and Telephone Systems to automatically trigger the associated CCTV camera(s) to display live video images of the location to the ETS Transit Security Control Centre workstation upon activation of a BLT;
 9. that are powered via PoE ports on network access switches backed by UPS;
 10. that are configured to time-out after nine (9) minutes if not properly hung up;
 11. provide a Manufacturer Warranty for BLTs for a minimum of five (5) years; and
 12. provide hearing loops for hearing aid compatibility; and
 13. provide self testing functionality.
- Z. Provide public washroom access phones:
1. outside all public washroom facilities;
 2. that are the consistent with those in Valley Line LRT Stage 1;
 3. that are ADA compliant hands-free devices, equipped with a distinctive push button;
 4. that are powered via PoE ports on network access switches backed by UPS;
 5. that are configured to automatically connect through telephone system head-end equipment to the ETS Transit Security Control Centre when activated;
 6. that are configured to time-out after two (2) minutes if not properly hung up; and
 7. provide a Manufacturer Warranty for public washroom access phones for a minimum of five (5) years.
- AA. Provide washroom emergency phones:
1. for the public on the inside wall of all public washroom facilities located within arm's reach of the toilet fixture;
 2. for the operator on inside wall of all operator washroom facilities;
 3. that are the consistent with those in Valley Line LRT Stage 1;
 4. that are clearly visible ADA compliant hands-free devices equipped with a distinctive push button;
 5. that are powered via PoE ports on network access switches backed by UPS;
 6. that are configured to automatically connect through telephone system head-end equipment to the ETS Transit Security Control Centre for public and ETS operator emergency phones;
 7. that are configured to automatically connect to the OCC for LRT operator emergency phones;

8. that are configured to time-out after nine (9) minutes if not properly hung up; and
 9. provide a Manufacturer Warranty for washroom emergency phones for a minimum of five (5) years.
- BB. Provide elevator emergency phones:
1. in each elevator;
 2. with a VoIP terminal adapter in each elevator closet;
 3. that are configured to automatically connect through telephone system head-end equipment to the ETS Transit Security Control Centre;
 4. that are configured to time-out after nine (9) minutes if not properly hung up;
 5. that interface using CAT6 cable to the VoIP terminal adapter; and
 6. provide a Manufacturer Warranty for Elevator emergency phones for a minimum of five (5) years.
- CC. Provide entrance access phones:
1. located at the:
 - a. entrance to each Utility Complex;
 - b. Lewis Farms Storage Facility yard entrance;
 - c. Lewis Farms Storage Facility Building front door;
 - d. Lewis Farms Storage Facility Building delivery entrance;
 - e. Gerry Wright OMF Building B building front door; and
 - f. Gerry Wright OMF Building B building delivery entrance.
 2. that are powered via PoE ports on network access switches backed by UPS; and
 3. provide a Manufacturer Warranty for entrance access phones for a minimum of five (5) years.
- DD. Provide signage for all public phones (emergency, elevator help and washroom access) in English and Braille following the method used in Valley Line LRT Stage 1 as a guideline.
- EE. Provide space in locked cabinets for any additional voice recording storage devices required in the Data Centre(s), accessible only to authorized City Persons.
- FF. Key any locked cabinets for any additional voice recording storage devices using the same key management scheme used in Valley Line LRT Stage 1.
- GG. Provide all keys to locked cabinets for any additional voice recording storage devices to the City's Representative.
- HH. Configure the Voice Recording System to time stamp all recordings using the Master Clock system.
- II. Collect and store all information recorded by the telephone system in compliance with the requirements of Schedule 18 [*Freedom of Information and Privacy Protection*] and all Applicable Laws, including the *Freedom of Information and Protection of Privacy Act* (Alberta).

JJ. For Quality Assurance:

1. provide only telephone instruments registered under FCC Regulations, 47 CFR, Part 68 and that comply with UL1459 (UL/CSA 60950);
2. provide only telephone instruments compliant with ADA;
3. design and install all telephones in accordance with the most current ADA Standards for Accessible Design, 28 CFR Part 36;
4. provide only telephone instruments that meet local codes and/or regulations for emergency operation as established by the entity having jurisdiction;
5. provide all grounding in accordance with local standards. Ground each piece of equipment in accordance with the recommendations of the manufacturer; and
6. do not provide or use discontinued product models, refurbished equipment, or products scheduled for end-of life, end-of-sale, or end-of-service within two (2) calendar years of the Construction Completion Date.

KK. For field tests and inspections:

1. perform network performance tests for the individual telephone instruments:
 - a. verify voice telephone communications demonstrates a minimum mean opinion score of 4.0 for both calls within the system and external to the system;
 - b. verify the network demonstrates an end to end latency of less than 100 ms between each end telephone and the telephone server;
 - c. perform functional testing;
 - d. verify successful operation of a test call to each telephone;
 - e. verify full-duplex two-way communication once call is connected;
 - f. verify both standard ringing and call connection features upon incoming test call to the instrument;
 - g. verify disconnect function for each telephone; and
 - h. verify caller ID for all telephones; and
2. perform checking and verification activities relating to individual components, sub-systems, software, Equipment and facilities associated with the telephone system that are required prior to Commissioning and that are necessary to demonstrate the fully integrated operation and successful Commissioning of the telephone system.

LL. For end-to-end system testing:

1. verify off-hook dial tone, dialing, signaling, loop closure, and call connection of instruments during test calls placed to and from the OCC, ETS Transit Security Control Centre, and the City 311 call centre by:
 - a. placing test calls using the manual keypad or programmed autodial call buttons, depending on the type of telephone; and

- b. using actual programmed auto-dial number(s) to test telephones with this capability;
- 2. verify all secondary number(s) programmed for auto-dial operation are functional in the event of primary line non-availability;
- 3. verify full-duplex two-way communication once call is connected;
- 4. functionally verify audio performance of instrument during test call. Set transmission level points for specified audio levels;
- 5. verify standard ringing or splash-tone upon incoming call to the instrument;
- 6. verify silent monitoring function upon incoming call to the instrument;
- 7. verify proper operation of all disconnect functions initiated by the control center and that calls cannot be disconnected by pressing the Emergency call button on the telephone;
- 8. verify remote password protection and programming capability;
- 9. verify operation of ADA call acknowledgement visual indication; and
- 10. verify, from the ETS Transit Security Control Center and the OCC, that the on-demand identification of the calling instrument, including correct circuit identification and telephone location for all new telephones displays upon an incoming call.

6-1.14 BUILDING SCADA SYSTEM

6-1.14.1 System Specific Reference Standards

- A. Design, construct and test the Building SCADA system in compliance with the latest revisions and applicable sections of the following codes and standards.
 - 1. National Fire Code Alberta Edition Fire Code 2014;
 - 2. Canadian Electrical Code;
 - 3. Alberta Occupational Health and Safety (OH&S) Act; and
 - 4. NFPA 130.

6-1.14.2 Building SCADA

- A. Provide a Building SCADA system to centrally monitor and control conditions within the Building Structures including the Lewis Farms Storage Facility Building, Gerry Wright OMF Building B, Stations, and Utility Complexes. The requirements of this Section 6-1.14 [*Building SCADA System*] do not apply to the Traction Power SCADA System.
- B. Not Used.
- C. Provide Building SCADA system equipment comprised of the following equipment:
 - 1. sensors and actuators;
 - 2. field RTUs and PLCs;
 - 3. redundant PLC control and power supplies;

4. hot swappable SCADA cards;
 5. Building SCADA system data storage;
 6. Building SCADA system systems servers and workstation;
 7. Building SCADA headend and operator software; and
 8. associated cabling and terminations.
- D. Provide a Building SCADA system for the Valley Line LRT Stage 2 that is able to be controlled from a single HMI platform with the primary location in the Gerry Wright OMF Building A and a backup location in the Lewis Farms Storage Facility Building.
- E. Provide a SCADA headend HMI at the Lewis Farms Storage Facility and Gerry Wright OMF Building B.
- F. The Building SCADA System shall be designed to facilitate all control and monitoring functions that can be integrated into a future IP based ICS;
1. include the electrical and functional interface requirements of the Building SCADA system for ICS integration in the ICS Interface Control Document.
- G. Provide new Building SCADA servers and data storage to provide redundancy across the entire Valley Line LRT to continue full functionality and allow for no loss of data in the event of a loss of a Data Centre, and provide full Building SCADA functionality for Valley Line LRT Stage 2;
1. Provide sufficient Building SCADA capacity for all control and monitoring points to allow for future integration with the Valley Line LRT Stage 1 building SCADA system in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*].
- H. Submit an Integration plan for the integration of Building SCADA system with the Building SCADA system deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**Building SCADA System Integration Plan**”).
- I. Configure the Building SCADA system to use the existing primary and secondary Master Clocks.
- J. Provide the ability to operate the Building SCADA system from a backup location in the Lewis Farms Storage Facility Building.
- K. Provide a Building SCADA system that monitors each of the following:
1. elevators;
 2. escalators;
 3. HVAC systems;
 4. fire suppression & fire alarm;
 5. fire alarm health monitoring;
 6. building inside temperature;
 7. hydrogen sensors;
 8. sump pumps;

9. smoke control;
 10. flood sensing;
 11. high water level sensor on vaults for the Systems Duct Bank and the Traction Power Duct Bank; and
 12. any other condition to be monitored or controlled, as determined in accordance with the Safety and Security Certification Program and the RAM Program;
 13. power distribution system; and
 14. building power distribution system.
- L. Provide power to field RTUs and PLCs backed by UPS.
- M. Interface field RTUs and PLCs to the CTS located in the nearest communications cabinet or closet.
- N. Provide Building SCADA system functionality that includes:
1. data historian application with remote-user-configurable querying and report generation with a minimum of one (1) year storage of alarms and events;
 2. control;
 3. monitoring;
 4. reporting;
 5. prioritized alarming;
 6. time stamped data logging;
 7. remote command; and
 8. capable of integration with the ICS.
- O. Conduct testing to verify:
1. device calibration;
 2. dip switch and jumper settings;
 3. each field RTU and PLC is to be automatically operational when powered;
 4. all I/O points have been configured and wired correctly;
 5. all monitoring and control functions act as designed; and
 6. all HMI functionality acts as designed.
- P. Provide a Manufacturer Warranty for the Building SCADA system for a minimum of five (5) years.
- Q. With the first Interim Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim Building SCADA Design Package**”):

1. a detailed description of the Building SCADA system;
 2. preliminary drawings for the Building SCADA system; and
 3. a qualification test plan for the Building SCADA system.
- R. With the second Interim Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used on the Building SCADA system (the “**Second Interim Building SCADA Design Package**”).
- S. With the Final Design submission for the Communication Systems as defined in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final Building SCADA Design Package**”):
1. the qualification test reports for the Building SCADA system; and
 2. updated drawings, specifications, designs and plans for the Building SCADA system.

6-1.15 SECURITY AND ALARM SYSTEM

- A. Provide a security and alarm system that is compatible with and provides the same functionality as the security and alarm system used in the Valley Line LRT Stage 1 within the Building Structures including the [REDACTED], [REDACTED], Stations, and Utility Complexes.
- B. Provide the security and alarm system comprised of the following equipment:
1. smart card readers;
 2. request-to-exit detectors;
 3. door contacts;
 4. electrified lock sets;
 5. motion detectors;
 6. smoke detectors;
 7. heat detectors;
 8. Access Control Panels;
 9. security alarming, including door intrusion detection;
 10. management software; and
 11. associated cabling and terminations.
- C. Submit a PICO test plan for the security and alarm system components not less than 90 days before application of the plan, detailing step by step operations (the “**Security and Alarm System PICO Test Plan**”).
- D. Obtain approval for a PICO test plan for the security and alarm system components.
- E. Interface Access Control Panels to the CTS through the nearest network access switch.

- F. Provide the security and alarm system that is IP-based and centrally managed via the future [REDACTED].
- G. Include the electrical and functional interface requirements of the security and alarm system for [REDACTED] integration in the [REDACTED].
- H. Provide a single interface to access the integrated security and alarm systems from both Valley Line LRT Stage 1 and Valley Line LRT Stage 2.
- I. Submit an integration plan for the integration of security and alarm systems with the security and alarm systems deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**Security and Alarm Systems Integration Plan**”).
- J. Integrate the security and alarm system with the security and alarm system deployed on Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*].
 - 1. There shall be no impacts to the operation of the Valley Line LRT Stage 1 during implementation.
- K. Configure the security and alarm system to use the existing primary and secondary Master Clocks.
- L. Configure the centrally managed card access system per design discussions with the City to provide the Operator with restricted entry and intrusion detection for each protected area, including:
 - 1. all Utility Complexes, including TPSS buildings, signal rooms, communications rooms, and electrical rooms;
 - 2. one (1) exterior entrance at each Station for after-hour access;
 - 3. all non-publicly accessible areas of Stations;
 - 4. Stop shelter doors for after-hour access;
 - 5. Operator Washrooms at Stops;
 - 6. [REDACTED]; and
 - 7. [REDACTED].
- M. Provide access card readers and all associated infrastructure, interfaced directly with the City’s C-Cure card access system per design discussions with the City for City personnel restricting entry to:
 - 1. City Communication Room at the [REDACTED];
 - a. including all associated entrances to provide City access to the City Communication Room from the exterior of the [REDACTED];
 - 2. Retail Kiosk at WEM Station;
 - a. including all associated entrances to provide City access to the Retail Kiosk from the exterior of the WEM Station; and
 - 3. Security Office at WEM Station;
 - a. including all associated entrances to provide City access to the Security Room from the exterior of the WEM Station;

to be administered by City. Notify the City once the card readers are installed and tested in accordance with manufacturer's requirements, and provide such assistance as may be reasonably requested by the City to integrate the card readers with the City's C-Cure card access system, in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- N. Provide security alarming, including door intrusion detection, automatically reported to the ICS;
 - 1. Any use of a key where card access system is active shall be alarmed and automatically reported to the ICS.
- O. Send all status and alarm signals directly to the security and alarm system for processing.
- P. Design the security and alarm system such that intrusion sensors for unauthorized entry or tampering to security and alarm system equipment shall sound an audible alarm locally, initiate indoor and outdoor building lights, and trigger an automatic alarm notification to the ICS.
- Q. Provide public washroom access by means of:
 - 1. remotely activated door locks controlled from the ETS Transit Security Control Centre;
 - 2. an indicator light located at each washroom doorway to indicate which door has been remotely unlocked;
 - 3. single occupancy washrooms lockable from the inside using a thumb latch which shall not be released by the remote door lock;
 - 4. an exterior lit "Occupied" sign for single occupancy washrooms, located near the washroom doorway and activated by motion sensor inside the washroom. The sign shall be visible to the ETS Transit Security Control Centre via CCTV; and
 - 5. an automatic door paddle located adjacent to the door inside the washroom allowing the remote lock to automatically release once the paddle is pressed. For single occupancy washrooms, the thumb latch shall also release once the door handle is turned.
- R. Design and implement the security and alarm system to ensure that all access decisions/credential transactions are processed locally at the card reader interface board as it receives data from the system controller, minimizing network traffic while also providing real-time access determinations.
- S. Design and implement the security and alarm system to incorporate an interface to the fire alarm panel to allow override of door locks in an emergency situation. Ensure that any door lock that restricts egress is code compliant and includes approved hardware and signage.
- T. Interlock door security and access controls with the fire alarm systems in accordance with the NBCAE.
- U. Design and implement the security and alarm system in a way that all access-controlled doors are monitored by the CCTV System.
- V. Interface the security and alarm system with the CCTV system to allow the display of video on the CCTV system upon activation of an access control alarm or use of an access control device.
- W. Design and implement the security and alarm system to ensure that in the event of a power outage, access control equipment remains operational for a minimum of four (4) hours through the use of uninterruptible power supplies, generators, batteries, and/or other backup power equipment.

- X. Provide security motion detectors and annunciate occupancy conditions to the ETS Transit Security Control Centre inside all public washrooms and the ETS operator washrooms.
- Y. Provide separate conduit for all security system components.
- Z. Provide concealed conduits in public areas.
- AA. Provide capability to allow automated disabling of alarm functions in public areas, based on pre-set occupancy schedules.
 - 1. Provide a minimum of one smoke and heat detector for each Utility Complex electrical room, communications room, and signal room, which shall be tied to the fire alarm panel in the nearest TPSS, as described in Table 6-2-1: Mainline *TPSS Minimum*] of this Schedule; and
 - 2. Provide a display at operators' workstations that automatically display the status all of these security and alarm points.
- BB. Perform integration tests on the security and alarm system including the following:
 - 1. Functionality tests to prove the functionality as described in item Section 6-1.15 [*Security and Alarm System*] of this Schedule.
- CC. Provide a Manufacturer Warranty for the security and alarm system for a minimum of five (5) years.
- DD. With the first Interim Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the "**First Interim Security and Alarm System Design Package**"):
 - 1. a detailed description of the security and alarm system;
 - 2. preliminary drawings for the security and alarm system; and
 - 3. a qualification test plan for the security and alarm system.
- EE. With the second Interim Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used on the security and alarm system (the "**Second Interim Security and Alarm System Design Package**").
- FF. With the Final Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the "**Final Security and Alarm System Design Package**"):
 - 1. the qualification test reports for the security and alarm system; and
 - 2. updated drawings, specifications, designs and plans for the security and alarm system.

6-1.16 NETWORK MANAGEMENT SYSTEM

- A. Assess the capability of the Stage 1 Network Management System (NMS) to determine if it is able to accommodate all Valley Line LRT Stage 2 network connected switches, servers, and end devices.
- B. Upgrade the existing Valley Line LRT Stage 1 NMS If it is determined that the existing Valley Lines LRT Stage 1 NMS cannot handle the required additional Valley Line LRT Stage 2 network components.

- C. Integrate all network connected switches, servers, and end devices into the Valley Line LRT Stage 1 NMS to provide the same functionality.
- D. Submit an integration plan for all network connected switches, servers, and end devices into the NMS deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**NMS Integration Plan for Switches, Servers and End Devices**”).
- E. Provide an NMS that includes disaster recovery through the use of NMS redundancy to protect against switch, network device or equipment failure, or any Valley Line LRT network failure.
- F. Submit an NMS plan for integrating Valley Line LRT Stage 1 and Valley Line LRT Stage 2 network components not less than 90 days before application of the plan, detailing step by step operations (the “**NMS Integration Plan for Network Components**”).
- G. Integrate and commission the network connected devices into the NMS of Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- H. Ensure the NMS uses the existing primary and secondary Master Clocks.
- I. Configure the NMS to provide the following functionality:
 - 1. central monitoring of all network connected devices;
 - 2. discovery of new plug-in applications and custom applications that need monitoring, and to support the management of multiple instances of an application;
 - 3. application status polling to continuously monitor discovered applications to check their status and ensure optimal functioning;
 - 4. host resource monitoring for usage criteria such as CPU, memory, disk utilization and system loading for all discovered devices on the network;
 - 5. user defined alarm and event handling with real-time email and text message notification;
 - 6. remote I/O monitoring;
 - 7. diagnostics;
 - 8. fault reporting; and
 - 9. event registration.
- J. Perform integration tests of the NMS including functionality tests to prove the functionality as described in Section 6-1.16I [*Network Management System*] of this Schedule.
- K. Include the electrical and functional interface requirements of the NMS for ICS integration in the ICS Interface Control Document.
- L. Submit a detailed description of the NMS with the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**First NMS Interim Design Submission**”).
- M. Submit specifications of the components to be used on the NMS with the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Second NMS Interim Design Submission**”).

- N. Submit updated designs for the NMS with the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Final NMS Design Submission**”).

6-1.17 TICKET VENDING MACHINE INFRASTRUCTURE

- A. Provide TVM infrastructure at each Stop, Station and the WEM Transit Centre as defined below.
- B. Provide spaces for TVMs of dimensions 1905 mm (height) x 915 mm (width) x 635 mm (depth) and Validators of dimensions 1335 mm (height) x 315 mm (width) x 315 mm (depth) in accordance with Section 5-2.6.11 [*Passenger Interface Equipment*] of this Schedule:
 - 1. the base cabinet footprint for the TVM shall not be raised and shall be 890 mm (width) x 407 mm (depth). A total clearance of 1438 mm (depth) x 1454 mm (width) shall be provided for each TVM. Each TVM shall be centered relative to the width of the clearance, and abutting the relative rear of the clearance to allow the TVM cabinet door to open fully with a 100mm clearance behind the TVMs; and
- C. Provide conduit stub up(s) extending 60 mm from the finished floor surface within the footprint of the TVM cabinet positioned centered relative to the depth of the cabinet and from the back of the TVM as shown in Figure 5-2.6.11.2 [*TVM Baseplate requirements*].
- D. Provide a 120V 20A circuit in an embedded conduit, left unenergized (with 1 m coiled ends until City performs final TVM installation), in compliance with the CEC, to each TVM cabinet stub up from the nearest Level 1 “Emergency” load centre.
- E. Provide a dedicated 19 mm embedded conduit to the TVM cabinet stub up from the ETS LAN Cabinet.
- F. Provide dedicated 19 mm embedded conduit from the ETS LAN Cabinet to each Validator location.
 - 1. Terminate conduit at each Validator location with 60 mm stub up centered at Validator location. All conduits extending into each Validator shall fit within a 70 mm pole diameter.
- G. Install outdoor rated CAT-6 and 12 strand SM 100W hybrid fibre cabling from the ETS LAN Cabinet through the embedded conduits to each TVM and Validator location.
- H. Provide embedded conduit, which may be daisy chained, from the nearest Level 1 “Normal” load centre, extending to and terminated with 60 mm stub up at every Validator location to allow future City installation of electrical cable.
 - 1. The conduit capacity shall be designed to allow sufficient electrical cabling to energize up to nine (9) 120V AC, 30 W heater loads concurrently in compliance with the CEC.
- I. Provide a minimum 120V 15A circuit in an embedded conduit, left unenergized (with 1 m coiled ends until City performs final Validator installation), in compliance with the CEC, to each Validator stub up from the nearest Level 1 “Emergency” load centre
- J. Provide an insulated ground wire sized as required by the system short circuit analysis from the Station / Stop ground grid to each TVM and Validator, extending and coiled 600 mm from the floor, positioned so that it will extend directly into interior of the TVM/Validator.
- K. Provide two (2) pairs of contact wires from each TVM, for City to terminate to TVM door open and equipment malfunction sensors located within each TVM. Upon sensing of an open contact, automatically trigger the associated CCTV camera(s) to display live video images of the TVM location to the ETS Transit Security Control Centre workstation.

- L. Promptly following installation of all TVM and Validator spaces, and associated cabling and conduits at each Stop, Station and the WEM Transit Centre, provide notice to the City and provide the City with access to the spaces and associated infrastructure in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.18 Screens and Signage

- A. Provide the infrastructure required for the screens and signage infrastructure at each Stop, Station and WEM Transit Centre as described in Section 5-2.4 [*Signage*] and 5-2.6 [*Platforms and Platform Amenities*] of this Schedule.
- B. Notify and provide access to the City once all the infrastructure required for screens and signage as described in this Section 6-1.18 [*Screens and Signage*] of this Schedule are available, in accordance with Section 1-1.3 [*City Works*] of this Schedule.

6-1.18.1 ETS TV Screens

- A. Provide two (2) NEMA 4X rated 100 mm x 100 mm surface mounted junction boxes at each ETS TV screen enclosure location, as required by Section 5-2.6.11.6 [*ETS TV Screens*] of this Schedule;
 - 1. the junction boxes shall both be readily accessible to facilitate the future installation of ETS TV screens and ETS TV screen enclosures by the City.
- B. Provide a concealed 25 mm EMT conduit from one junction box at each ETS TV screen enclosure location to the nearest concrete surface and extend through 25 mm embedded conduit to the ETS LAN Cabinet.
- C. Install and terminate outdoor rated CAT-6 and 4 strand SM 100W hybrid fibre cabling from the ETS LAN Cabinet through the embedded and concealed conduits to the junction box at each ETS TV screen end.
- D. Provide a 120V 20A circuit in concealed EMT conduit from the other junction box at each ETS TV screen enclosure location to the nearest concrete surface and extend through embedded conduit to the nearest "Normal" electrical load centre;
 - 1. terminate the circuit at a duplex receptacle internal to the junction box.
- E. Provide an insulated ground wire sized as required by the system short circuit analysis from the Station / Stop ground grid to each ETS TV screen enclosure.

6-1.18.2 Corporate Advertising Screens

- A. Provide 25 mm embedded conduit from each corporate advertising screen, placed in accordance with Section 5-2.6.11.7 [*Corporate Advertising Screens*] of this Schedule, to the ETS LAN Cabinet.
- B. Install one (1) outdoor rated CAT-6 and one (1) 4-strand SM hybrid fibre cable from the ETS LAN Cabinet through the embedded and concealed conduits to each ETS screen enclosure.
- C. Provide a 120V 20A circuit in concealed 65 mm EMT conduit from each corporate advertising screen to the nearest concrete surface and extend through 65 mm embedded conduit to the nearest "Normal" electrical load centre.
- D. Provide an insulated ground wire sized as required by the system short circuit analysis from the Station / Stop ground grid to each corporate advertising screen location.

6-1.18.3 Global Wayfinding

- A. Provide 25 mm embedded conduit from each Global Wayfinding Map, placed in accordance with Section 5-2.6.11.5 [*Global Wayfinding Maps*] of this Schedule, to the ETS LAN Cabinet.
- B. Provide a 120V 20A circuit in embedded 19 mm conduit from each Global Wayfinding Map to the nearest "Normal" electrical load centre.
- C. Provide an insulated ground wire sized as required by the system short circuit analysis from the Station / Stop ground grid to each Global Wayfinding Map location.
- D. Install outdoor rated CAT-6 cables from the ETS LAN Cabinet through the embedded and concealed conduits to each Global Wayfinding Map

6-1.19 AUTOMATIC GRADE CROSSING WARNING SYSTEMS

- A. Provide the necessary clearances for future installation of Automatic Grade Crossing Warning Systems, designed in accordance with Section 6-1.19 [*Automatic Grade Crossing Warning Systems*] of this Schedule, at the following locations:
 - 1. Lewis Farms Park and Ride gravel parking area access;
 - 2. Anthony Henday Drive Northbound ramp; and
 - 3. Anthony Henday Drive Southbound ramp,

so that the Automatic Grade Crossing Warning Systems can be constructed without obstructing or requiring re-alignment of any Track, road lanes or SUPs.

- B. If after the Effective Date, the City or Alberta Transportation requires the installation of an Automatic Grade Crossing Warning System, such system shall:
 - 1. operate such that any failure of the Grade Crossing warning device shall automatically activate the red flashing lights and cause all equipped gate arms to descend;
 - 2. be designed in accordance with *Transport Canada Grade Crossings Standards, July 2014*, except as modified herein;
 - 3. be activated by an audio frequency Track Circuit or wheel counters placed to allow adequate warning time for approaching Trains in accordance with AREMA C&S Manual Part 3.3.10, *Recommended Instructions for Determining Warning Time and Calculating Minimum Approach Distance for Highway-Rail Grade Crossing Warning Systems*;
 - 4. be designed to provide a call on signal to provide crossing warning system activation status to the Train Driver;
 - 5. have all associated equipment housed in Wayside Equipment Enclosures meeting the requirements of Section 6-1.6 [*Wayside Equipment and Enclosures*] of this Schedule;
 - 6. be energized directly from a Vital DC operating bank. The operating bank shall consist of an AC charging rectifier and a standby battery bank. The AC charging rectifier shall be rated for sufficient amperage to continuously operate the activated Grade Crossing warning system without relying on battery bank reserves. The battery bank shall be rated at adequate capacity to operate all activated Grade Crossing warning equipment for a period of at least eight (8) hours in the event of AC power loss;

7. have each Vital operating bank isolated from earth ground and all other DC power sources. Power off or ground fault conditions shall be alarmed to the ICS and LCP;
 8. have gate mechanisms that:
 - a. are of a service proven model and version with a demonstrated capability to provide the number of activations associated with operation of the Valley Line LRT Stage 2 as defined in the Operability and Maintainability Parameters; and
 - b. comply with AREMA C&S Manual Part 3.2.13, Recommended Design Criteria for Gate Arm Operating Mechanism for Highway-Rail Grade Crossing Warning Device;
 9. be designed such that if a second Train will arrive at the Grade Crossing within 10 seconds after the first Train clears, the gate arms shall remain in the lowered position;
 10. include a Pre-emption interface to the associated Traffic Controller to coordinate Train, vehicular and pedestrian movements through the Grade Crossing. The traffic signal timings for Pre-emption shall be provided on the final Traffic Signal Timing Sheets as defined in Section 6-4.3.11 [*Traffic Signal Timing Plans*] of this Schedule;
 11. include an external switch on each applicable Wayside Equipment Enclosure that can be used to manually activate the crossing gate equipment. The switch shall require a key for access/operation and shall be situated such that the switch operator has a clear view of the crossing signals it controls. The switch shall be equipped with an additional position which shall allow for the complete deactivation of the Automatic Grade Crossing Warning System. Provide a means to ensure the switch cannot be inadvertently left in the deactivation position and alarm the deactivation condition to the ICS and LCP; and each crossing warning location is equipped with a pair of switches that can be used to manually activate or deactivate the crossing warning devices on a “per track” basis; and
 12. include a means to delay crossing warning activation for a Train that is held at a Stop or Station, as required in advance of Grade Crossings that are subject to the requirements of Section 6-4.5 [*Transit Signal Priority*] of this Schedule, until the associated Traffic Controller has released the Hold in Station condition.
- C. For clarity, Automatic Grade Crossing Warning Systems are not included in the scope of the Project Work as of the Effective Date.

6-1.20 PUBLIC ADDRESS/VARIABLE MESSAGE SIGNS

- A. The Public Address/Variable Message Sign (PA/VMS) system consists of:
1. PA/VMS system to provide coverage of Stops, Stations, the Lewis Farms Storage Facility, Gerry Wright OMF Building B to be integrated into the Valley Line LRT Stage 1 system in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule; and
 2. Future provisions for the ETS Passenger Information system to service the VMS installed at WEM Transit Centre in accordance with Section 6-1.20.3 [*ETS Passenger Information*] of this Schedule.

6-1.20.1 System Specific Reference Standards

- A. Design and construct the PA/VMS system in accordance with the following standards:
1. NFPA 130, Standards for Fixed Guideway Transit Systems;
 2. International Electrotechnical Commission (IEC);

3. 60268-16 - Objective Rating of Speech Intelligibility by Speech Transmission Index;
4. Canadian Electrical Code (CEC);
5. CSA Standards;
6. Electrical & Electronic Manufacturers Association of Canada (EEMAC) Standards;
7. Electronic Industries Alliance/Telecommunications Industries Associations (EIA/TIA);
8. EIA/TIA RS160-51 – Sound Systems;
9. EIA/TIA SE103-49 – Speakers for Sound Equipment;
10. IEEE – C62.41 Surge Voltages in Low – Voltage AC Power Circuits; and
11. Underwriters Laboratories of Canada (ULC) Standards:
 - a. UL 48 – Standard for Safety Electric Signs; and
 - b. UL 1433 – Standard for Safety Control Centres for Changing Message Type Electric Signs.

6-1.20.2 PA/VMS System

- A. Provide a PA/VMS system that can be integrated with the system and provides the same functionality as the PA/VMS system used in the Valley Line LRT Stage 1.
- B. The PA/VMS system is comprised of the following equipment:
 1. PA amplifiers;
 2. ambient noise sensors;
 3. paging microphones;
 4. remote microphones;
 5. fireman microphones;
 6. ceiling speakers;
 7. surface mount speakers;
 8. horn speakers;
 9. Variable Message Signs;
 10. associated cabling and terminations; and
 11. hearing loops design to IEC 60118-4 on all stops and station platforms at locations to be Accepted by the City.
- C. Submit an integration plan for the integration of PA/VMS system with the PA/VMS system deployed in Valley Line LRT Stage 1, not less than 90 days before application of the plan, detailing step by step operations (the “**PA/VMS Integration Plan**”).
- D. Configure the PA/VMS system to use the existing primary and secondary Master Clocks.

- E. Design and implement the PA/VMS system to maintain the spare recording capacity ratio of Valley Line LRT Stage 1 for the combined Valley Line LRT PA/VMS.
- F. Integrate and configure the PA/VMS system with the PA/VMS system deployed in Valley Line LRT Stage 1 to provide full functionality for the Valley Line LRT, minimize impacts to the operation of the Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.
- G. Perform integration tests on the PA/VMS system including the following:
 - 1. functionality tests to prove the functionality as described in item Section 6-1.20.2 [*PA/VMS System*] of this Schedule.
- H. Provide a PA/VMS system that enables the broadcast of live announcements and pre-recorded announcements at each Stop, Station, Utility Complex, the Lewis Farms Storage Facility Building, Gerry Wright OMF Building B, the WEM Transit Centre and locations in Valley Line LRT Stage 1.
- I. Provide a PA/VMS system such that live announcements can be made from microphones in the Lewis Farms Storage Facility Building, Gerry Wright OMF Building A and B, locations in Valley Line LRT Stage 1, the ETS Transit Control Centre as well as from authorized telephones.
- J. Configure the PA/VMS system to be centrally managed via a future Integrated Control System (ICS) from the Lewis Farms Storage Facility Building and Gerry Wright OMF Building A.
 - 1. Include the electrical and functional interface requirements of the PA/VMS for ICS integration in the ICS Interface Control Document.
- K. Provide interfaces from the PA/VMS system station equipment to the PA/VMS system managers.
- L. Provide the ability to operate the PA/VMS system from the Lewis Farms Storage Facility Building, in addition to the Gerry Wright OMF Building B and ETS Transit Security Control Centre.
- M. Ensure that the PA/VMS system integrates with the existing Human Machine Interface (HMI) which shall serve as the means of interface between the system and the operator.
- N. Configure pre-recorded announcements to be initiated from the TRPS and the ICS and triggered using head end equipment to initiate messages sent to the PA system based on the train locations.
- O. Provide the functionality of the Valley Line LRT Stage 1 PA/VMS system throughout the combined Valley Line LRT.
- P. Provide notice to the City and provide the City with access to the PA subsystem in accordance with Section 1-1.3 [*City Works*] of this Schedule promptly following installation and testing of the remote access to the PA/VMS system.
- Q. Provide PA/VMS infrastructure and equipment supporting:
 - 1. zoning such that messages can be directed to either a single or any user selectable combination of Stops, Stations and the WEM Transit Centre within the Valley Line LRT;
 - 2. monitoring and remote diagnostics, including automatic fault finding, detection of open or shorted speakers and failure of VMS within the Valley Line LRT; and
 - 3. full functionality under all environmental conditions applicable to the location at which the infrastructure and equipment is installed.

- R. Configure the PA/VMS system to:
1. provide related audible and text messages that are displayed and played to the public simultaneously;
 2. allow unrelated audible and text messages to be transmitted independently of each other; and
 3. provide PA zoning, allowing for all-zone, configurable zone groups and individual zone selection capability.
- S. Configure the VMS subsystem to display predetermined, ad-hoc (from typed input), and automated (pre-programmed inputs from the TRPS and the ICS) text messages.
- T. Design the VMS subsystem such that each Stop or Station has one VMS zone for each track.
- U. Configure the PA subsystem: to broadcast predetermined, ad-hoc (operator entered or from typed input), and automated (based on inputs from the TRPS and the ICS) audible messages.
- V. Design the PA subsystem such that
1. each of the Stop or Station has one zone per platform; and
 2. the WEM Transit Centre is a single zone.
- W. Configure the PA/VMS system to prioritize message types such that live messages from the ETS Transit Security Control Centre have the highest priority, live messages from the operator have the second priority, ad hoc messages (from typed input) third priority, automated messages fourth priority, and pre-recorded messages the lowest priority, subject to the requirements of NFPA-72.
- X. Configure the PA/VMS system such that higher priority messages Pre-empt lower priority messages, with a user configurable option to continue a Pre-empted message or not, subject to the requirements of NFPA-72.
- Y. Provide a Manufacturer Warranty for the PA amplifiers and Variable Message Signs for a minimum of five (5) years.
- Z. With the first Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**First Interim PA/VMS Design Package**”):
1. a detailed description of the PA/VMS;
 2. preliminary drawings for the PA/VMS; and
 3. a qualification test plan for the PA/VMS.
- AA. With the second Interim Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit specifications for the components to be used on the PA/VMS (the “**Second Interim PA/VMS Design Package**”).
- BB. With the Final Design submission for the Communication Systems as described in Appendix 4B [*Project Specific Submission Requirements*], submit at minimum (the “**Final PA/VMS Design Package**”):
1. the updated drawings, specifications, designs and plans for the PA/VMS; and
 2. the qualification test reports for the PA/VMS.

CC. Synchronize all time dependent PA/VMS events with the Master Clock system.

6-1.20.2.2 Variable Message Signs

- A. In accordance with Section 5-2.6.11.4 [*Variable Message Signs*] of this Schedule, provide Variable Message Signs (VMS) with a minimum 48 x 144 LED matrix array with two (2) lines of static text and third line scrolling capability.
 - 1. Minimum text height shall be 100mm. Words and numbers displayed on the VMS shall contrast with their background and not be red in colour.
 - 2. Each VMS shall have an integrated strobe light capable of signaling deaf patrons when a visual message is being broadcast.
 - 3. Enclosure shall be NEMA 4 rated.
 - 4. Each VMS shall be visible and legible under all lighting conditions.
- B. Configure VMS scrolling speed such that messages containing any Stop or Station names (which may be abbreviated) and any other complete words or messages are displayed for a minimum of two (2) seconds.
 - 1. Configure VMS horizontal scrolling speed to not exceed six (6) characters per second.
- C. Configure displayed text on VMS such that characters are displayed in lower case with capitalization, with ascenders and descenders having a minimum size ratio of 20% to upper case characters.
- D. Provide VMS at the locations specified in Section 5-2.6.11.4 [*Variable Message Signs*] of this Schedule.
- E. Configure the PA/VMS system such that each VMS, except those at Terminus Stops:
 - 1. provides information for Trains only on the Track it serves; and
 - 2. displays the status of the next two (2) revenue service Trains scheduled to arrive on the Track it serves, including Trip identifier, arrival time (accurate to within 30 seconds for the first Train to arrive, and 120 seconds for the second), arrival Track, and Train destination.
- F. Configure the PA/VMS system such that each VMS at Terminus Stops:
 - 1. provides information for Trains only on the Track it serves; and
 - 2. displays the status of the next two (2) revenue service Trains scheduled to depart from the Track it serves, including Trip identifier, departure time, departure Track and Train destination.
- G. Provide cabling from VMS to the CTS in concealed EMT conduit and/or embedded conduit.
- H. Interface each VMS to the CTS through the network access switch in the nearest communications cabinet.
- I. Design, supply, install and test the VMS subsystem infrastructure including conduits, mounting brackets, etc.
- J. Design, manage the interfaces, procure, install, conduct PICO, SAT, SIT, and Commission the VMS subsystem.

6-1.20.2.3 Public Address

- A. Provide a Public Address subsystem that complies with the most restrictive requirements of the City of Edmonton Community Standards Bylaw 14600 and of the audio requirements shown in Table 6-1.20.2.3 [*PA Subsystem Audio Requirements*] of this Schedule.

Table: 6-1.20.2.3: PA Subsystem Audio Requirements

Sound Levels	6-10 dBa above ambient noise levels
Typical Ambient Sound Pressure Levels (SPL) non-residential (7AM to 10PM)	75 dBa (+/- 2 dB) at 1.2 m above floor level.
Typical Ambient Sound Pressure Levels (SPL) non-residential (10PM to 7AM)	60 dBa (+/- 2 dB) at 1.2 m above floor level.
Typical Ambient Sound Pressure Levels (SPL) residential (7AM to 10PM)	65 dBa (+/- 2 dB) at 1.2 m above floor level.
Typical Ambient Sound Pressure Levels (SPL) residential (10PM to 7AM)	50 dBa (+/- 2 dB) at 1.2 m above floor level.
Reverberance Level	< 1.0 seconds @ 500 Hz
Overall System Hum and noise	< -70 dBm
Harmonic Distortion	< 2% measured at stated operating sound pressure levels and specified frequency response.
PA Subsystem Frequency Response	Uniform from 200Hz to 6000 Hz +/- 2 dB measured with a 1/3 octave broadband signal.
Automatic Gain and Compression	Speech levels from loudspeakers to public areas remain constant within +/- 2 decibels SPL
Speech Transmission Index Public Address (STIPA) Min Performance Value at Stops and Stations	>= 0.55
Speech Transmission Index Public Address (STIPA) Min Performance Value at the Lewis Farms Storage Facility Building and Gerry Wright OMF Building B	>= 0.55
Fail safe automatic muting function when not in use.	

- B. Submit a comprehensive acoustic analysis study with the Final Design submission for the Systems Integration and Commissioning as described in Appendix 4B [*Project Specific Submission Requirements*] of each Stop and Station within the Valley Line LRT Stage 2 to demonstrate the PA subsystem complies with the acoustic coverage and intelligibility requirements of this Section 6-1.20 [*Public Address/Variable Message Signs*] of this Schedule (each, a “**Coverage Study**”).

- C. Provide PA speakers at all Stops and Stations to provide uniform audio coverage (+/- 3 dB) at 1.2 meters above floor level over a minimum of 90% of each Passenger area.
- D. Provide the Station PA amplifiers and Utility Complex PA amplifiers with connectivity to the Gerry Wright OMF Building A and the Lewis Farms Storage Facility Building via the CTS.
- E. Provide redundant PA amplifiers at each Station or Stop to ensure continued operation in the event of an amplifier failure.
- F. Integrate the provided PA amplifiers with the PA/VMS system.
- G. Provide cabling from PA amplifiers to speakers in concealed EMT or embedded conduit.
- H. Provide an interface to the Stop and Station platform speakers from a PA amplifier in the nearest Utility Complex via speaker cables run between the Utility Complex and the Stop speakers.
- I. Station and Stop loudspeakers shall be driven as independent A/B strings from the redundant PA amplifiers.
- J. Provide ceiling speakers mounted flush in area with false ceilings of Valley Line LRT Stage 2.
- K. Provide surface mount speakers, with IP67 rating and able to operate to -40 °C, at Stations, Stops, the Lewis Farms Storage Facility Building and the Gerry Wright OMF Building B.
- L. Provide horn speakers, with IP67 rating and able to operate to -40 °C, in outdoor spaces, vehicle storage and shop areas at the Lewis Farms Storage Facility Building and Gerry Wright OMF Building B.
- M. Provide PA amplifiers at Utility Complexes to service Stops equipped with automatic gain control interfaced with Ambient Noise Sensors (ANS) that are operator configurable.
- N. Provide PA amplifiers at Stations equipped with automatic gain control interfaced with ANS that are operator configurable.
- O. Provide PA amplifiers at the Lewis Farms Storage Facility Building and Gerry Wright OMF Building B equipped with automatic gain control.
- P. Provide ANS, rated at minimum IP65 and able to operate to -40 °C, at each platform and Station levels.
- Q. Configure the PA amplifiers to achieve noise compensation based on ambient noise at each Stop and Station that will prevent reaction to transient ambient noise
- R. Configure the PA amplifiers to adjust output volume based on time of day at the Lewis Farms Storage Facility Building and Gerry Wright OMF Building B.
- S. Provide microphone in the Lewis Farms Storage Facility Building to broadcast live announcements when required.
- T. Provide fireman microphone in the Lewis Farms Storage Facility Building, WEM Station, Misericordia Station and Gerry Wright OMF Building B.
- U. Design, manage the interfaces, procure, install, conduct PICO, SAT, SIT, and Commission of the Stop or Station PA subsystem.
- V. Design, supply, install and test the PA subsystem infrastructure including conduits, mounting brackets, etc.

6-1.20.3 ETS Passenger Information

6-1.20.3.1 ETS Departure Information Signs

- A. To permit the future installation and operation, by Other Contractors, of ETS departure information signs at the WEM Transit Centre in accordance with Section 5-2.4.8 [*ETS Departure Information Boards*] of this Schedule, provide the following infrastructure:
1. 25mm embedded and concealed conduit, not to exceed 90m, and mounting space for ETS departure information sign access points, to be provided by Other Contractors at the following locations:
 - a. WEM Station building interior from the communications room to two (2) locations as Accepted by The City.
 - b. each tab sign location at the front of each bus berth from the communications room in the WEM Station.
 2. Provide a nylon pull string for each conduit run;
 3. Cable will be installed by Other Contractors.

6-1.20.3.2 ETS Schedule Boards

- A. To permit the future installation and operation, by Other Contractors, of electronic ETS schedule boards in accordance with Section 5-2.4.7 [*ETS Schedule Boards*] of this Schedule, provide the following systems infrastructure:
1. a dedicated 19 mm embedded conduit behind each ETS Schedule Board, placed in accordance with Section 5-2.4.7 [*ETS Schedule Boards*] of this Schedule to the ETS LAN Cabinet; and
 2. a 120V, 20A circuit in a dedicated concealed 19 mm EMT conduit from each ETS Schedule Board to the nearest concrete surface and extend through 19 mm embedded conduit to the nearest "Normal" electrical load centre.

6-1.21 WIRE AND CABLE

- A. The requirements of this Section 6-1.21 [*Wire and Cable*] apply to all wire and cabling required for the Rail Systems described within Section 6-1 [*Rail Systems*] of this Schedule, except Traction Power System cabling described in Section 6-2.3.5 [*Traction Power Cables and Connections*] of this Schedule
- B. Except as modified herein, provide only wire and cable that complies with the Canadian Electrical Code, Table 19.
- C. Install all exterior cable in underground or embedded local conduit or duct bank conduits.
- D. Provide exterior cable that is:
1. crush rated; and
 2. suitable for use when 100% submerged in water and ice in the environments in which they are installed.
- E. Encase all interior cable routed through exposed areas in conduit or in flexible, non-metallic, liquid tight, electrical tubing.

- F. Provide conduit and ducts such that:
 - 1. no conduit or duct exceeds a wire/cable fill ratio of 40%;
 - 2. conduit runs shall not exceed 180 degrees of bends between pull boxes; and
 - 3. all communication conduit is designed to support fibre optic cabling at a later date.
- G. Provide wire and cable for Vital signaling applications that complies with AREMA Communications and Signals Manual Part 10.3, Recommended Wire and Cable. Wherever a conductor forming part of a Vital system is subject to vibration, stranded copper conductors shall be used.
- H. Provide all wire and cable installed in Confined Spaces, not including pull boxes or Access Vaults, as low smoke zero halogen (LSZH).
- I. All conductors and cable inner/outer jacketing installed in Confined Spaces shall be flame test rated FT4. Notwithstanding the preceding sentence, all conductors and cable inner/outer jacketing which forms part of a Vital application shall comply with the more stringent of:
 - 1. flame test rated FT4; and
 - 2. the requirements of AREMA C&S Manual Part 10.3.
- J. Install all cables in one contiguous length, without splices, between termination points.
- K. Provide minimum 10 m slack loops for all cables in Access Vaults.
- L. Do not exceed cable bend radius limitations, as specified by the applicable manufacturer.

6-1.21.1 Fibre Optic Cable

6-1.21.1.1 Fibre Optic Cable Standards

- A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
 - 1. TIA/EIA-455-8, FOTP-8 - Measurement of FO Splice and Connector Loss Using an OTDR;
 - 2. ASTM D1248 - Standard Specification for Polyethylene Plastic Extrusion Material for Wire and Cable; and
 - 3. ASTM E 814 - Standard Test Method for Fire Tests of Through – Penetration Fire Stops;
- B. Electronic Industries Alliance (EIA)/Telecommunication Industry Association (TIA):
 - 1. TIA/EIA 455-25C, FOTP-25 - Impact Testing of Fibre Optic Cables;
 - 2. TIA/EIA 455-B - Standard Test Procedure for Fibre Optic Fibre Cables, Transducers, Sensors. Connecting and Terminating Devices and other Fibre Optic Components;
 - 3. TIA/EIA 455-3-A, FOTP-3 - Procedure to Measure Temperature Cycling Effects on Optical Fibres, Optical Cable, and Other Passive Fibre Optic Components;
 - 4. TIA/EIA 455-13-A, FOTP-13 - Visual and Mechanical Inspection of Fibre Optic Components Devices and Assemblies;
 - 5. TIA/EIA 455-33-A, FOTP-33-B - Fibre Optic Cable Tensile Loading and Bending Test;

6. TIA/EIA 455-37-A, FOTP-37 - Low or High Temperature Bend Test for Fibre Optic Cable;
7. TIA/EIA 455-41-A, FOTP-41 – Compressive Loading Resistance of Fibre Optic Cables;
8. TIA/EIA-455-59, FOTP-59- Measurement of Fiber Point Discontinuities Using an OTDR;
9. TIA 455-78-B, FOTP-78B - Optical Fibres: Measurement Methods and Test Procedures - Attenuation;
10. TIA/EIA 455-81 B, FOTP-81 - Compound Flow (Drip) Test for Filled Fibre Optic Cable;
11. TIA 455-82B, FOTP-82 - Fluid Penetration Test for Fluid-Blocked Fibre Optic Cable;
12. TIA/EIA 455-85-A, FOTP-85 - Fibre Optic Cable Twist Test;
13. TIA/EIA 455-88, FOTP-88 - Fibre Optic Cable Bend Test;
14. TIA/EIA 455-91, FOTP-91 - Fibre Optic Cable Twist-Bend Test;
15. TIA/EIA 455-104-A, FOTP-104 - Fibre Optic Cable Cyclic Flexing Test;
16. TIA/EIA- 455-107A, FOTP-107, Return Loss Measurements for Fiber Optic Components;
17. TIA/EIA -455-124, FOTP-124, Polarization-mode Dispersion Measurement for Single-mode Optical Fibers by Interferometry Method;
18. TIA/EIA 455-133-A, FOTP-133 IEC-60793-1-22 Optical Fibres - Part 1-22: Measurement Methods and Test Procedures – Length Measurement;
19. TIA/EIA 455-171-A, FOTP-171 – Attenuation by Substitution Measurement for Short-Length Multimode Graded-Index and SM Optical Fibre Cable Assemblies;
20. TIA/EIA-455-175-B, FOTP-175-B - Measurement Methods and Test Procedures-Chromatic Dispersion;
21. TIA/EIA 455-177-B, FOTP-177 - IEC 60793-1 -43 Optical Fibres Part 1-43: Measurement Methods and Test Procedures – Numerical Aperture;
22. TIA-472COOO-B, Standard for Optical Fibre Premises Distribution Cable;
23. TIA/EIA 455-181, FOTP-181 – Lighting Damage Susceptibility Test for Optic Cables with Metallic Components;
24. TIA/EIA 492-AAAA-A, Detail Specification for 62.5- μm Core Diameter/125 μm Cladding Diameter Class 1a Graded-Index Multimode Optical Fibres;
25. TIA/EIA 492-CAAB - Detail Specification for Class IVa Dispersion – Unshifted SM Optical Fibres with Low Water Peak;
26. TIA/EIA-526-7 - OFSTP-7 Measurement of Optical Power Loss of Installed SM Fibre Cable Plant;
27. TIA/EIA-526-14-A, OFSTP-14 - Optical Power Loss Measurement of Installed Multimode Fibre Cable Plant;
28. TIA/EIA-568-B.1-3 - Commercial Building Telecommunications Cabling Standard;
29. TIA/EIA-598-C - Optical Fibre Cables Color Coding; and

30. TIA/EIA-606 -Administration Standard for the Telecommunications Infrastructure of Commercial Buildings.
- C. Institute of Electrical and Electronic Engineers (IEEE) 1. IEEE 802.3u – Supplement to Local and Metropolitan Area Networks Media Access Control (MAC) Parameters, Physical Layer, Medium Attachment Units, and Repeater for 100 Mb/s Operation, Type 100BASE-T (Clauses 21 - 30)- Supplement to ISO/IEC 8802-3:1993 (ANSI/IEEE 802.3,1993 Edition).
- D. Insulated Cable Engineers Association (ICEA) 1. ICEA S-87-640-1999 – Standard for Optical Fibre Outside Plant Communications Cable.
- E. International Organization for Standards (ISO) 1. ISO 9001 - Quality Management Systems.
- F. National Electric Manufacturers Association (NEMA) 1. NEMA Standards Publication 250, Enclosures for Electrical Equipment (1000 Volts Maximum).
- G. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electrical Code (NEC);
 2. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces; and
 3. Occupational Safety Administration (OSHA) and Health.
- H. Underwriters' Laboratories, Inc. (UL):
1. UL 910 - Test for Flame-Propagation and Smoke-Density Values for Electrical and Optical-Fibre Cables Used in Spaces Transporting Environmental Air;
 2. UL 1581 - Reference Standard for Electrical Wires, Cables, and Flexible Cords;
 3. UL 1666 - Test for Flame Propagation Height of Electrical and Optical-Fibre Cables Installed Vertically in Shafts; and
 4. UL 2024 - Standard for Optical Fibre and Communication Cable Raceway.

6-1.21.1.2 Fibre Optic Cable Products

- A. Provide fibre optic cable:
1. with the useful life expectancy of a minimum of 30 years for service in a railroad and transit environment;
 2. designed for installation and operation in underground conduit, wet or dry environments, including alternating wet and dry conditions with extreme temperature conditions (-40 °C to +70 °C); and
 3. with a Manufacturer Warranty for the fibre optic cable for a minimum of 25 years.
- B. Provide all fibre optic cable run in conduits or duct banks that are an accepted product of the USDA Rural Utilities Service (RUS) 7 CFR 1755.900 and meet the requirements of ICEA S-87-640-1999; and
- C. Provide outside plant (OSP) cables for installation in underground ducts, cable trays, open air and subway systems or other areas where uncontrolled temperature and humidity exist and/or where cable may be exposed to water and pest damage.

1. SM fibres must be Corning SMF-28e or equivalent as follows:
 - a. fibre core diameter 8.2 – 8.8 Microns;
 - b. fibre diameter: 125 microns;
 - c. fibre type step index;
 - d. attenuation: < 0.03 dB/km @ 1285 - 1330 nm;
 - e. attenuation: < 0.02 dB/km @ 1525 - 1525 nm;
 - f. cut-off wavelength: < 1260 nm;
 - g. zero dispersion wavelength: $1310 < \lambda_0 < 1324$ nm;
 - h. zero dispersion slope: < 0.092 ps/(nm²*km);
 - i. environmental induced attenuation: < 0.05 dB/km @ 1310, 1550 nm;
 - j. for water immersion: $+23 \pm 2$ °C;
 - k. for humidity cycling: -10 °C to +85 °C up to 98% RH;
 - l. for temp. dependence: -60 °C to +85 °C;
 - m. proof test stress: > 100 kpsi; and
 - n. coating diameter: 245 ± 5 microns.

- D. Provide only OSP fibre optic cable that is certified to meet applicable tests of TIA-455 and shall meet the following:
 1. When tested in accordance with TIA 455-3-A, FOTP-3, the change in attenuation at extreme operational temperatures (-40 °C and +70 °C) shall not exceed 0.15 dB/km at 1550 nm;
 2. When tested in accordance with TIA 455-82-B, FOTP-82, a one (1) meter length of un-aged cable shall withstand a one (1) meter static head or equivalent continuous pressure of water for one hour without leakage through the open cable end;
 3. When tested in accordance with TIA/EIA 455-81 -B, FOTP-81, the cable shall exhibit no flow (drip or leak) of filling and/or flooding material at +70 °C;
 4. When tested in accordance with TIA/EIA 455-41 -A, FOTP-41, the cable shall withstand a minimum compressive load of 220 N/cm applied uniformly over the length of the sample;
 - a. The 220 N/cm load shall be applied at a rate of 2.5 mm (0.1 in) per minute. The load shall be maintained for a period of one minute. The load shall then be decreased to 110 N/cm (63 lbf/in).
 - b. Alternatively, it is acceptable to remove the 220 N/cm load entirely and apply the 110 N/cm (63 lbf/in) load within five (5) minutes at a rate of 2.5 mm (0.1 in) per minute.
 - c. The 110 N/cm load shall be maintained for a period of 10 minutes. Attenuation measurements shall be performed before release of the 110 N/cm load. The change in attenuation shall not exceed 0.15 dB at 1550 nm.

5. When tested in accordance with TIA 455-104-A, FOTP-104, the cable shall withstand 25 mechanical flexing cycles around a sheave diameter not greater than 20 times the cable diameter. The change in attenuation shall not exceed 0.15 dB at 1550 nm;
 6. When tested in accordance with EIA 455-25-C, FOTP-25, except that the number of cycles shall be two (2) at three (3) locations along a one-meter (1) cable length and the impact energy shall be a minimum of 4.4 Nm (in accordance with ICEA S-87-640), the change in attenuation shall not exceed 0.15 dB at 1550 nm;
 7. When tested in accordance with TIA 455-33-A, FOTP-33B, using a maximum mandrel and sheave diameter of 560 mm, the cable shall withstand a rated tensile load of 2670 N and residual load of 30 percent of the rated installation load;
 - a. The axial fibre strain shall be \leq 60 percent of the fibre proof level after completion of 60-minute conditioning and while the cable is under the rated installation load.
 - b. The axial fibre strain shall be \leq 20 percent of the fibre proof level after completion of 10-minute conditioning and while the cable is under the residual load.
 - c. The change in attenuation at residual load and after load removal shall not exceed 0.15 Db at 1550 nm.
 8. When tested in accordance with TIA/EIA 455-85-A FOTP-85A, a length of cable no greater than two (2) meters shall withstand 10 cycles of mechanical twisting. The change in attenuation shall not exceed 0.15 dB at 1550 nm;
 9. When tested in accordance with TIA/EIA 455-181, FOTP-181, the cable shall withstand a simulated lightning strike with a peak value of the current pulse equal to 105 kA without loss of fibre continuity;
 - a. A damped oscillatory test current shall be used with a maximum time to-peak value of 15 us (which corresponds to a minimum frequency of 16.7 kHz) and a maximum frequency of 30 kHz.
 - b. The time to one half value of the waveform envelope shall be from 40 to 70 ps.
 10. When tested in accordance with TIA/EIA 455-37-A, FOTP-37, the cable shall withstand four (4) full turns around a mandrel of $<$ 20 times the cable diameter after conditioning for four (4) hours at test temperatures of -40 °C and +60 °C; and
 - a. Neither the inner or outer surfaces of the jacket shall exhibit visible cracks, splits, tears, or other openings. The change in attenuation shall not exceed 0.30 dB at 1550 nm.
 11. Insulated Cable Engineers Association (ICEA) 1. ICEA S-87-640-1999 - Standard for Optical Fibre Outside Plant Communications Cable relevant to water tightness.
- E. Provide fibre cables constructed in accordance with the following:
1. Optical fibres shall be placed loose inside a buffer tube. The nominal outer diameter of the buffer tube shall be either 2.5 mm or 3.0 mm.
 - a. Each buffer tube shall contain 12 fibres.
 - b. The fibres shall not adhere to the inside of the buffer tube. The buffer tubes shall be resistant to external forces and shall meet the buffer tube cold bend and shrinkback requirements of USDA RUS7CFR 1755.900.

2. Each fibre shall be distinguishable by means of color coding in accordance with TIA-598-C. The fibres shall be colored with ultraviolet (UV) curable inks.
3. Buffer tubes containing fibres shall be color coded with distinct and recognizable colors in accordance with TIA-598-C.
 - a. Buffer tube colored stripes shall be inlaid in the tube by means of co-extrusion when required. The nominal stripe width shall be 1.0 mm.
 - b. In buffer tubes containing multiple fibres, the colors shall be stable across the specified storage and operating temperature range and not subject to fading or smearing onto each other or into the surrounding tubing.
 - c. Colours shall not cause fibres to stick together.
4. Fillers may be included in the cable core to lend symmetry to the cable cross-section where needed. Fillers shall be placed so that they do not interrupt the consecutive positioning of the buffer tubes.
 - a. In dual layer cables, any fillers shall be placed in the inner layer.
 - b. Fillers shall be nominally 2.5 mm or 3.0 mm in outer diameter.
5. The central member shall consist of a dielectric, glass reinforced plastic (GRP) rod. The purpose of the central member is to provide tensile strength and prevent buckling. The central member shall be over coated with a thermoplastic when required to achieve dimensional sizing to accommodate buffer tubes/fillers.
6. Two polyester yarn binders shall be applied contra-helically with sufficient tension to secure each buffer tube layer to the dielectric central member without crushing the buffer tubes.
 - a. The binders shall be non-hygroscopic, non-wicking, and dielectric with low shrinkage.
7. For single layer cables, a water swellable tape shall be applied longitudinally around the outside of the stranded tubes/fillers.
 - a. The water swellable tape shall be non-nutritive to fungus, electrically nonconductive, and homogenous. It shall also be free from dirt and foreign matter.
8. For dual layer cables, a second (outer) layer of buffer tubes shall be stranded over the original core to form a two-layer core.
 - a. A water swellable tape shall be applied longitudinally over both the inner and outer layer. The water swellable tape shall be non-nutritive to fungus, electrically non-conductive, and homogenous. It shall also be free from dirt and foreign matter.
9. Cables shall contain two (2) ripcords under the outer jacket for easy jacket removal.
10. Tensile strength shall be provided by the central member, and additional dielectric yarns as required. The dielectric yarns shall be helically stranded evenly around the cable core.
11. Cables shall have an inner sheath of Medium Density Polyethylene (MDPE).
 - a. The minimum nominal jacket thickness of the inner sheath shall be 1.0 mm.
 - b. The inner jacket shall be applied directly over the tensile strength members (as required) and water swellable tape.

- c. A water swellable tape shall be applied longitudinally around the outside of the inner jacket.
 - d. The outer jacket shall be a MDPE with a minimum nominal jacket thickness of 1.4 mm.
 - e. The polyethylene shall contain carbon black to provide ultraviolet light protection and shall not promote the growth of fungus.
12. The MDPE jacket material shall be as defined by ASTM D1248, Type II, Class C, Category 4 and Grades J4, E7 and E8. The jacket or sheath shall be free of holes, splits, and blisters.
- a. The cable jacket shall contain no metal elements and shall be of a consistent thickness.
13. The outer surface of the jacket of each shipping length of cable shall be permanently identified by printing (in a contrasting color) descriptive information on the outer surface of the jacket at intervals of 1500 mm (5 feet) or less.
- a. The information shall include identification (City CTS), country of origin (made in), count of fibres, fibre type, date of manufacturing (month and year), manufacturer's part number, manufacturer's name, sequential meter or foot markings, a telecommunication handset symbol as required by Section 350G of the National Electrical Safety Code® (NESC®), fibre count, and fibre type.
 - b. The actual length of the cable shall be within -0/+1 percent of the length markings. The print color shall be white, with the exception that cable jackets containing one or more coextruded white stripes, which shall be printed in light blue. The height of the marking shall be approximately 2.5 mm.
14. If the initial marking fails to meet the specified requirements, i.e., improper text statement, color legibility, or print interval, the cable may be remarked using a contrasting alternate color.
- a. The numbering sequence shall differ from the previous numbering sequence, and a tag shall be attached to both the outside end of the cable and to the reel to indicate the sequence of remarking.
 - b. The preferred remarking color shall be yellow, with the secondary choice being blue.
- F. During installation, account for the size and construction of the cables, recognizing the nature of fibre optic cables regarding installation, especially at manholes. Allowance for such fibre characteristics shall be made in cable pull budgets. SM optical fibre characteristics. SM (Dispersion Un-shifted) with Low Water Peak fibre utilized in the optical fibre cable shall meet TIA-492CAAB, and ITU recommendation G.652.C.
1. Provide the following fibre loss calculations:
- a. span loss (total loss of span from patch panel to patch panel);
 - b. optical loss margin;
 - c. return loss;
 - d. splice loss; and
 - e. termination loss.
2. The following test values shall be used as pass criteria:
- a. splices < 0.1 dB loss;

- b. termination < 0.25 dB loss and > 55 dB return loss(matching);
 - c. total loss < Calculated span loss; and
 - d. optical loss margin > 10 dB.
3. Test data shall be provided in static and dynamic format:
- a. Static format shall be compatible with all project delivery requirements;
 - b. Dynamic format shall be in native testing machine format suitable for additional analysis by ETS; and
 - c. Provide all additional software needed to read native format.
- G. Provide fibre optic cabling meeting the following mechanical specifications:
1. Each optical fibre shall be proof tested by the fibre manufacturer at a minimum of 100 kpsi (0.7 GN/m²).
 2. The fibre shall be coated with a dual layer acrylate protective coating. The coating shall be in physical contact with the cladding surface.
 3. crush resistance:
 - a. 10 kN/m length of cable.
 4. cable outside diameter:
 - a. < 1.651 meters.
 5. weight per 305 linear meter:
 - a. <352.74 kg.
 6. minimum bending radius:
 - a. installation, 15X diameter.
 - b. static, 12X diameter.
 7. temperature:
 - a. operational:
 - i. -40 °C to +70 °C.
 - ii. continuous operation at -40 °C without cracking or becoming brittle.
 8. storage:
 - a. -40 °C to +70 °C on reel.
 9. humidity:
 - a. 0 to 100%, inclusive.
 10. tensile strength:

- a. installation:
 - i. 2,700 N static.
 - ii. 890 N.

6-1.21.1.3 Fibre Connectors Products

- A. Provide all FDP connectors as LC type, unless otherwise directed.
- B. Provide connectors for media converter equipment as LC type. Provide jumper cables terminated suitably for use between the equipment at each end of the cable.
- C. Optical parameters of the connectors shall meet the requirements of TIA/EIA-568.
- D. Comply with GR-326-CORE.
- E. Provide outside plant fibre optic connectors that qualify in accordance with GR-3120.

6-1.21.1.4 Fibre Distribution Panel Products

- A. Provide enclosures to house the splice shelf and connector sleeve panels for all optical connections. Do not provide enclosures capable of providing less than 48 connections for SM fibres.
 - 1. Secure all OSP cable jackets and central strength members to the FDP to relieve strain.
 - 2. Provide fibre splice enclosures that comply with GR-771-CORE.
- B. Distribution panels:
 - 1. Provide Fibre Distribution Frames that comply with GR-449-CORE.
 - 2. Provide distribution panels as a complete system of components by a single manufacturer.
 - 3. Provide rack mountable connector housings for cross-connecting or interconnecting purposes. The units shall provide for direct connectorization and pigtail splicing.
 - 4. Provide housings that are mountable in an EIA-310 compatible 19-inch rack.
 - 5. Provide only units meeting the design requirements of TIA-568.
 - 6. Provide only molded plastic parts that meet flammability requirements of UL 94 V-0.
 - 7. Provide connector housings with a labeling scheme that complies with TIA/EIA-606. The housing shall incorporate labeling via an adhesive backed label and a retractable sliding label panel that pulls out from the bottom front of the housing.
 - 8. Provide housings manufactured using 16- gauge aluminum and anodized for durability. Include Installation fasteners that are black in color.
 - 9. Provide units capable of connectorization and jumper management.
 - 10. Provide units capable of splicing or combination connectorization/splicing with the use of an additional splice tray kit.

11. Provide units having a fibre routing guide platform located in the rear of the housing that is removable using two (2) plunger style latches so that room can be made for an optional splice tray kit.
 12. Provide units having a hinged top jumper management panel capable of locking in the horizontal or vertical position. When the top panel is locked in the horizontal position, it shall act as a jumper routing area in the top front of the housing and shall enclose the top of the housing. When the hinged panel of the unit is locked in the vertical position it shall serve as a horizontal jumper management panel capable of routing jumpers out of the top of the housing.
 13. Provide provisions for mounting up to 12 fibre fan-out devices incorporated into the housing via a removable slack storage platform in the rear of the housing.
 14. Provide fan-outs that comply with GR-2866-CORE.
 15. Provide splice capacity of 12 splice trays.
 16. Provide units that include a clamshell-type cable clamping mechanism to provide cable strain relief that:
 - a. accepts one cable from .94 -2.845 cm in diameter;
 - b. accepts multiple smaller fibre count cables when used with a multiple cable insert with a total cable capacity per clamp shall be five (5) cables (1.016 cm) OD;
 - c. incorporates two (2) clamps; and
 - d. has an available accessory kit with additional cable clamps.
 17. Provide housings with four (4) grommet openings for cable entry in the rear of the housing and two (2) removable panels on both the left and right rear of the housing if more than four (4) cable entries are required.
 18. Provide housings with front and rear doors that are hinged and removable for ease of cable installation.
 19. Provide access doors that:
 - a. are made from tinted polycarbonate;
 - b. utilize a single slide latch to provide ready access and closing;
 - c. have an opening for an optional key lock kit that is filled with a removable plastic insert to prevent dust entry if the optional lock kit is not used; and
 - d. have a removable retaining bracket to prevent the door from being unintentionally slid off the hinges.
 20. Provide housings that accommodate the future installation of LC, ST, FC, D4, or MTRJ, type connector modules. Each module shall provide 12 connector sleeves.
- C. Splice shelf:
1. Provide splice shelves that accept slide in/out splice trays for a maximum number of connectors and for the fibre types to be installed.
 2. Provide splice trays that restrain and protect fusion splices.

D. Connector sleeve:

1. Provide LC type connector sleeves meeting TIA-568-B.1-3 requirements when connecting mated pairs.
2. Provide FDPs fully populated with connector sleeves.
3. Provide dust caps for all sleeves.
4. Provide connections such that Loss across the connection does not exceed 0.6 dB for SM, with optical attenuators removed.
5. Provide sleeves that accept optical attenuators as required for maintaining the Optical Loss budget.
6. Slack retention:
 - a. Coil and retain slack in pigtails and patch cords such that the minimum-bending radius is not be exceeded.
 - b. Provide sufficient slack for accessing splice shelves and connectors.

6-1.21.1.5 Optical Fibre Patch Cord Products

- A. Provide patch cord cable assemblies consisting of flexible optical fibre cable with LC compatible connectors that are complete factory fabricated assemblies from manufacturer's standard product lines.
- B. Patch cord assemblies:
 1. Provide patch cord assemblies whose construction allows a small bend radius for installation in space-constrained areas and contain dielectric strengthening fibres and protective outer jackets.
 2. Provide patch cord that comply with the requirements of TIA-568-B. 1-3.
- C. Connectors:
 1. Provide patch cords with two (2) duplex connectors.
- D. Fibre cable:
 1. Provide patch cords utilizing a duplex zip-cord type jacketed cable, in lengths required to meet minimum bend radius while connected and routed through cable management hardware but no less than 1.83 m in length.
 2. Provide cable jacket colours that are orange for multimode and yellow for SM cable, with the fibre core size identified on the outer jacket.
 3. Provide patch cords whose optical fibre meets the same characteristic requirements of the distribution panel terminated cable to which it mates.
 4. Provide patch cords with tensile strength of the jacketed cable greater than or equal to 44.09 kg.

6-1.21.1.6 Optical Fibre Pigtail Products

- A. Pigtails shall be cable assemblies consisting of flexible optical fibre cable with LC compatible connectors. Pigtails shall be complete factory fabricated assemblies from manufacturer's standard product lines.
- B. One duplex connector shall be provided on pigtails, with the other end prepared for splicing.

6-1.21.1.7 Innerduct Products

- A. Innerduct products shall be used in all conduit runs that do not utilized to their maximum fill ratio as specified in Section 6-1.21 [*Wire and Cable*] of this Schedule.
- B. Construct innerduct products with either Maxcell or Microduct flame-retardant flexible material that meet the following flammability requirements:
 - 1. OSP, inside building horizontal, and inside building riser innerduct shall meet the UL 2024 (raceways) flame test; and
 - 2. Innerduct installed in any air plenum environment shall meet NFPA 262-2002.
- C. Inside building horizontal and riser innerducts shall be flexible and corrugated type.
- D. Compatible with the fibre optic cable installed within.
- E. Inner diameter shall be 3.175 cm minimum.
- F. Couplers, if used, shall not reduce the inside diameter of the innerduct.
- G. All unused innerduct shall be preinstalled with lubricated pull tape or line.

6-1.21.1.8 Installation of Fibre Optic Cable

- A. All optical cable installation plans will comply with the following:
 - 1. All LAN fibre optic cable shall be installed in innerduct. OSP fibre optic cable shall be installed in innerduct, through Vaults/Manholes, and through duct bank conduits.
 - a. All duct bank 10.16 cm communications conduits serving fibre optic cable shall contain three (3) 3.157 cm innerducts each.
 - b. No more than one OSP fibre optic cable shall be installed in a single innerduct. The innerduct shall be installed without coils or twists.
 - 2. The installed cable shall not exceed the cable's minimum bend radius for cable under tension or long-term installation/storage.
 - 3. Continuity of cable shall be maintained between termination or splice locations.
 - a. Additional splices shall not be allowed without the prior written City approval.
 - b. Only the specified buffer tubes are to be cut. All un-effected buffer tubes shall be continuous and un-cut at any splice point.
 - 4. All cable entrance openings in equipment enclosures, houses, rooms and junction boxes shall be sealed with either a compression type fitting or pliable sealing compound after the cable is in place.

- a. Sealing compounds for rooms, houses, walls, or other partitions shall be fire retardant per ASTM E-814.
- b. Sealing compound shall be used to seal the area around cable where the cable emerges from the end of a conduit, pipe, or duct bank. All spare conduits shall be sealed or plugged in an approved manner.

B. Termination:

1. Slack in vaults and manholes shall be carefully coiled in order to avoid violating the short- and long-term minimum bend radius. Refer to manufacturers' recommendations for bend radius for each cable type.
2. Slack in FDP's shall be restrained and shall be sufficient for strain relief.
3. The central strength member of cable shall be attached to the FDP. The outer jacket of cable shall be attached to the FDP with a cable clamp.
4. All fibre optic splices shall be fusion splices. Fusion shall be performed by qualified personnel utilizing a splicer equipped with Local Injection and Detection (LID) to optimize splices. The loss across each spliced fibre shall be less than or equal to 0.04 dB.
5. All fibre optical terminations at communications and wayside facilities shall be field or factory terminated.

C. Installation:

1. Install the cable in accordance with manufacturer recommended temperature specifications.
2. 10 m service loop shall be added at each termination location and at every vault and manhole location for future adds, moves and changes.

6-1.21.1.9 Cable Plant Testing

A. Cable plant field tests:

1. Tests shall be performed after installation is complete.
2. Optical attenuation from FDP to FDP shall be recorded.
3. Test every fibre optic cabling link installed in accordance with the field test specifications defined by the TIA standard TIA-568-B.1-3 (or by the required network application standards) whichever is more demanding.
4. TIA-568-B.1-3 shall be used to define the passive cabling network, to include cable, connectors, and splices (if present), between two (2) optical fibre patch panels (connecting hardware).
 - a. The TIA-568-B.1-3 shall be used to describe all applicable link segments. Tests shall include the representative connector performance at the connecting hardware associated with the mating of patch cords but not the performance of the connector at the interface with the test equipment.
5. All of the cabling links installed shall be tested and shall pass the requirements of the standards referenced in this Schedule 5 [*D&C Performance Requirements*].
 - a. Any failing link shall be diagnosed and corrected prior to the system acceptance. The corrective action shall be followed with a new test to prove that the corrected link meets the performance

requirements. The final and passing result of the tests for all links shall be provided in the test results documentation.

6. Field test instruments for SM fibre cabling shall meet the requirements of TIA- 526-7. The light source shall meet the launch requirements of TIA-455-78-B.
 - a. This launch condition can be achieved either within the field test equipment or by use of an external mandrel wrap (as described in clause 11 of TIA-568-B) with a Category 1 light source.
 7. The test instrument calibration date shall be within the calibration period recommended by the vendor in order to achieve the vendor specified measurement accuracy.
 8. The fibre optic launch cables and adapters shall be of high quality and the cables shall not show excessive wear resulting from repetitive coiling and storing of the test instrument interface adapters.
 9. The pass or fail condition for the link-under test is determined by the results of the required individual tests.
 10. A pass or fail result for each parameter is determined by comparing the measured values with the specified test limits for that parameter.
- B. Cable plant performance test parameters:
1. In compliance to TIA standard 568-B, the single performance parameter for field-testing of fibre optic links shall be link attenuation (insertion loss).
 2. All SM cable links shall be tested at 1310 nm and 1550 nm in accordance with TIA-526-7, Method A.1, One Reference Jumper or the equivalent method. All SM links shall be certified with test tools using laser light sources at 1310 nm, 1550 nm and 1625 nm.
 3. Links to be used with network applications that use laser light sources (under-filled launch conditions) shall be tested with test equipment based on laser light sources.
 - a. This rule shall be followed for cabling systems to support Gigabit Ethernet. Gigabit Ethernet only specifies laser light sources. For Gigabit Ethernet compliant certification (IEEE Std 802.3Z application), use test equipment that uses a VCSEL (Vertical cavity surface emitting laser) at 850 nm (compliant with 1000BASESX) and a FP laser at 1310 nm (compliant with 1000BASELX).
 4. Each fibre optical link terminated with an optical adapter system that does not impose a transmission direction because the adapters are not or cannot be ganged shall be tested and documented in both directions since the direction of the signal transmission cannot be predicted at the time of installation.
 5. OTDR testing:
 - a. All cables shall be OTDR tested at 1310 nm and 1550 nm operating wavelengths for anomalies and to ensure uniformity of cable attenuation and connector insertion loss;
 - b. OTDR tests shall be performed utilizing a pulse suppressor such that the FDP termination shall be shown;
 - c. All OTDR testing procedures and field test instruments shall comply with applicable requirements of:

- i. TIA-455-133-A; and
 - ii. TIA-455-78-B; and
- d. Each fibre link and channel shall be tested in one direction;
 - e. A launch cable shall be installed between the OTDR and the first link connection;
 - f. A receive cable shall be installed after the last link connection;
 - g. Optical return loss for each link shall be measured;
 - h. Fibre Length shall be measured;
 - i. Test Results:
 - i. Reflective events shall not exceed -40 dB;
 - ii. Connections shall not exceed +0.75 dB for multimode, and 0.6 for SM of attenuation;
 - iii. Non-reflective events (splices) shall not exceed +0.3 dB;
 - iv. Point discontinuities shall not exceed +0.1 dB in continuous fibre; and
 - v. Optical return loss shall be less than -30 dB; and
 - j. OTDR test results shall include OTDR link and channel traces and event tables at the required wavelength(s) and the length for each optical fibre as calculated by the OTDR.
6. An optical spectrum scan of each link shall be performed using an optical spectrum analyzer and optical switch to examine fibre nonlinear effects including but limited to Brillouin scattering and four (4) wave mixing across the fibre's usable light spectrum.

6-1.21.2 Copper Cable

- A. Provide cable with the useful life expectancy of a minimum of 30 years for service in a railroad and transit environment.
- B. Provide a Manufacturer Warranty for the copper cable for a minimum of 25 years.

6-1.21.2.2 Copper Cable Standards

- A. ASTM International (Formerly known as American Society for Testing and Materials) (ASTM):
 - 1. ASTM B 3 - Standard Specification for Soft or Annealed Copper Wire;
 - 2. ASTM D 470 - Standard Test Methods for Cross-linked Insulations and Jackets for Wire and Cable;
 - 3. ASTM D 2863 - Standard Test Method for Measuring the Minimum Oxygen Concentration to Support Candle-like Combustion of Plastics;
 - 4. ASTM D 4101 - Standard Specification for Polypropylene Injection and Extrusion Materials;
 - 5. ASTM E 662 - Standard Test Method for Specific Optical Density of Smoke Generated by Solid Materials; and

6. ASTM E 814 - Standard Test Method for Fire Tests of Through-Penetration Fire Stops.
- B. Insulated Cable Engineers Association (ICEA):
1. ICEA S-84-608-2002 - Filled Telecommunications Cable, Polyolefin, Insulated, Copper Conductor.
- C. National Fire Protection Association (NFPA):
1. NFPA 70 - National Electric Code (NEC);
 2. NFPA 130 - Standard for Fixed Guideway Transit Systems and Passenger Rail Systems; and
 3. NFPA 262 - Standard Method of Test for Flame Travel and Smoke of Wires and Cables for Use in Air-Handling Spaces.
- D. Telecommunications Industry Association (TIA)/Electronics Industry Alliance (EIA):
1. TIA-758-A - Customer-owned Outside Plant Telecommunications Infrastructure Standard;
 2. TIA-568-B - Commercial Building Telecommunications Cabling Standard;
 3. TIA-569-B - Commercial Building Standard for Telecommunications Pathways and Spaces;
 4. TIA/EIA-606-A - Administration Standard for Telecommunications Infrastructure of Commercial Buildings; and
 5. TIA J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications.
- E. Underwriters Laboratories (UL):
1. UL 444 - Communications Cables;
 2. UL 1581 - Reference Standard for Electrical Wire, Cable, and Flexible Cords;
 3. UL 1666 - Test for Flame Propagation Height of Electrical and Optical-Fibre Cables Installed Vertically in Shafts; and
 4. UL 1690 - Data-Processing Cable.

6-1.21.2.3 Furnished Materials for Copper Cables

- A. Telephone, Public Address (PA), Variable Message Signs (VMS), and Data Cable:
1. Local inside facility distribution of low-level voice circuits shall, at a minimum, be by standard CAT-6, telephone cable.
 2. Wire conductors shall be composed of soft or annealed copper, meeting insulating, sensitivity and elongation requirements of ASTM B3, latest edition.
 3. The insulation shall be colored virgin propylene copolymer meeting the requirements of ASTM D4101, or equivalent, for propylene plastic. High molecular weight polyethylene is also acceptable.
 4. Insulated conductors shall be in twisted pairs. Each pair shall be individually colored. The average length of pair twist shall not exceed 40.6 cm. To minimize noise and crosstalk, each pair of a multi-pair cable shall have a different average length of twist from any other pair in the cable.

5. Inside wire (wiring run within any building) from telephone terminals to telephone instruments shall be CAT-6 unshielded twisted pair cable.
 6. In addition to the requirements listed herein, all cables shall meet the requirements of NFPA 70 and 130 latest editions and shall be manufactured to telephone industry standards.
- B. Low-Smoke Jacket:
1. Telephone, supervisory control and data acquisition, BMS/O or data cable entering from an outside environment exceeding 15.24 m in length inside a facility shall be low smoke.
 2. Low-smoke jacket material for cables shall be flame retardant cross-linked polyolefin, as City approved. The jacket thickness shall be 60 mils minimum.
 3. Jacket material shall meet or exceed the following specifications:
 - a. tensile strength (ASTM D 470) 77.34 kgf/cm² minimum;
 - b. elongation (ASTM D 470) 200 percent minimum;
 - c. tear strength (ASTM D 470) 15.4324 kg/m minimum;
 - d. oxygen index (ASTM D 2863) 27 minimum;
 - e. smoke density (ASTM E 662):
 - i. flaming mode specific optical density 4-minute 50 minimum;
 - ii. flaming mode maximum specific optical density 20-minute 175 minimum;
 - iii. non-flaming mode specific optical density 4-minute 65 minimum; and
 - iv. non-flaming mode maximum specific optical density 20-minute 300 minimum; and
 - f. smoke index (MTL-DTL-32180) 25 minimum;
 - g. halogens content (MTL-DTL-32180) 0.2 percent minimum ;
 - h. toxicity index (MTL-DTL-32180) 8.0 minimum;
 - i. acid gas equiv. (MTL-DTL-32180) 2.0 percent minimum; and
 - j. ozone resistance (ASTM D 470) pass (150ppm @+25 °C).
- C. Outside Cable:
1. Conductors must be 22 AWG, or larger, tinned cooper, meeting Canadian Electrical Code for the intended application.
 2. Conductors and cable inner/outer jacketing must be insulated with Polyethylene (PE), Polyolefin (XLPO), or Cross-linked Polyethylene (XLPE or UL type XHHW-2) that will meet the following minimum requirements:
 - a. sunlight resistant;
 - b. flame test rated FT4;

- c. CSA cold impact/bend test at -40 °C;
 - d. suitable for direct burial; and
 - e. rated for wet/dry environments with temperature range from -40 °C to +70 °C.
3. Cables must meet all other requirements of direct burial outside plant cables as listed by ANSI/ICEA for the intended application (i.e. control wiring, telephony, or broadband).
 4. Cables exposed or installed aerially must be rated for installations to -50° C.
 5. Cables installed confined spaces, intended for personnel or public use, must not use polyethylene and must comply with the following toxicity requirements and as measured using BSS 7239:
 - a. Carbon Monoxide (CO) < 35000 ppm;
 - b. Carbon Dioxide (CO2) < 90000 ppm;
 - c. Hydrogen Fluoride (HF) < 200 ppm;
 - d. Nitrogen Dioxide (NO2) < 100 ppm;
 - e. Hydrogen Chloride (HC) < 500 ppm;
 - f. Hydrogen Cyanide (HCN) < 150 ppm;
 - g. Sulfur Dioxide (SO2) < 100 ppm; and
 - h. Hydrogen Bromide (HB) < 100 ppm.
 6. All outside communications cables (e.g. those run in conduits, trough or duct-banks) shall be foam/skin insulated conductors that meet RUS Specification 7CFR 1755.890 and shall be protected using armor taping or approved equivalent.

6-1.21.2.4 Public Address Cable

- A. Provide and install loudspeaker wiring for connection of all speakers at all Stations and Stops. Loudspeaker cables shall be twisted pairs, stranded No. 14 AWG minimum and rated for extreme temperature conditions (-40 °C to +70 °C).
- B. Local distribution cables for the PA System shall be placed in dedicated conduit or raceways and NOT shared with any other power, communications or electrical cable of any kind.
 1. Cable jacket shall have a 600V rating.
- C. Provide and install cable for connection of all ambient sensing microphones. Cable shall be No. 18 AWG, shielded twisted pairs and rated for extreme temperature conditions (-40 °C to +70 °C).

6-1.21.2.5 CAT-6 Cable

- A. Provide and install all CAT-6 cables for data and telephone service.
 1. Meet all manufacture requirements for the installation and termination of CAT-6 within the Stations, Stops, TPSS facilities, Gerry Wright OMF and Lewis Farms Storage Facility Building as well as service to all Service and ROW phones as described in the contract drawings.
- B. CAT-6 UTP cable shall meet the following physical criteria:

1. Jacket: NEC CL2P, Low Smoke;
 2. Wires: Uniquely Color Coded;
 3. Cable Type: Unshielded Twisted Pair;
 4. Outside diameter of conductor: 0.059 mm (23 AWG);
 5. Outside diameter of insulation: 1.045 mm;
 6. Outside diameter of sheath: 5.8 mm;
 7. Number of twisted pairs: 4;
 8. Conductor type: bare Cu wire; and
 9. Sheath printing: batch number and meter marking.
- C. CAT-6 UTP cab shall meet the following minimum electrical requirements:
1. Characteristic impedance(1-100Mhz): 100+/-15 Ohms;
 2. Characteristic impedance(100-250Mhz): 100+/-18 Ohms;
 3. DC Conductor Loop resistance: 25 Ohms/100 m;
 4. Nominal Capacitance: 50 pF/m; and
 5. Insulation resistance (500V) >= 2000 MegaOhms/km.
- D. CAT-6 UTP cab shall meet the following minimum cable properties:
1. Installation temperature: -20 °C to +50 °C; and
 2. Operating temperature; -40 °C to +70 °C.
- E. CAT-6 UTP cab shall meet the following applicable standards:
1. ISO/IEC 11801:2002;
 2. EN 50173(2002); EN 50288-6-1;
 3. ANSI/TIA/EIA-568; and
 4. Fire Propagation Test: IEC60332.1; EN50265-2-1.

6-1.21.2.6 Data Cable

- A. Serial data cables used for RS-232 applications shall meet the following characteristics:
1. Jacket: NEC CL2P, Low Smoke;
 2. Wires: Uniquely Color Coded;
 3. Cable Type: Twisted pair;
 4. Conductor gauge: No. 24 AWG (7 X 32 AWG) stranded, minimum;

5. Shield: One overall foil shield, with a braided shield minimum;
6. Capacitance: 12 pf/.305 m;
7. Resistance: 30 ohms/304.8 m; and
8. Conductors: 6 to 12-1/2 pairs.

6-1.21.2.7 RS-422 Data Communications Cable

- A. Serial data cables used for RS-422 balanced electrical transmission of data shall have a 600V insulation rating and meet the following characteristics:
 1. Jacket: NEC CL2P, Low Smoke;
 2. Wires: Uniquely Color Coded;
 3. Cable Type: Twisted Pair;
 4. Conductor gauge: No. 24 AWG (7 X 32 AWG) stranded, minimum;
 5. Shield: Individually foil shielded pairs each with a drain wire. One overall foil shield, with a braided shield minimum;
 6. Capacitance: 13 pf/.305 m;
 7. Resistance: 16 ohms/304.8 m; and
 8. Conductors: 2 to 12 pairs.

6-1.21.2.8 Outdoor Telephone, Building SCADA I/O and Data Cable

- A. Provide, install and terminate outdoor telephone and I/O data cabling.
- B. The multi-pair No. 22 AWG filled cable shall conform to RUS Specification 7 CFR 1755.890 except as noted in this Section 6-1.21.2.8 [*Outdoor Telephone, BMS Building SCADA I/O and Data Cable*] of this Schedule.
- C. The conductors shall be solid annealed bare copper conforming to the latest requirements of ASTM-B-3.
 1. Conductors shall be individually insulated with a colored, solid insulating grade, high density polyethylene or polyolefin of ICEA S-56-434.
 2. The insulating material color shall be coded per U.S. telephone industry standards with color concentrates chosen for permanency and electrical balance of individual circuits. The colors of insulated conductors shall be provided in accordance with ICEA S56-434, Section II-7 and shall comply with the requirements of EIA TIA-359.
 3. The insulated conductors shall be twisted into pairs. The length of pair twists shall be designed to meet ICEA S45-434 latest edition.
 4. The average twist length of any pair in the finished cable shall not exceed 15 cm.
 5. The insulated pairs shall be twisted into specified color combinations to provide pair identification as well as low susceptibility to noise pick-up and with varying lay lengths to minimize crosstalk.

6. The insulated pairs shall be assembled into a cable core. Cable cores of 25 or less pairs shall be assembled concentrically.
- D. The filling compound, a petroleum jelly base multi-component, shall be applied to the cable core in such a way as to provide as near to 100 percent fill of the available air space within the core as is commercially practicable.
 1. The filling compound shall be applied in a manner to fill all voids and conductor interstices under the core to restrict the migration of moisture.
 2. The filling compound shall be compatible with the insulation and other cable components.
 - E. The filled core shall be completely covered with a layer of non-hygroscopic, non-wicking polymeric tape applied with overlap over the cable core to ensure high dielectric strength from cable core to shield.
 - F. A 202.3 micron thick corrugated aluminum tape shall be applied over the core. The tape shall be coated with a 51 micron thick copolymer compound and shall be applied longitudinally with overlap.
 - G. The outer jacket shall be of virgin, black high molecular weight polyethylene copolymer except low smoke jacketed cables that shall be as specified below.
 1. The overall jacket shall be sequentially marked at 60 cm intervals with cable type, year of mfg., footage, pair count, conductor size and manufacturer.
 2. The jacket shall be free from holes, splits, blisters or other imperfections and shall be smooth and concentric.

6-1.21.2.9 Public Wi-Fi

- A. Provide and install all infrastructure, cabling, and Wi-Fi access point equipment required for public Wi-Fi access points at each Stop and Station including:
 1. two (2) mounting spaces under the roof structure or canopy per Platform and all Station levels for public Wi-Fi access points, to be agreed upon by the City at the second Interim Design review of the Stops and Stations;
 2. 25 mm embedded and concealed conduit from each mounting space to the nearest ETS LAN Cabinet, not to exceed 90 m;
 3. power and CAT-6 cabling; and
 4. two (2) access points of a type to be specified by the City at the first Interim Design review.
- B. Provide and install all infrastructure, cabling, and Wi-Fi access point equipment required to permit installation and operation, by Other Contractors, of public Wi-Fi access points at the WEM Transit Centre including:
 1. two (2) mounting spaces under roof structure or canopy in the WEM Station interior, to be agreed upon by the City at the second Interim Design review of the Transit Centre; one (1) mounting space in each bus shelter on the north side of the WEM Transit Centre, to be agreed upon by the City at the second Interim Design review of the Transit Centre;
 2. 25 mm embedded and concealed conduit from each mounting space to the WEM Station communications room, not to exceed 90 m;

3. power and CAT-6 cabling; and
 4. a Wi-Fi access point for each agreed upon mounting space, the make and model of which will be specified by the City at the first Interim Design.
- C. Network connectivity for the Wi-Fi access points will be provided by the City.

6-1.22 MASTER CLOCK SYSTEM

- A. Configure all systems in the Valley Line LRT Stage 2 to use the primary and secondary Master Clocks used for Valley Line LRT Stage 1.

6-1.23 ELECTRIC VEHICLE CHARGING STATIONS

- A. Provide electric vehicle charging stations at the Lewis Farms Park and Ride parking lot in accordance with Section 3-4.3.1 [*Lewis Farms Park and Ride Requirements*] of this Schedule.
- B. Provide level 2 charging stations with an integrated pay system.
1. The electric vehicle charging stations shall:
 - a. have self-retractable cords;
 - b. be compatible with the SAE J1722 plug; and
 - c. be manufactured by ChargePoint, Sun Country, or Flo.
- C. Design the electric revenue metered utility service to allow for future charging stations to be added as the need grows for more stations.
- D. Provide necessary secure phone/communication services to handle electronic transactions at the electric vehicle charging stations.

6-1.24 AUTOMATED TELLER MACHINE

- A. Provide the following systems infrastructure for the ATM within the WEM Station, in accordance with Section 5-2.10.1 [*Program Requirements*] of this Schedule:
1. Provide a duplex isolated ground NEMA 5-15R wall mounted receptacle in the wall directly behind the ATM, centred relative to the width of the ATM and positioned such that the centre of the receptacle is 400 mm above the finished floor;
 2. Provide a dedicated 120V 20A circuit with a dedicated neutral conductor and a dedicated ground conductor, sized in accordance with the CEC. Connect the circuit to the duplex receptacle and leave it unenergized. The dedicated ground conductor shall have no splices and be electrically connected only at the duplex receptacle and the source panel. Circuit to be fed from the nearest Level 1 "Emergency" load centre;
 3. Provide a CAT-6 data outlet with two (2) jacks mounted in the wall directly behind the ATM, centred relative to the width of the ATM and positioned such that the centre of the outlet is 400mm above the finished floor; and
 4. Provide two (2) CAT-6 cables from the data outlets to the ETS LAN Cabinet. Terminate cables at outlet location. Coil and leave 1 m at the ETS LAN Cabinet for termination by the City. Install cables in accordance with all applicable EIA and TIA standards.

SECTION 6-2 – TRACTION POWER SYSTEM

6-2.1 INTRODUCTION

6-2.1.1 General

- A. This section outlines the Design and Construction requirements for the Traction Power System, and Traction Power SCADA System for the Valley Line LRT Stage 2 and integration to Valley Line LRT Stage 1.

6-2.1.2 Purpose and Scope

- A. The Project Works for the Traction Power System is the detailed design, manufacture, factory acceptance testing, delivery, installation, integration, site acceptance testing, and Commissioning of the Traction Power System.
- B. This Section 6-2 [*Traction Power System*] presents the system Design and Construction requirements for the:
1. the Traction Power System, which includes the system requirements for the Traction Power Cable, Traction Power Duct Banks and traction power equipment that deliver the propulsion energy from the Traction Power Substations (TPSS) to the LRVs;
 2. Mainline TPSS at the locations listed in Table 6-2-1 [*Mainline TPSS Minimum Ratings*] of this Schedule;
 3. TPSS within the Gerry Wright OMF Building B site and the Lewis Farms Storage Facility, including the TPSS facilities for both the Yard track and the shop areas referenced in Table 6-2-1 [*Mainline TPSS Minimum Ratings*] of this Schedule;
 4. integration into Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule;
 5. Traction Power SCADA System, which defines the requirements for the central monitoring and control of traction power equipment shall be provided such that it can be integrated into the ICS.
 - i. Include the electrical and functional interface requirements of the Traction Power SCADA System for ICS integration in the ICS Interface Control Document.
 6. Traction Power System using a nominal output voltage 750 VDC, as defined in EN 50163, Traction Power Distribution system, with a floating traction return system (for the mainline route) which isolates the rail from ground in order to reduce the likelihood of stray current corrosion.

6-2.2 APPLICABLE CODES, STANDARDS AND REGULATIONS

- A. Ensure that the Traction Power System and all associated infrastructure comply with the following codes, standards and regulations, to the extent applicable, provided that any electrical facilities, infrastructure and systems that are not subject to the NBCAE shall comply with Transportation Electrical Service Plan, as described in Section 6-5 [*Transportation Electrical Service Plan*] of this Schedule:
1. IEEE Standard C37.2 IEEE Standard Electrical Power System Device Function Numbers and Contact Designations;
 2. AREMA C&S Manual;

3. ASTM A780 Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings;
4. Canadian Electrical Code Part I;
5. Canadian Electrical Code Part II;
6. EN 50122-1 Railway Applications - Fixed Installations - Electrical Safety, Earthing and the Return Circuit - Part 1: Protective Provisions Against Electric Shock;
7. EN 50122-2 Railway Applications - Fixed Installations - Electrical Safety, Earthing and the Return Circuit - Part 2 Provisions against the effects of stray currents caused by d.c. traction systems;
8. EN 50388 Railway Applications – Power supply and rolling stock – Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability;
9. BS IEC 61000-5-2 Electromagnetic Compatibility (EMC) – Part 5: Installation and mitigation guidelines – Section 2: Earthing and cabling
10. IEC 62271-202 High Voltage/Low Voltage Prefabricated Substation;
11. IEEE 80 Guide for Safety;
12. IEEE 142 Recommended Practice for Grounding of Industrial and Commercial Power Systems;
13. IEEE 519 Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems;
14. IEEE 1653.1 Traction Power Rectifier Transformer for Substation Applications up to 1500 VDC Nominal Output;
15. IEEE 1653.2 Uncontrolled Traction Power Rectifiers for Substation Applications Up to 1500 VDC Nominal Output;
16. IEEE 1653.3 Guide for Rail Transit Traction Power Systems Modeling
17. IEEE 1653.4 DC Traction Power System Field Testing and Acceptance Criteria for System Applications up to 1500 VDC Nominal;
18. IEEE 1653.6 Recommended Practice for Grounding of DC Equipment enclosures in Traction Power Distribution Facilities;
19. TPSS equipment specific standards set out in Section 6-2.3 [*Design Requirements*] of this Schedule;
20. ANSI C37.09 Standard Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis;
21. ANSI C37.14 Low-Voltage DC Power Circuit Breakers Used in Enclosures;
22. ANSI C37.20.1 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear;
23. ANSI C37.20.2 Metal-Clad and Station-Type Cubicle Switchgear;
24. ANSI C37.20.3 Standard for Metal-Enclosed Interrupter Switchgear;
25. ANSI C37.41 Standard Design Tests for High-Voltage Fuses, Distribution Enclosed Single-Pole Air Switches, Fuse Disconnecting Switches and Accessories;

26. ANSI C37.90 Relays and Relay Systems Associated with Electric Power Apparatus;
27. ANSI C39.1 Requirements for Electrical Analog Indicating Instruments;
28. ANSI C57.13 Standard Requirements for Instrument Transformers;
29. IEEE C57.12.01 Standard General Requirements for Dry-Type Distribution and Power Transformers, Including Those with Solid-Cast and/or Resin Encapsulated Windings;
30. IEEE C57.12.91 Test Code for Dry-Type Distribution and Power Transformers;
31. IEEE C57.12.519 General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
32. IEEE C57.18.10 Standard Practices and Requirements for Semiconductor Power Rectifier Transformers;
33. IEEE P1653.2 Standard for Traction Power Rectifier Transformers for Substation Applications Up to 1500 V DC Nominal Input;
34. ANSI C62.11 Metal Oxide Surge Arresters for AC Power Circuits;
35. ANSI / NETA ATS Standard for Acceptance Testing Specifications for Electrical Power Equipment and Systems;
36. IEEE C37.04 Standard Rating Structure for AC High-Voltage Circuit Breakers;
37. IEEE C37.06 AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis- Preferred Ratings and Related Required Capabilities;
38. IEEE C37.20.1B Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear Amendment 2: Additional Requirements for Control and Auxiliary Power Wiring in DC Traction Power Switchgear;
39. IEEE C37.34 IEEE Standard Test Code for High-Voltage Air Switches;
40. IEEE 400 Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field;
41. IEEE 404 IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2500V to 500000V;
42. ANSI C119.4 Connectors for Use Between Aluminum-to-Aluminium or Aluminum-to-Copper Conductors;
43. IEEE 80 Guide for Safety in AC Substation Grounding;
44. IEEE 81 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System;
45. IEEE 1106 Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Ni-Cad Batteries for Stationary Applications;
46. IEEE 1115 Recommended Practice for Sizing Ni-Cad Batteries for Stationary Applications;
47. IEEE C37.20.3 Standard for Metal-Enclosed Interrupter Switchgear.
48. NEMA PE5 Constant Potential Type Electric Utility Battery Chargers;
49. NEMA SG-4 Alternating Current High-Voltage Circuit Breakers;

50. EN 50122-1 Railway applications - Fixed installations - Electrical safety, earthing and the return circuit - Part 1: Protective provisions against electric shock;
51. EN 50328 Railway applications - Fixed installations - Electronic power converters for substations.
52. EN 50123-1 Railway applications - Fixed installations – DC switchgear - Part 1: General;
53. EN 50123-2 Railway applications - Fixed installations - DC switchgear - Part 2: DC Circuit Breakers;
54. EN 50123-3 Railway applications - Fixed installations - DC switchgear - Part 3: Indoor DC Disconnectors, Switch-Disconnectors and Earthing Switches;
55. EN 50123-4 Railway applications - Fixed installations - DC switchgear - Part 4: Outdoor DC Disconnectors, Switch-Disconnectors and Earthing Switches;
56. EN 50123-5 Railway applications - Fixed installations - DC switchgear - Part 5: Surge Arresters and Low-Voltage Limiters for Specific Use in DC Systems;
57. EN 50123-6 Railway applications - Fixed installations - DC switchgear - Part 6: DC Switchgear Assemblies;
58. EN 50123-7 Railway applications - Fixed installations - DC switchgear - Part 7-1: Measurement, Control and Protection Devices for Specific Use in DC Traction Systems - Application Guide; and
59. EN 50163 Railway applications – Supply Voltages of Traction Systems; 2004+A1:2007.

6-2.3 DESIGN REQUIREMENTS

6-2.3.1 Traction Power - General

- A. Land parcels have been secured for Mainline TPSS at the locations listed in Table 6-2 1 [*Mainline TPSS Minimum Ratings*] of this Schedule.
- B. Submit the results of a load flow simulation study as described in Section 6-2.3.2.2 [*Load Flow*] of this Schedule, with each of the first and second Interim Design submissions and the Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Load Flow Simulation Study**”).
 1. The load flow simulation tool utilized shall be commercially available and has been previously independently validated on a 750V DC nominal Traction Power System.
- C. The TPSS for the Lewis Farms Storage Facility maintenance yard may be physically located within the same building as the Lewis Farms Main Line TPSS. Mainline TPSS redundancy shall be maintained.
- D. Provide a dedicated TPSS at Gerry Wright OMF Stage 2. The supply from this TPSS shall be segregated into a Yard Track TPSS and a Shop TPSS. Parallel redundancy shall be provided between the traction power supply for Yard Track for Gerry Wright OMF Stage 2 and the Yard Track for Gerry Wright OMF Stage 1. The redundancy scheme shall be accepted by the City.
 1. Prepare and submit the design to achieve this redundancy and provide this design with the first Interim Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Gerry Wright OMF Stage 2 TPSS Design Package**”).

- E. Parallel redundancy shall also be provided between the Utility feeds to the Gerry Wright OMF Stage 2 to avoid a loss of power in the event of a failure.

6-2.3.2 TPSS

- A. Minimum TPSS ratings shall comply with the requirements in Table 6-2-1 [Mainline TPSS Minimum Ratings]
1. Final TPSS ratings to be determined based on the Load Flow Simulation Study in accordance with Section 6-2.3.2.2 [Load Flow] of this Schedule.

Table 6-2-1: Mainline TPSS Minimum Ratings

Number	Traction Power Substations	Minimum Ratings (kW)
1	Lewis Estates	1 x 1000
2	190 Street (87 Avenue and 190 Street)	1 x 1000
3	Aldergrove (87 Avenue and 182 Street)	1 x 1000
4	Misericordia (87 Avenue and 165 Street)	1 x 1000
5	Meadowlark (89 Avenue and Meadowlark Road)	1 x 1000
6	94 Avenue (156 Street and 94 Avenue)	1 x 1000
7	Jasper Place (100A Avenue and 156 Street)	1 x 1000
8	144 Street (Stony Plain Road and 144 Street)	1 x 1000
9	Glenora (Stony Plain Road and 132 Street)	1 x 1000
10	125 Street (125 Street and 105 Avenue)	1 x 1000
11	Oliver Square (118 Street and 104 Avenue)	1 x 1000
12	107 Street (107 Street and 104 Avenue)	1 x 1000
13	Gerry Wright OMF Stage 2	2 x 1000
14	Lewis Farms Storage Facility	2 x 1000

- B. Not used.
- C. The maximum cable size for positive and negative track feeder cables shall be 500 kcmil.
- D. Design rectifiers for Mainline TPSS and Yard Track Traction Power System to provide parallel redundancy to one another in the event of an outage.
 - 1. Prepare and submit the redundancy design with each of the first Interim Design and Final Design submissions for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Mainline TPSS Design Package**”).
- E. Provide system integration between the Valley Line LRT Stage 1 and Valley Line LRT Stage 2 for control and protection schemes as described in SCADA and transfer trip sections below.
- F. Provide TPSS capacity to permit all LRVs when stored with full auxiliary load running and LRVs being hosted for service and maintenance within Lewis Farm Storage Facility Site and Gerry Wright OMF Building B site.

6-2.3.2.1 Not Used

6-2.3.2.2 Load Flow

- A. The Load Flow Simulation Study shall confirm the TPSS locations, track and negative feeder cable numbers, parallel feeders and the ratings of the TPSS. The Traction Power requirements for Gerry Wright OMF Site, and Lewis Farms Storage Facility site shall be considered as part of this study.
- B. Base the Load Flow Simulation Study on the worst-case operating scenario to support the Operability and Maintainability Parameters:
 - 1. use the Stage 1 LRV in both static and dynamic cases for mainline operation and Gerry Wright OMF and Lewis Farms Storage Facility operation;
 - 2. develop and assess the Traction Power System design using computer simulation software intended for the purposes of Traction Power System modelling as specified in IEEE 1653.3;
 - 3. ensure that the Traction Power System design can sustain LRV operations based on AW2 passenger loading, two (2) consist Trains and the Operability and Maintainability Parameters;
 - a. consider LRVs to be operated with full auxiliary loads maintained 24 hours a day, seven (7) days a week, in both normal and Contingency Conditions, along the entirety of the Valley Line LRT Stage 2.

6-2.3.3 Substation Enclosure

- A. All TPSSs, whether pre-fabricated or built-in-place, shall:
 - 1. provide sufficient ventilation to ensure that all equipment is maintained within its specified operating temperature under all operating conditions;
 - 2. provide sufficient fresh air exchanges based on battery hydrogen discharge rates;
 - 3. prevent unauthorized access;
 - 4. ensure that all persons are protected from exposure to hazards, including exposure to hazardous voltages, arc flashes, toxic/harmful liquids, gases and explosion risks; and

5. allow any piece of equipment in the TPSS to be safely and reliably maintained and where required, to be removed, replaced, reinstalled, Commissioned and returned to full operation.
- B. Pre-fabricated TPSS buildings shall comply with IEC 62271-202.
- C. Each built-in-place TPSS shall use Traction Power equipment of consistent make, model and ratings to every other Valley Line LRT Stage 2 built-in-place TPSS.
- D. Each pre-fabricated TPSS shall use Traction Power equipment of consistent make, model and ratings to every other Valley Line LRT Stage 2 pre-fabricated TPSS.

6-2.3.3.2 Substation Arrangements

- A. Make arrangements with and obtain primary power connection to each TPSS from the Utility Company. Confirm TPSS equipment compatibility and interoperability in compliance with the Utility Company's Customer Connection Guide.
- B. Coordinate the design of the Traction Power System protection scheme with the Utility Company to achieve margins between all levels of protection systems sufficient to ensure that all schemes and time current characteristics allow for full use of the rated capacity of all equipment.
- C. House each TPSS within a Utility Complex that follows the requirements of Section 2-9.9 [*Utility Complexes*] of this Schedule and the Design Guide.
- D. Provide pad mounted switchgear within each Utility Complex containing a TPSS, for the incoming AC feed, equipped with controlled access and security fencing to limit access, and terminated in accordance with the electric Utility Company's requirements.
 1. Construct all infrastructure and cabling elements from the TPSS structure to the pad mounted switchgear, including metering compartment, duct banks, foundations, grounding, and maintenance hole, in accordance with the electric Utility Company's standards.
- E. Provide auxiliary power supplies for non-Traction Power equipment housed in the Utility Complex which are co-located with the TPSS. The auxiliary power supplies shall be rated for the equipment to be supplied.
- F. At each Utility Complex, provide within an electrical room:
 1. an electrical load centre panel energized from a TPSS auxiliary feed in accordance with Section 6-2.3.3.2E [*Substation Arrangements*] of this Schedule;
 2. transformers; and
 3. such other electrical distribution equipment as required to support the functionality of the applicable Utility Complex.

6-2.3.4 Shop TPSS and Yard TPSS

- A. The Traction Power System within the Lewis Farm Storage Facility site and Gerry Wright OMF Site shall be segregated into a Yard Track Traction Power System and a Shop Traction Power System.
- B. The Yard Track Traction Power System shall provide DC power for LRV movements on all Yard Track and shall be fed from a Yard TPSS, sized to satisfy all Operations and Maintenance activities on the Yard Tracks.

- C. The positive circuits and negative rail return for the Yard Track Traction Power System shall be electrically isolated from the positive circuits and negative rail returns of the Shop Traction Power System.
 - 1. The negative rail returns for the Yard Track Traction Power System shall be a floating system, electrically continuous throughout, and shall be directly connected to the negative return of the Yard TPSS.
- D. The running rails on all Shop Tracks shall be deliberately and permanently grounded in accordance with IEEE 142.
- E. The Shop TPSS shall be connected to each Shop Track contact wire through an isolation switch.
 - 1. The isolation switch shall be wall-mounted for manual operation with a kirk key interlock and shall also be interlocked with each Shop Track contact wire, any crane, lifting, jacking, maintenance device (wheel truing), shop catwalk access, and other device that may cause injury or damage if Traction Power should be left unintentionally energized as determined by the preliminary hazard analysis.
 - 2. Prepare and submit the isolation switch design with each of the second Interim Design and Final Design submissions for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Isolation Switch Design Package**”).
- F. Operation of the isolation switch shall only occur when circuit loads have been unloaded via lowering of the LRV Pantograph.
 - 1. Appropriate visual signage describing the operation shall be placed on the isolation switch face.
- G. The Shop Traction Power System shall be interlocked throughout the Shop Track through a resettable visual and audible emergency trip system which automatically de-energizes the TPSS to the Shop Traction Power System in the event of a trip caused by a fault condition or manually activated emergency Traction Power System shutoff.
- H. Make arrangements with and obtain primary power connection to each TPSS from the electric Utility Company.
 - 1. Confirm TPSS equipment compatibility and interoperability in compliance with the electric Utility Company's Customer Connection Guide.
- I. Coordinate the design of the Traction Power System protection scheme with the electric Utility Company to achieve margins between all levels of protection systems sufficient to ensure that all schemes and time current characteristics allow for full use of the rated capacity of all equipment.
 - 1. Prepare and submit the Traction Power System protection scheme with each of the second Interim Design and Final Design submissions for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Traction Power System Protection Scheme**”).
- J. Provide pad mounted switchgear for the incoming AC feed, equipped with controlled access and security fencing to limit access, and terminated in accordance with the electric Utility Company's requirements.
 - 1. Coordinate with the electric Utility Company to ensure sufficient space is available. Construct all infrastructure and cabling elements from the TPSS structure to the pad mounted switchgear, including metering compartment, duct banks, foundations, grounding, and maintenance hole, in accordance with the electric Utility Company's standards.

6-2.3.5 Traction Power Cables and Connections

6-2.3.5.1 Traction Power Cables and Cable Termination

- A. Ensure that each switchgear assembly has adequate space for termination of power cables to feeder circuit breakers entering from below or above.
 - 1. Necessary means for supporting and connecting the cables at the terminals shall be furnished. The cable entry cover plate shall be bolted to permit field drilling of holes for conduit entry.
- B. Provide DC switchgear that are equipped for receipt of 750 VDC copper single core 500 kcmil cables and ensure that cable connectors / lugs for cable terminations are suitable for their intended use.
- C. All Traction Power cabling shall be run as contiguous cables lengths with no splices or junctions.
- D. Provide Medium Voltage Alternating Current (MVAC) switchgear that are equipped for receipt of three (3) core power cables or three (3) single-core cables in accordance with ANSI C37.20.2.
 - 1. The MVAC infeed supplies to the Utility Complexes shall comply with the electric Utility Company's Customer Connection Guide.
- E. Provide gland plates, where required that are equipped for receipt of all control and auxiliary multicore and multipair cables.
- F. Ensure that all Traction Power Cables are suitable for the application and rated for the load and fault currents to which it may be subjected, and where applicable, the de-rating effects when multiple cables are grouped together, and have insulation selected to ensure that emission of harmful products is avoided in any Confined Space through the use of low smoke zero halogen cabling.
- G. Ensure all conductors forming part of the Traction Power Distribution system are electrically rated for the maximum load and fault currents to which they may be subjected under all environmental conditions applicable to the location at which they are installed.
- H. If Track Circuits are used provide impedance bonds between each set of adjoining Track Circuits, with center taps and high current carrying cables to carry the Traction Power return current from Track to Track and back to the TPSS rectifiers.
 - 1. Un-tuned impedance bonds shall comply with the requirements of AREMA C&S Manual - *Part 8.4.5 Recommended Design Criteria for Low Frequency Untuned Impedance Bonds*.
 - 2. Tuned impedance bonds shall comply with the requirements of AREMA C&S Manual - *Part 8.4.9 Recommended Design Criteria for Low Frequency Tuned Impedance Bonds*.
- I. Provide cross bonding, if Track Circuits are not used, to ensure balanced negative return current through the running rails.
- J. Cable connections shall be corrosion protected.
- K. Provide a label at each end of each Traction Power Cable to identify the type, size and function of the cable.

6-2.3.6 Traction Power Duct Bank

- A. Provide manholes in Traction Power Duct Banks where required for access to, or installation of Traction Power Cable, and at a maximum spacing of 120 m.
- B. Locate the Traction Power Duct Bank away from the tree line, where Street Trees are provided along the LRT Corridor, to prevent tree root intrusion of the Traction Power Duct Bank.

- C. Provide Traction Power Duct Banks from each TPSS exiting point to the intersect point of the Traction Power Distribution system. Traction Power Duct Banks shall:
 - 1. be constructed of non-conductive material;
 - 2. be encased in concrete;
 - 3. be sloped at a minimum of 1:250 towards manholes;
 - 4. be provided with drainage into a subdrain system to prevent accumulation of standing water in manholes;
 - 5. be provided with a utility marking tape (with magnetic tracer), placed at a maximum 330mm above each underground raceway;
 - 6. include one spare empty conduit per each duct bank;
 - 7. provide separate positive and negative duct banks and pull vaults;
 - 8. maintain a minimum separation of 1 m from the Systems Duct Bank;
 - 9. on the Elevated Guideways, be concealed within the Structure;
 - 10. be provided with expansion fittings at all deck joints on Elevated Guideways to accommodate movements; and
 - 11. be provided with appropriate fittings, designed to accommodate all movements and prevent damage to the Traction Power Duct Bank, and the associated conduit, at any locations where rotations, horizontal displacements or vertical displacements may occur.
- D. Manholes shall meet the requirements as described in Section 6-1.5 T [*Systems Duct Bank and Associated Infrastructure*] of this Schedule.
- E. The Design of the cable routes, including the traction power duct banks shall ensure that the minimum bending radius of the traction power cables are adhered to.
 - 1. Pulling tension calculations shall be performed by Project Co and submitted with the Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the "**Pulling Tension Calculations**").

6-2.3.7 Substation and Earthing Connections

- A. Provide the substation earthing and ground grid design around the perimeter of substation building in accordance with IEEE 80 - *Guide for Safety*.
 - 1. Ground grid design for the TPSS will be coordinated with the Utility Complex ground grid.
- B. Prepare and submit the design and associated calculations / simulations with each of the second Interim Design and Final Design submissions for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the "**TPSS Ground Grid Design**").
- C. Prepare and submit each site's soil resistivity readings used for ground grid designs with the second Interim Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (each, a "**Site Soil Resistivity Reading**").
- D. Prepare and submit each site's final ground grid resistivity readings to confirm ground grid designs with the Final Design submission for the Traction Power Substation Supply and Distribution as

described in Appendix 4B [*Project Specific Submission Requirements*], (each, a “**Final Ground Grid Resistivity Reading**”).

- E. Mitigate any ground grids that do not meet project specifications.

6-2.3.8 Medium Voltage AC Switchgear

- A. Ensure that the AC switchgear is a front access, freestanding metal cubicle with withdrawable circuit breakers.
 - 1. The AC switchgear shall be of the metal-clad construction and shall be designed and fabricated in accordance with ANSI C37.20.2 - *Metal-Clad and Station-Type Cubicle Switchgear* with the exception of the rear bus compartment that shall be manufactured to ANSI C37.20.3 - *Standard for Metal-Enclosed Interrupter Switchgear* or equivalent as accepted by the City.
- B. Ensure that the AC switchgear is manufactured to ANSI C37.20.7 - *Guide for Testing Metal-Enclosed Switchgear for Internal Arcing Faults* and is afforded with Accessibility Type 2C.
- C. Ensure that the equipment is suitable for use in an indoor environment, including the requirements associated with ambient temperature.

6-2.3.9 DC Power Switchgear

- A. Ensure that the DC switchgear assemblies at each substation consist of four (4) track feeder breakers and one rectifier breaker.
 - 1. The DC switchgear assemblies shall comply with the requirements of ANSI C37.20 and shall form a lineup of dead-front freestanding indoor sheet-steel enclosures.
 - 2. Enclosures shall be designed for high resistance grounding system.
- B. Include draw out, single pole DC power circuit breakers, DC positive buses and bus connections, indicating lights, terminal blocks, protective and auxiliary relays, control circuitry, wiring and all other devices necessary to make a complete and operable assembly on each switchgear assembly.
- C. Ensure that the height of components allows for the required servicing, maintenance or adjustment of the relays and devices installed in or on the switchgear assembly. Such components, relays and devices shall be accessible from the front of the lineup.
- D. Ensure that the switchgear shall serve as the control and protective equipment for the distribution of DC power to the LRVs.
- E. Ensure that switchgear assemblies are provided with appropriate ratings for the loads and environment.
- F. Prepare and submit the DC switchgear shop drawings (the “**DC Switchgear Shop Drawings**”) with the Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*].

6-2.3.10 Negative DC Disconnect Switch

- A. Provide a negative DC disconnect switch mounted in a separate cubicle in each TPSS DC switchgear assembly, and:
 - 1. install them between the negative return cable and the rectifier negative pole;
 - 2. ensure that the rating of the disconnect switch is appropriate for the TPSS ratings and the environment in which it is installed;

3. ensure that it has a solid copper blade with silver plated contacts that is manually-operated, single-pole and jaw-pressure-type, and an insulated operating handle;
4. design them with interlocking feature to ensure it can be opened only under no-load;
5. provide a green and red indicating light on the front panel of cubicle where:
 - a. green indicates switch open; and
 - b. red indicates switch closed; and
6. provide a simple operation instruction nameplate on the cubicle door.

6-2.3.11 Transformer Rectifier Unit (TRU)

- A. Provide a TRU that consists of a dry-type rectifier transformer, complete with all equipment from the high voltage bus work entrance on the transformer to the AC cable connection to the rectifier unit and from the rectifier unit bus connections to the DC switchgear.
- B. For each TRU provide auxiliaries, controls, wireways, interconnecting AC and DC buses, enclosures and necessary hardware, wiring and devices from the high voltage side of the transformer to the DC bus connections to the DC switchgear and negative enclosure.
- C. Ensure that the transformer-rectifier unit conforms to the following standards, except as otherwise specified:
 1. IEEE C57.12.01;
 2. IEEE C57.12.91, and 519; and
 3. IEEE P1653.2.
- D. The transformer rectifier unit shall convert the utility 60 Hz AC, three-phase, three-conductor primary power to nominal 750 VDC, minimum 1130 kVA at 100 percent of full load.
- E. Ensure that transformer-rectifier units are 12-pulse and double-way.
- F. Ensure that the TRUs after constant full load temperatures are reached, are designed to operate at 150 percent of rated load Amperes for two (2) hours and a superimposed cycle of overloads consisting of five (5) periods of 1 minute each at 300 percent of rated load Amperes followed by one period of 450 percent of rated load Amperes for 15 seconds at the end of the period.
- G. For the TRU provide protection against transient surge voltages on the DC side of the rectifier. If fuses are used in suppression networks, they shall be monitored by visual indicators and equipped with indication devices wired to LCMS and SCADA.
- H. Provide the following tap settings on the TRU's rectifier transformer:
 1. $3 \pm 2.5\%$ taps on primary side windings where the tap positions shall be clearly marked, and the lowest output voltage tap position shall be tap 1.
- I. It shall not be possible to leave the tap switch in an intermediate position between taps with an open circuit winding.
- J. Provide single line display decal of the equipment lineup on the front of TRU rectifier cubicles.

6-2.3.12 Transformer Enclosure and Base

6-2.3.12.1 Transformer Base

- A. Construct each transformer base from structural steel members suitable for rolling or skidding in any direction.
- B. Provide jacking facilities to permit insertion of rollers between floor and transformer base.
- C. Design transformer base mounting to minimize vibration by using vibration isolation dampers.

6-2.3.12.2 Nameplate

- A. Provide each traction power transformer with a corrosion-resistant metal nameplate marked in accordance with IEEE C57.12.01 - *Standard General Requirements for Dry-Type Distribution and Power Transformers, Including those with Solid-Cast and/or Resin Encapsulated Windings*.
 - 1. Securely fasten nameplate to the front of the transformer enclosure.

6-2.3.12.3 AC Surge Arrester

- A. Provide AC surge arresters on each traction power transformer primary side.
- B. Provide a separate rigid steel, self-supporting and self-contained, welded or bolted compartment for the AC surge arresters within and at an accessible location on the back of transformer enclosure.

6-2.3.12.4 Type and Rating

- A. Construct a TRU rectifier assembly in accordance with IEEE C37.20.3 *Standard for Metal-Enclosed Interrupter Switchgear*, as modified herein.
- B. Ensure that each TRU rectifier is an operative assembly, consisting of silicon diodes, internal buses, terminals for connection to external power and control wiring or buses, shunts, base or bleeder load resistors, protective devices, control wiring, terminal blocks, compartments, cubicles and all other necessary accessories.
- C. Design each TRU rectifier for extra heavy-duty traction service as defined in this section.
- D. Ensure that all TRU rectifier assemblies are identical.

6-2.3.12.5 DC Surge Arrestor

- A. Equip TRU rectifier unit with DC surge arrestors and ensure that the arresters fail in a safe manner.

6-2.3.12.6 Heating and Cooling System

- A. TRU rectifier shall be natural convection air-cooled at the extra heavy traction loading specified.
- B. For maintenance, heat transfer surfaces and characteristics shall be designed for easy cleaning and to minimize accumulations of dust and other contaminants expected in the operating environment.

6-2.3.12.7 Nameplate

- A. Ensure that each TRU rectifier has a corrosion resistant metal nameplate containing the following information:
 - 1. name of manufacturer;

2. year of manufacture;
3. serial number(s);
4. output rated power;
5. output rated voltage;
6. output rated current;
7. overload currents - magnitude and duration; and
8. schematic diagram number.

6-2.3.13 Traction Power SCADA System

- A. Furnish the Traction Power SCADA System and ensure that it is fully integrated with all related traction power equipment and systems specified within the TPSS via serial communication link to the RTU.
- B. Provide a SCADA headend HMI at the Lewis Farms Storage Facility and Gerry Wright OMF Building B. The SCADA headend will provide all control and monitoring functionality described within Section 6-2.3.3.2 [*Substation Arrangements*] of this Schedule.
- C. Provide password protected login credential based on the following levels and access permissions:
 1. administrator – full access rights including ability to reset lower level access credentials. This will include the ability to create new levels of access and logins;
 2. viewer – ability to view information only; and
 3. maintenance – full access to all functionality. No ability to reset credentials or create new logins.
- D. Ensure that the Traction Power SCADA System has sufficient capacity for all control and monitoring points for future integration with the Valley Line LRT Stage 1 traction power system in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*].
- E. Ensure that the Traction Power SCADA System has capacity for all control and monitoring points, with an additional 25% local I/O expansion capacity at each TPSS, and with corresponding processing capacity of the head end equipment at the Data Centre(s).
- F. Prepare and submit an I/O schedule for the Traction Power SCADA System with each of the first Interim Design submission, second Interim Design submission and Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**Traction Power SCADA System I/O Schedule**”).
 1. The Traction Power SCADA System I/O Schedule shall be consistent with that of the Valley Line LRT Stage 1.
- G. Base the Traction Power SCADA System architecture upon PLCs networked to micro-processor based protective relays, IEDs and other smart substation components to facilitate distributed monitoring and control of the TPSS.
- H. The Traction Power SCADA System shall be designed to facilitate all control and monitoring functions that can be integrated into a future IP based ICS;
 1. include the electrical and functional interface requirements of the Building SCADA system for ICS integration in the ICS Interface Control Document.

- I. Ensure that the PLCs include all the necessary hardware and software to ensure a fully operational coordinated system.
- J. The PLC system must be designed to integrate and control all switchgear functions, system monitoring and data logging.
 - 1. the PLC shall communicate directly to the SCADA Network Switch that in turn communicates to the Control Centre.
- K. Provide a PLC based control and interface system for the Traction Power System which shall as a minimum monitor the following:
 - 1. remote operation and status indication of all MVAC breakers. MVAC circuit breaker relays status/trip information;
 - 2. remote operation and status indication of all DC circuit breakers;
 - 3. rectifier negative disconnect switch position;
 - 4. transformer over-temperature;
 - 5. rectifier over-temperature;
 - 6. rectifier fuse failure;
 - 7. negative overvoltage;
 - 8. Utility power failure;
 - 9. rail ground switch status; and
 - 10. feeder and tie switch status.
- L. The following building status information must be communicated from Building SCADA in accordance with Section 6-1.14 [*Building SCADA*] of this Schedule:
 - 1. substation intrusion alarm;
 - 2. building inside temperature;
 - 3. fire alarm; and
 - 4. manhole high water level.
- M. Fire alarms must be interlocked with the HVAC system in accordance with the NBCAE and NFCAE.
 - 1. The intrusion alarm system must initiate indoor and outdoor building lights. Status and alarm signals may also be sent directly to monitoring locations at the Operations Control Centre.

6-2.3.14 Local Central Monitoring System (LCMS)

- A. Provide an LCMS for control and visualization of the items of equipment within the TPSS and ensure that the LCMS has an HMI that displays a mimic of the Traction Power System being monitored, providing clear displays, and facilities for easy operation and monitoring.
- B. Ensure that the LCMS has facilities to provide a status on each of the traction power equipment and an interface to perform functionality such as open/close. Local annunciation shall as a minimum include the following:

1. AC breakers status;
 2. DC breakers status;
 3. rectifier diode alarm;
 4. rectifier diode trip;
 5. relay trip warning;
 6. status of control power;
 7. rectifier diode temperature alarm and trip;
 8. frame fault trip;
 9. rail overvoltage alarm and trip;
 10. AC over/under voltage;
 11. DC over voltage;
 12. rectifier over voltage;
 13. DC door open trip;
 14. reverse current trip;
 15. Tx winding temperature alarm and trip;
 16. rectifier over temperature alarm and trip;
 17. negative disconnect switch status;
 18. feeder and tie switch status; and
 19. ground switch status.
- C. Ensure that remote control and monitoring of the substation equipment can be provided from both the LCMS and the SCADA headend system, by ensuring that:
1. when the local/remote switch on each of the AC/DC switchgear cubicle is set to "local", the switchgear operation is controlled locally only. Neither SCADA level nor LCMS level is able to send control commands to the switchgear;
 2. the LCMS is provided with a local/remote option, and when "local" option is selected, the switchgear which has been set to "remote" at TPSS equipment level is controllable from LCMS HMI only.
 - a. SCADA is not able to send control commands to the switchgear. When "remote" option is selected, LCMS is not able to send operation commands to any switchgear.
 - b. all switchgear which have been set to "remote" at equipment level are controlled remotely from the SCADA headend; and
 3. operation command of switchgear from SCADA headend is valid only when both TPSS equipment and LCMS have been set to "remote".

6-2.3.15 Protection Schemes

- A. Prepare and submit the DC and AC protection coordination studies and short circuit analysis with each of the second Interim Design submission and Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**DC and AC Protection Coordination Studies and Short Circuit Analysis**”)

6-2.3.15.2 Intelligent Electronic Device (IED)

- A. Provide IEDs for the following functions associated with protection, measuring, and control in the Traction Power System:
 - 1. reclosing/load measuring;
 - 2. transfer trip and transfer trip lockout;
 - a. associated transfer trip and reclosing logic;
 - 3. reverse current;
 - 4. rail-to-ground over-voltage;
 - 5. rate of rise;
 - 6. rectifier over-temperature;
 - 7. undervoltage;
 - 8. transformer overtemperature;
 - 9. phase fault time overcurrent;
 - 10. ground fault time overcurrent;
 - 11. position of breaker;
 - 12. high resistance frame fault detection and monitoring;
 - 13. position of DC breakers;
 - 14. rectifier diode failure alarm; and
 - 15. voltage presence detector.

6-2.3.15.3 AC Switchgear Protective Device

- A. Provide, as a minimum, the following relaying protection functions/devices for each AC incoming feeder breaker, where numbers in brackets are the IEEE Electric Power System device function numbers:
 - 1. phase inverse time and instantaneous overcurrent protection *(50/51P);
 - 2. ground inverse time and instantaneous overcurrent protection (50/51N);
 - 3. AC Undervoltage/Overvoltage protection (27/59P);
 - 4. loss of 125VDC control voltage (27A);

5. transformer/Rectifier thermal overload relay (49);
6. AC main lock-out relay (86);
7. AC transformer and rectifier lockout relay (86A);
8. AC overvoltage (59); and
9. AC breaker fail (50BF).

6-2.3.15.4 DC Switchgear Protective Device

- A. Provide as a minimum the following protective functions/devices for the feeder breakers of the DC switchboard, where numbers in brackets are the IEEE Electric Power System device function numbers:
 1. direct acting DC instantaneous overcurrent trip device (76);
 2. loss of 125VDC control voltage (27A);
 3. DC instantaneous overcurrent (50D);
 4. DC feeder time overcurrent relay (151);
 5. DC rate-of-rise overcurrent relay (150);
 6. Delta I overcurrent relay (150/151);
 7. DC breaker fail (150/BF);
 8. load measure and reclose relays (182, 183);
 9. transfer trip relay (85); and
 10. DC overvoltage (59D).
- B. In addition, the DC switchgear must include the following;
 1. DC main breaker reverse current relay (32);
 2. DC main breaker fail (150BF);
 3. primary frame fault relay (64A);
 4. secondary frame fault relay (64B); and
 5. rail overvoltage relay (59T).
- C. For high-resistance frame fault:
 1. connect a high-resistance frame fault relay between the structure and the ground mat;
 2. insulate the DC switchgear enclosure from ground;
 3. provide adjustable settings for annunciation/alarm and trip functions; and
 4. detect occurrence of any grounded structure or energized structure and trip and lock-out the TPSS.

- D. Reclose the DC feeder breakers after the main DC circuit breaker is opened, except when a frame fault occurs the DC breaker shall be locked out.
 - 1. In the event of a trip due to a momentary fault, three (3) attempts will be made to re-close the circuit if the voltage between the positive catenary line and negative rails through a resistance bridge exceeds a pre-set value.
 - 2. In the case that the re-close attempts fail, the re-closing relay must lock out.
- E. Operate the main DC circuit breaker to isolate the transformer-rectifier unit in case of an internal fault while allowing continuity of the overhead distribution system.
- F. Provide and install fiber optic cable as the communication media between substations for transfer trip function including the Churchill Connector Utility Complex for Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule. The transfer trip shall;
 - 1. provide interface to and termination of the fibers for a complete operating transfer trip function;
 - 2. monitor the condition of the fiber optic cable continuously;
 - a. generate an alarm and send to LCMS if a fault condition is detected;
 - 3. initiate direct transfer tripping between feeder breakers supplying power to the same section of Overhead Catenary System; and
 - 4. initiate tripping of the remote active breaker feeding the same section when tripping of a DC breaker occurs.
- G. Provide two (2) types of transfer trip and integrate into the Valley Line LRT Stage 1 protection coordination scheme:
 - 1. the first type shall be automatically resettable. Automatic resetting shall be controlled by the load measure reclose relay and occurs on di/dt faults;
 - 2. the second type shall require manual resetting. It shall trip the DC lockout relay in both the originating and receiving substations, and is required for DC instantaneous over-current, frame faults, rail-to-earth potential faults, incomplete sequence faults, and emergency shutdown; and
 - 3. fiber optic monitoring and transfer trip shall be integral to protection relays.
- H. For reverse current:
 - 1. provide reverse current detection for the main DC breaker; and
 - 2. the protection shall detect current flow from the distribution bus into the rectifier unit and trip and lock out the main DC and AC circuit breakers.
- I. Provide a DC protection study that incorporates the protection features listed above and is aligned to the philosophy and approach that has been designed for the Valley Line LRT Stage 1.

6-2.3.15.5 Rail to Ground Voltage Monitoring

- A. Provide multiple stage rail to ground voltage protection trip functionality at each TPSS to monitor the rail to ground potential and provide automatic grounding of the rail by activating a high current GTO thyristor when the voltage exceeds the pre-set limits.

- B. Apply VLDs to automatically and temporarily bond the running rails to ground, when pre-set limits are exceeded;
 - 1. all instances of VLDs engaging shall be automatically reported to the OCC and be provided with electrical protection to enable isolation of the Traction Power Distribution system in the event of electrical faults; and
 - 2. the settings of the VLDs shall be subject to a Hazard Analysis, that considers both the Infrastructure design and the Valley Line LRT Stage 1 rail to ground protection scheme.
- C. Coordinate the rail to ground voltage monitoring and DC protection scheme with the monitoring and DC protection design of the Valley Line LRT Stage 1.

6-2.3.16 DC Battery and Battery Charger

- A. Provide a DC battery system and charger to power the control, monitoring and protective devices.
 - 1. include a primary input circuit breaker, isolation transformer, the batteries, battery charger, DC filter, fused disconnect switch, battery racks, 125V and 24 VDC panel boards, and accessories and all connections for an operating battery system; and;
 - 2. The battery system shall conform to the requirements of CEC, section 14 requirements for batteries.

6-2.3.16.2 Batteries

- A. Provide batteries that are designed to provide float service under normal usage for the intended duty cycle.
- B. Batteries shall be valve-regulated, lead acid or Ni-Cad, heavy-duty design, sealed cell type, consisting of individual cells in molded cases for durability, high impact resistant.
- C. Size battery capacity in accordance with IEEE 1115.
- D. Provide rated ampere-hours for at least 10-hour discharge rate.
- E. Provide battery bank with a stainless-steel nameplate with the following information:
 - 1. manufacturer's name;
 - 2. battery and cell type;
 - 3. month and year of manufacture;
 - 4. 1 minute, 1 hour and 8-hour ampere rating;
 - 5. Ampere-hour capacity of C/8 (8 hours) and C/10 (10 hours); and
 - 6. accessories.
- F. Provide both local and remote annunciation via the SCADA system in the event of battery charger failure. At a minimum the following failures shall be detected and annunciated as a battery charger failure:
 - 1. loss of AC input supply;
 - 2. loss of DC output;

3. ground fault;
4. 750 VDC shorted to 125 or 24 VDC;
5. low DC output voltage; and
6. main DC circuit breaker position.

6-2.3.17 Telephones and Controlled Access

- A. Provide administrative telephones at each Utility Complex, as prescribed in Section 6-1.14 [*Telephones*] of this Schedule.

6-2.3.18 Material Requirements

6-2.3.18.1 Shop Drawings

- A. All shop drawings of TPSS equipment shall be available at and after the Final Design submission, to the City upon request.

6-2.3.18.2 Materials and Equipment

- A. TPSS materials and equipment shall be new and suitable for the use intended and of the manufacturer's latest standard design.
- B. Provide TPSS materials and equipment which are standard products of manufacturers regularly engaged in the production of such material and equipment.
- C. Where two (2) or more units of the same class of TPSS material or equipment are required, provide products of a single manufacturer.
- D. The use of discontinued TPSS materials or products are not permitted.
- E. Each type of TPSS material and equipment shall be of the same manufacture and quality throughout each of the TPSS.

6-2.3.18.3 TPSS Environment

- A. Provide TPSS material and equipment suitable for its intended environment:
 1. for wet locations, provide NEMA 4X corrosion resistant stainless-steel enclosures;
 2. for wet locations, provide corrosion resistant fittings or supports, hot-dip galvanized or as otherwise specified; and
 3. for exposed dry locations, corrosion resistant painted finishes may be used for equipment and enclosures, as acceptable to the City acting reasonably.
- B. Dissimilar metals shall only be permitted at permanent connections provided that the following conditions are met:
 1. connections are provided with a suitable electrochemical isolation; and
 2. isolation treatments are permanent with no requirement for maintenance or replacement for the life of the equipment or installation.

6-2.4 FACTORY ACCEPTANCE TESTING

6-2.4.1 General

- A. Perform all work necessary for planning and conducting of the required tests.
 - 1. Prepare the required documentation for the performed tests.
 - 2. Provide qualified personnel to perform all required testing.
- B. Perform necessary corrections and retesting to prove compliance and acceptance by the City when any system or subsystem does not meet the requirements of this specification.
- C. Prepare and submit a factory acceptance test plan that describes the tests to be performed, the pass / fail criteria for each test, the test documentation to be submitted, correction procedures and anticipated test dates, the ("**TPS Factory Acceptance Test Plan**").
 - 1. The TPS Factory Acceptance Test Plan shall be submitted with the Final Design submission for the Traction Power Substation Supply and Distribution as described in Appendix 4B [*Project Specific Submission Requirements*], or 90 days prior to the first test, whichever comes first.
- D. The City shall have the right to witness any or all tests at the manufacturer's plant, Project Co's shop or construction site. Notify the City in writing at least 60 calendar days prior to start of any test.
 - 1. Any tests performed without notifying the City in writing will be deemed not to have been performed.

6-2.4.2 Factory Tests

- A. Conduct, as a minimum, the factory tests detailed in this Section 6-2.4.2 [*Factory Tests*] of this Schedule.

6-2.4.2.1 Traction Power Transformer

- A. Factory dielectric tests shall be in accordance with IEEE C57.12.91.
- B. Applied-voltage and induced-voltage tests shall be in accordance with IEEE C57.12.91.
- C. Resistance measurements of all windings shall be on all taps.
- D. Ratio tests on the rated voltage connections and on all taps shall be in accordance with IEEE C57.12.91.
- E. Polarity and phase relation shall be in accordance with IEEE C57.12.91.
- F. No-load losses and excitation current shall be in accordance with IEEE C57.12.91.
- G. Perform the following partial discharge tests:
 - 1. subject transformer to an induced voltage of 1.5 times the rated voltage at a frequency between 100 and 400 Hz;
 - 2. partial discharge extinction level shall be reached at an induced voltage of not less than 1.2 times the rated line-to-line voltage; and
 - 3. partial discharge extinction level will be defined as the point when the reading at 1.9 MHz is less than ten (10) microvolts or 100 picocoulombs.

6-2.4.2.2 Rectifier

- A. Dielectric tests shall be in accordance using IEEE 1653.2
- B. Perform continuity tests of all cables and buses.
- C. Rated voltage test shall be in accordance using IEEE1653.2.
- D. For DC Switchgear, follow ANSI C37.20.1 for:
 - 1. dielectric tests;
 - 2. mechanical operation tests; and
 - 3. electrical functionalities and control wiring continuity.

6-2.4.3 DC Circuit Breaker

- A. Test each DC circuit breaker following ANSI C37.14 to mounting inside DC switchgear:
 - 1. calibration test;
 - 2. control, secondary wiring and device check test;
 - 3. dielectric withstand voltage test; and
 - 4. no-load operation test.

6-2.4.3.2 DC Disconnect Switch

- A. Test each DC disconnect switch complying with production tests in ANSI C37.41. Check for gaps and confirm with manufacturing specifications.
- B. Test functionality of all components.
- C. Perform power frequency dielectric withstand test.
- D. Test electric resistance of current path.
- E. Test DC protection relays and control devices complying with ANSI C37.90.
- F. Check for accuracy and functionality of meters, instruments and instrument transformers complying with ANSI C39.1 and ANSI C57.13.

6-2.4.3.3 Substation Local Centralized Monitoring System (LCMS)

- A. Verify electrical operation and accuracy complying with ANSI C37.20.1.
- B. Test control wiring continuity by actual electrical operation of control devices.

6-2.5 TRANSPORTATION

- A. All equipment shall be capable of withstanding without damage the normal vibrations and shocks liable to be encountered in transit to site. If required, special packaging shall be provided to achieve this.

6-2.6 SITE WORKS

- A. After installation, demonstrate that all equipment including wiring is properly installed, in operational condition, complying with confirmed drawings and schematics.
 - 1. Energize only low voltage circuit (600 V or less) for the electrical functionality testing.
 - 2. No equipment shall be energized or placed in operating mode until completion of field installation testing and permission of test engineer.
 - 3. Check the interlocks on the enclosure and panels for proper functioning alarm and operation of shutdown circuitry.
 - 4. Use oscilloscope, test and record the functionalities of the protective functions.
- B. For electrically insulated floor and wall tests:
 - 1. prior to the installation of substation equipment, perform hi-potential dielectric tests on the epoxy floor and wall insulation installed in each traction power substation room; and
 - 2. use a hi-potential tester with a voltage range of 0-15,000 VDC and a current range of 0-2000 microamperes DC to perform the tests.
- C. For wire and cable testing:
 - 1. perform tests after factory or field wiring has been pulled in place and terminations installed; and
 - 2. for continuity tests, check continuity from point to point and check for shorts to ground with an ohmmeter.
- D. High potential tests shall be in accordance with IEEE 400 - Guide for Making High-Direct-Voltage Tests on Power Cable Systems in the Field.
 - 1. Passing criteria shall have no insulation breakdown or excessive leakage current.
 - 2. For failures, locate and determine the trouble, replace defective wires, cables or components, make necessary corrections to installation, and retest without additional cost to the City.
- E. Test 600 V control circuit wiring for continuity and insulation.
 - 1. Protect semiconductor devices against the test voltage by means of shorting jumpers or equivalent methods, if they are not inherently protected by the circuit in which they are used.
- F. For grounding in TPSS:
 - 1. using agreed grounding plan, verify correct grounding of all equipment requiring grounding.
- G. Re-test of the substation ground:
 - 1. retest the ground at each substation in accordance with IEEE 81 - Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System; and
 - 2. an established metallic ground may be utilized as the test reference.
- H. For DC switchgear high-potential tests:
 - 1. disconnect high-resistance ground relay (use electrical schematics to find the location and number of this device);

2. perform test between the AC and DC switchgear, including fasteners and the isolation laminate, at 2500 VDC. Leakage current must be less than 50 microamperes;
 3. perform test from dc switchgear enclosure to ground at 2500 VDC. Leakage current shall be less than 50 microamperes;
 4. perform continuity tests on all interconnecting cables and buses;
 5. perform insulation test on all interconnecting feeder cables using a 2500 VDC megohmmeter for 1 minute;
 6. test positive and negative feeder buses to ground using a 2500 VDC megohmmeter for 1 minute;
 7. verify load measuring and reclosing functions;
 8. verify functional tests of the emergency trip stations; and
 9. verify proper operation of all interlocks and Kirk key schemes.
- I. For DC disconnecting switches:
1. perform continuity and insulation tests on all interconnecting cables and buses;
 2. test positive or negative feeder buses to ground using a 2500 VDC megohmmeter for 1 minute;
 3. verify proper operation of all interlock schemes; and
 4. verify proper operation of voltage presence detector.
- J. For DC relays:
1. verify proper operation and setting of all relays including rate of rise, frame fault relay and rail to earth relay; and
 2. where applicable, settings to be in accordance with approved relay coordination curves.
- K. For Traction Power transformers:
1. perform insulation tests between windings and between windings to ground and between the core to ground using a 2500 VDC megohmmeter for 1 minute; and
 2. perform functional tests of temperature protective devices.
- L. For rectifiers:
1. perform insulation tests between the diode strings and rectifier enclosure using a 2500 VDC megohmmeter for 1 minute;
 2. perform insulation tests between the enclosure and ground using a 2500 VDC ohmmeter for 1 minute; and
 3. perform a functional test of all temperature, protective, monitoring and alarm devices.
- M. For Substation Local Centralized Monitoring System (LCMS):
1. perform control circuit functional test by actuating control switches and observing the operation of circuit breakers;

2. simulate alarm functions at each device at the switchgear, transformer and rectifier and verify correct indication at substation LCMS; and
 3. verify correct operation of each function and display.
- N. For frame fault tests:
1. check for connection using single line diagram;
 2. for tests, simulate a 1500 VDC to frame fault by passing low DC current levels through the relays;
 3. for confirmation from the City, provide graphical outputs, including time-current characteristics, onsite at the time of testing for review and approval;
 4. for criteria, maximum total clearing time including operation of the relay, the substation lock-out relay, and the tripping of the main AC and DC feeder breakers shall not exceed 300 ms; and
 5. for field adjustments in the event that certain test conditions do not conform to the test procedure, make necessary field adjustments, perform necessary calculations to demonstrate successful test completion, present the calculation method to design engineer for review, and include it with the test report.
- O. For rail voltage monitoring and grounding devices tests:
1. this will demonstrate proper function of the rail-to-earth relay and rail-to-earth clamping device; and
 2. simulate rail-to-earth voltages and currents to show that the substation will alarm, trip, and short circuit rail to earth when the voltage and currents exceed the alarm.
- P. For battery and battery charger:
1. perform after substation equipment has been installed onsite;
 2. perform acceptance tests in accordance with IEEE 1106 - Recommended Practice for Installation, Maintenance, Testing, and Replacement of Vented Ni-Cad Batteries for Stationary Application for batteries; and
 3. perform in accordance with NEMA PE5 - *Constant Potential Type Electric Utility Battery Chargers* for the battery charger.
- Q. For ancillary systems:
1. perform operational and functional tests on auxiliary and ancillary systems including auxiliary panel boards including auxiliary contacts, door interlocks, receptacles, emergency lights, fans, and all systems provided in this agreement which are not specifically called out in this section.
- R. For cable testing DC feeder cables:
1. conduct test prior to cables being connected to rails or OCS; and
 2. perform insulation-resistance test, step voltage test and dielectric test in accordance with ANSI NETA ATS or equivalent. Individually test each conductor.

6-2.7 SITE ACCEPTANCE TESTING (SAT)

6-2.7.1 Site Testing

- A. Provide the City with 90 days notice prior to any Traction Power Substation field installation and system tests.
 - 1. Test in accordance with ANSI NETA ATS or equivalent.
- B. Traction Power Substation field installation and system tests shall:
 - 1. demonstrate that each substation and section tie breaker are ready for energization and revenue service, both functionally and optically; and
 - 2. include testing of:
 - a. substation/section tie breaker equipment;
 - b. DC Protective relays;
 - c. auxiliary systems;
 - d. field installed power and control cable; and
 - e. wiring internal and external to substations/section tie breakers.
- C. System Integrated Testing shall:
 - 1. demonstrate that the installed traction electrification system functions properly in relation to other system elements specifically the transfer-trip between existing Churchill TPSS and the new 107 Street TPSS;
 - 2. demonstrate that all interfaces are correct and operable; and
 - 3. perform functional tests to prove satisfactory operation of all inter-tripping, interlock and supervisory control alarm and indication circuits.
- D. The SAT will not be commenced without Project Co having previously issued the City with a complete handover file. The handover file will include, but not be limited to the following:
 - a. a complete set of as-built drawings and documents;
 - b. completed factory acceptance test and calibration certificates;
 - c. completed installation test certificates; and
 - d. completed operations and maintenance documentation.

SECTION 6-3– OVERHEAD CATENARY SYSTEM

6-3.1 INTRODUCTION

6-3.1.1 General

- A. This Section 6-3 [*Overhead Catenary System*] sets out the requirements for Design and Construction of the Overhead Catenary System (OCS) light rail transit electrification for the Valley Line LRT Stage 2.

6-3.1.2 Purpose and Scope

- A. The Project Work for the OCS includes:
1. the design, manufacture of materials and equipment, fabrication, supply of materials, installation, testing, Commissioning, and incidentals necessary to complete the OCS construction and installation;
 2. limited demolition and reconstruction of OCS on the Valley Line LRT Stage 1 in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule including interim training of the Operator; and
 3. integration of the Valley Line LRT Stage 2 into the Valley Line LRT Stage 1 integrated at the 102 Street Stop and Gerry Wright OMF Site, where the OCS on Valley Line LRT Stage 1 terminates just to the west side of the 102 Street Stop.
- B. Supply all OCS special tools and spare parts as described in Schedule 4 [*Design and Construction Protocols*] and in Section 6-3.1.1 [*General*] of this Schedule to perform all preventative and corrective maintenance, and repairs.

6-3.2 APPLICABLE CODES AND STANDARDS

- A. The OCS and all associated infrastructure shall comply with and shall adhere to the following codes, standards and regulations, to the extent applicable:
1. the Canadian Electrical Codes, CAN/CSA No. 1-15;
 2. AISC American Institute of Steel Construction;
 3. ASTM American Society for Testing and Materials;
 4. NESC National Electrical Safety Code;
 5. IEEE Institute of Electrical and Electronics Engineers;
 6. UL Underwriters Laboratories;
 7. IEC International Electrotechnical Commission;
 8. NEMA National Electrical Manufacturers Association;
 9. AWS - D1.1 Structural Welding Code; and
 10. All relevant structural codes in accordance with Section 4-1.3 [*Codes and Standards*] of this Schedule.

6-3.3 DESIGN AND CONSTRUCTION REQUIREMENTS

6-3.3.1 OCS - General

- A. The OCS shall:
1. include all interface equipment between the DC Traction Power supply equipment at the TPSS and the pantograph equipment on the LRVs, including foundations, poles, cantilevers, span wires, supports, system conductors, registrations, hangers, jumpers, terminations, tensioning devices, sectioning equipment, and any other equipment for the operation and maintenance of the LRT System to the requirements as described in the Operability and Maintainability Parameters;
 2. include all interfaces equipment to integrate with Valley Line LRT Stage 1;
 3. be designed and use components similar to and interchangeable with those utilized on the Valley Line LRT Stage 1 which minimize its visual impact along the LRT Corridor.
 4. be double-insulated to create a safe working zone between energized and grounded equipment;
 5. provide uninterrupted current collection by all LRV pantographs for the operating speed range along the relevant section of the LRT alignment;
 6. operate without fault or failure under the dynamic pantograph characteristics created by the Stage 1 LRV; and
 7. conform to the SUI requirements as describe in Section 2.9 [*Support Systems*] of this Schedule and the Design Guide.
- B. The traction current return from the LRVs to each TPSS shall be via any combination of the running rails and parallel underground cables.

6-3.3.2 Overhead Catenary System Configuration

- A. Provide a single auto-tensioned contact wire with supplemental underground feeders on the OCS along 102 Avenue and 107 Street, as necessary.
1. Where underground feeders are required, connect to the contact wire at regular intervals to ensure the current carrying capacity of the contact wire is not exceeded.
 2. Support the contact wire along 102 Avenue from span wire arrangements extending across the Trackway and adjacent roadways similar to those utilized on the Valley Line LRT Stage 1.
- B. From 104 Avenue to the terminus at Lewis Farms, the OCS system shall be an auto-tensioned catenary system, consisting of a single messenger wire and single contact wire, via a construction overlap.
1. The overhead wires may be supplemented with underground feeders, which connects to the contact wire at regular intervals to ensure the current carrying capacity of the catenary wires are not exceeded.
 2. Additional aerial conductors are not acceptable.
 3. The contact and messenger wires vertical separation at the cantilever support or system height shall be 750 mm. This is considered a 'low-profile' system to minimize the visual impact of the system.
- C. Provide a single, fixed OCS contact wire system within the Gerry Wright OMF Building B site.

1. The wires shall be supported from wither cantilevers, span wire arrangements, or a combination of both.
- D. Provide a single, fixed OCS contact wire system within the Lewis Farms Storage Facility.
1. The wires shall be supported from wither cantilevers, span wire arrangements, or a combination of both.
- E. Not Used.
- F. Divide the OCS into tension sections with each tension section having an overlap with each adjacent section. Insulate the overlaps between adjacent tension sections at TPSS locations to provide isolation points.
- G. Section isolators can be used for Yard Track, Lead Track, Shop Track and crossover OCS sections and Mainline Track where overlaps are determined not practical;
- H. Design of the isolation points must take into consideration the highest risk locations for degraded operations to optimise use of platforms when short turning and interfacing with replacement bus services.
- I. Locate insulated overlaps or section insulators so that the DC power from the Traction Power System can be supplied independently to the line segments on either side of each TPSS.
- J. Complete OCS terminations with a balance weight anchor pole, a fixed termination pole, or a spring tensioner.
1. Conceal balance weights in the OCS poles.
 2. Pneumatic or hydraulic tensioning devices shall not be permitted.
- K. Provide a midpoint anchor assembly to prevent longitudinal movement of the OCS along the Track.
1. Midpoint anchors shall be placed as close as possible to the midway point between each set of tensioning devices.
- L. The contact wire and any messenger wire shall be maintained at a constant tension using a tensioning device which incorporates safety features to prevent unauthorized personnel from accessing the system.
- M. Comply to the minimum contact wire height as specified in CSA C22.1-18 and do not exceed the maximum working height of the pantograph for the Stage 1 LRV.
- N. The gradient of the contact wire relative to the gradient of the rail, shall not exceed the values set out in Table 6-3.3-1 [*Contact Wire Gradients*] of this Schedule:

Table 6-3.3-1: Contact Wire Gradients

Maximum Design Speed	Maximum Contact Wire Gradient
≤ 30 kph	+/- 1.3%
>30 kph to ≤ 50 kph	+/- 0.8%
>50 kph to ≤ 80 kph	+/- 0.6%

- O. The maximum gradient change from one span to the next shall not exceed one-half the maximum gradient for the maximum design speed of the applicable span.
- P. Stagger the contact wire on both tangent and curved tracks to achieve uniform wear of the pantograph. Where messenger wire is required, stagger the contact wire and position the messenger wire over the contact wire.
- Q. Prepare and submit an OCS pole spacing and stagger report based on the Stage 1 LRV with the first Interim Design submission for the OCS Line Wide as described in Appendix 4B [*Project Specific Submission Requirements*], (the “**OCS Pole Spacing and Stagger Report**”).
 - 1. Prepare the report in accordance with Good Industry Practice.
 - 2. Include the maximum span length and stagger (i.e. least number of support structures) required to ensure that pantograph de-wirement does not occur in the report.
- R. Provide cantilever arm assemblies to vertically support the OCS along at-grade sections of LRT alignment.
 - 1. The cantilever arm assemblies shall vertically support, and horizontally regulate the contact wire and any messenger wire.
 - 2. Cantilever arm assemblies shall be mounted directly to the OCS poles by brackets.
- S. Use cross spans or head spans between two (2) OCS poles to support the OCS where a pole cannot be placed between the Tracks or where the distance between the track and the nearest OCS pole is too great.
- T. Provide common grounding of OCS support poles on the Elevated Guideway through electrical connection to either bonded (welded) reinforcing steel in the deck or to each other and a common ground electrode system.

6-3.3.3 Interface with Valley Line LRT Stage 1

- A. Not Used.
- B. The two (2) locations where it is necessary to interface with the Valley Line LRT Stage 1 OCS are located at 102 Street and the Gerry Wright OMF Building B site.
- C. For further information and clarification of construction constraints regarding the OCS interfaces, refer to Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] of this Schedule.

6-3.3.4 Environment

- A. Design the OCS equipment to operate satisfactorily under all environmental conditions as described in this section and withstand the wind and ice non-operating conditions listed in Table 6-3.3-2 [*Design Climatic Conditions*] of this Schedule without permanent deformation.
- B. The LRT alignment is adjacent or integrated into the roadways, which may be treated with chemicals to deter ice. Some chemicals may create a spray environment adverse to insulators. Creepage distances shall be rated accordingly.
- C. For Environmental Climatic Conditions, refer to Section 1-2.1.9 [*Edmonton Climatic Requirements*] of this Schedule.

Table 6-3.3-2: Design Climatic Conditions

Factor	LRV Operating		LRV Non-operational	
Wind, kph	65	95	95	150
Ice, mm	12.5	0	12.5	0

6-3.3.5 Materials Selection

- A. Ensure all new components at the interface with the existing OCS are compatible OCS material and component styles to the supplied materials installed on the Valley Line LRT Stage 1.

6-3.3.6 Recovery of Redundant OCS Materials

- A. Remove and de-commission specific OCS poles and supports that the new trackwork and alignment use in service at the integration point with Valley Line LRT Stage 1.
 - 1. Remove all unused OCS line assemblies, poles and components for the locations as shown on the Design Drawings.
- B. Return all removed and de-commissioned materials to the City.

6-3.3.7 Field Testing

- A. Prepare and submit a complete and comprehensive OCS test plan and detailed, specific test procedures in accordance with Schedule 2 [Submittal Review Procedure] 90 days prior to starting any field testing (the “**OCS Test Plan**”).
- B. Perform all tests necessary to ensure that the OCS configurations and equipment performs according to the requirements identified within this Schedule.
- C. Perform electrical tests in accordance with Section 6-3.3.16 [Testing] of this Schedule. All tests may be witnessed by a representative of the City.

6-3.3.8 Design Drawing Set and Submittals

- A. With each of the first, second Interim Design and Final Design submissions for the OCS as described in Appendix 4B [Project Specific Submission Requirements], submit an OCS Design Drawing set comprised of site-specific and OCS layout plans (the “**OCS Design Package**”).
 - 1. Site-specific plans shall:
 - a. include sectionalizing diagrams – schematic single-line drawings that show the location of the TPSS and the sectioning requirements of the OCS that enable OCS section isolation in the event of a fault or for routine maintenance. The negative circuit does not need consider those circuit elements required for Train signaling purposes;
 - b. include master overlap charts – single-line diagrams drawn to an approximate along-track scale;
 - c. provide an overview of the layout of individual tension lengths of OCS conductors;

- d. show identification numbers for individual wire runs and the lengths of individual half tension lengths, with the type of anchor-fixed termination, balance weight termination or midpoint;
 - e. provide a legend for the OCS wiring layouts;
 - f. show track alignment with track speeds, curve radius and alignment equations, track profile with track grades, track turnouts and crossovers, stations, overpasses, underpasses and grade crossings;
 - g. show all wire run lengths on the master overlap charts and tabulated on a wire run chart drawing; and
 - h. include OCS Wiring Layouts - use scaled track plans as a background.
 - i. Show OCS equipment on a pole-by-pole basis, including the dimensional requirements to enable Project Co to install the OCS to line and elevation. Where poles are not practical, use alternative OCS support designs, and give the same type details. Supplementary plans may be referenced, as needed.
2. OCS layout plans shall include:
- a. OCS Standard Plans
 - i. general drawings; and
 - ii. OCS abbreviations, drawing legends and general notes in general drawings;
 - b. Technical Sheets
 - i. provide OCS technical sheets with information regarding design data including parameters, values conductor characteristics, conductor tensions, temperature conditions, maximum wiring spans on tangent and curved track, along track movement data, wind blow off data, maximum mid span offset, pantograph clearance envelope and steady arm dimensional criteria;
 - c. General Arrangement Drawings
 - i. show layout and dimensions on the general arrangement drawings for poles and wiring at overlaps, midpoint anchors, crossovers and terminations and show multiple poles and multiple spans. Reference typical structures, constrained corridors, and typical spans;
 - d. Typical Structure Drawings
 - i. provide elevations on typical structure drawings of typical OCS supports used for various common functions. Show typical heights and staggers of conductors and typical offsets of poles at track cross-sections on the drawings; and
 - ii. identify generically the assembly drawings required for complete installation of the site-specific structure;
 - e. Typical Span Drawings
 - i. provide elevations of typical single spans of OCS wiring, including those with any special features such as section insulators or out-of-running cut-in insulators on span drawings; and
 - ii. identify generically the in-span assemblies required in the spans, and where required, set out dimensions;

f. Assembly Drawings

- i. assembly drawings are common configurations of OCS components, such as cantilevers, balance weight terminations, down-guys and poles;
- ii. rationalize OCS assemblies and give discrete assembly references. Provide discrete assembly references by components used and their count – pipe, wires, and tie-wraps may not be counted or dimensioned; and
- iii. provide typical component details of the assembly references allocated on the wiring layouts to illustrate on the assembly drawings and quantify the materials required at each support location.

6-3.3.8.1 Final Design

- A. Reference the guidelines and adhere to standards that are indicated and shown in the OCS technical sheets, wiring layouts, arrangements and assembly drawings that are packaged for design completion, including shop drawings and other generated documents.
- B. Responsibilities for completion of the OCS design shall include the following tasks:
 1. the preparation of shop drawings for all assembly references, components and materials to be supplied;
 2. IFC drawings by applying the materials, assemblies, and methods to the OCS design; and
 3. OCS design for staging work, including preparation of drawings showing interim OCS installations in support of construction staging.

6-3.3.8.2 Shop Drawings

- A. Ensure that the component and equipment suppliers have a minimum of 10 years experience in the manufacture of OCS hardware for use on light rail systems.
 1. Prepare detailed shop drawings to identify the physical size, strength, form and fit of the assemblies, and the individual components, for each assembly reference used in the wiring layouts.
- B. Shop drawings shall show the precise quantity of each component required for each assembly in its materials list.
 1. Use the assembly references as the basis to prepare shop drawings.
 2. Where appropriate, assembly or component weights, design dimensions, maximum working loads, installation rules, etc. shall be given.
 3. Show registration assemblies pantograph clearance envelope to verify adequate mechanical clearance to pantographs.

6-3.3.8.3 Installation Documentation

- A. Ensure that the installation of the OCS is in accordance with this and the accompanying Schedules.
- B. Show the materials schedule and installation procedure, including the assembly references, on the OCS wiring layouts and for the final permanent OCS. The documents provided shall include:
 1. OCS poles, guys and foundations;

2. OCS supports, including cantilevers, insulators, cross-span wire supports and their mounting brackets;
3. OCS support attachments at overhead bridges and on retaining walls;
4. OCS conductor termination assemblies including balance weight terminations, fixed termination assemblies and mid-point guy assemblies;
5. section insulators, jumpers and in span assemblies;
6. grounding and bonding; and
7. incidental OCS system hardware, including safety screens.

6-3.3.8.4 Contract As-Built Records

- A. Provide As-Built documentation for the final OCS configurations installed in accordance with Schedule 4 [*Design and Construction Protocols*].

6-3.3.9 Foundations

- A. Construct OCS pole foundation from reinforced concrete, designed and constructed in accordance with the requirements in Part 4 [*Structures*] of this Schedule. They shall be:
 1. embedded in the earth, be an integral part of the track slab structure or provided as part of other structures forming part of the LRT System;
 2. designed to account for the structure loading and soil conditions;
 3. designed to take the maximum elastic bending capacity of the pole plus 20%;
 4. designed to accept bolted base poles and structure grounding; and
 5. designed to contain feeder or utility cables using concealed conduits.
- B. Ensure that all metallic OCS pole foundation components, including the pole baseplates, that are embedded in, or otherwise come in contact with, concrete surfaces are coated with a sacrificial/barrier coating. The sacrificial/barrier coating shall be applied to the entire component and shall extend a minimum of:
 1. 150 mm into the concrete; and
 2. 25 mm above the surface of the concrete.

6-3.3.9.2 OCS Foundations on Transportation Structures

- A. For OCS foundations on Transportation Structures refer to Section 4-2.12 [*Pole Foundations*] of this Schedule.

6-3.3.9.3 Quality Assurance

- A. Construction Tolerances
 1. locate the center of the OCS cast-in-place foundations horizontally within the following tolerances:
 - a. along track – +/- 1000 mm from the accepted Final Design; and
 - b. across track – +/- 75 mm from the accepted Final Design;

2. drilled pier out-of-plumb dimensions shall be checked after excavation and before concreting. The maximum tolerance shall be 150 mm out-of-plumb within each 3 m of excavation depth. This tolerance applies to the diameter dimension, and it does not include excavation over-cutting when it occurs;
 3. ensure the tops of all foundations and anchors are within ± 25 mm of design level; and
 4. install OCS foundation anchor bolts plumb and within the following tolerances relative to the top of the foundation:
 - a. horizontal – +/-10 mm off of square, the center of which shall meet the tolerance requirements of the foundation; and
 - b. vertical – +/-5 mm. Provide templates for all anchor bolts to ensure correct alignment.
- B. Measure and record the electrical resistance testing of the pole and foundation grounding systems. Ensure that the OCS poles have a ground resistance of 25 ohms or less.
1. Should the resistance be found to be more than the permissible value, drive and connect the additional ground rods into the grounding system.

6-3.3.9.4 Anchor Bolts

- A. Provide high-strength carbon steel bolts; ASTM F1554, Grade 55, over-tapped threads in accordance with AISC requirements for UNC Series.
- B. Galvanizing shall comply with ASTM A153.
- C. Nuts shall comply with ASTM A563, hot dip galvanized, over tapped threads in accordance with AISC requirements for UNC series.

6-3.3.9.5 Clevis Connector and Coupler Sleeve

- A. Ensure the clevis connector and coupler sleeves comply with ASTM A668 and with ASTM A153 for galvanizing.

6-3.3.9.6 Ground Wire

- A. Ensure that ground wires comply with ASTM B3 annealed, soft-drawn, bare copper, of Class B strand, with 98% conductivity.
- B. Ensure that the grounding wires comply with the requirements of the Canadian Electrical Code.
 1. Grounding wires shall, as a minimum, be 2/0 AWG bare.

6-3.3.9.7 Exothermic Welding Material

- A. Utilize exothermic welded type connections, Cadweld, or equivalent.
 1. Materials, including molds, weld material, tools and accessories, shall be supplied by one manufacturer to ensure compatibility.

6-3.3.9.8 Foundation Ground Rods

- A. Ensure that the foundation ground rods are in accordance with Section 6-3.3.13.4 [*Grounding and Bonding*] of this Schedule.

- B. Perform electrical resistance testing of all OCS foundation grounds in accordance with Section 6-3.3.13.4 [*Grounding and Bonding*] of this Schedule.

6-3.3.10 Poles

- A. This Section 6-3.3.7 [*Poles*] covers the design, fabrication, hot-dip galvanizing, painting and labeling of new tapered tubular steel poles for use as part of the OCS as specified herein.
- B. Ensure that the OCS poles are of a tapered tubular steel-galvanized type in accordance with ASTM A123.
- C. Pole design shall comply with the SUI requirements in Section 2-9.8 [*Overhead Catenary System*] of this Schedule and the Design Guide.

6-3.3.10.2 Pole Types

- A. Ensure that the poles are of the tapered tubular type and match those currently being used on the Valley Line LRT Stage 1.
 - 1. Balance weight anchor poles may be straight and not tapered.

6-3.3.10.3 Poles General

- A. Poles shall:
 - 1. provide a contemporary, unadorned design at the minimal height and diameter. Heavier wall thickness section poles and or other visually unobtrusive structural reinforcement innovations shall be utilized to achieve minimal pole diameters;
 - 2. be steel construction and tapered at approximately 6 mm/m, equivalent to a reduction in diameter of 12 mm/m;
 - 3. have a design bending capacity based on the yield stress of the material;
 - 4. deflect no more than 2% of their length when the rated maximum bending load is applied 600 mm from the top of the pole;
 - 5. be raked with a tolerance of ± 25 mm to appear vertical when under normal dead load conditions, i.e. no wind or ice;
 - 6. have a pole cap or finial to prevent water ingress;
 - 7. be designed to prevent water accumulation inside the pole; and
 - 8. be provided with sealed cable spouts wherever wires or cables exit through the side.
- B. Where employed, poles shall be designed such that the balanced weight assemblies are housed inside the OCS poles.
- C. Repair any damage to galvanized OCS pole finished surfaces in accordance with ASTM A780.
- D. Where OCS poles are combined with lighting, spacing between poles shall be optimized with the lighting and catenary design.
 - 1. Infill lighting poles may only be considered if it can be demonstrated that lighting levels in pedestrian areas and the Roadways cannot be achieved solely through the use of shared use poles.

2. Shared use poles shall comply with the SUI requirements of Section 2-9.8 [*Overhead Catenary System*] of this Schedule and the Design Guide.

6-3.3.10.4 Product Description

- A. Fabricate pole shafts from one structural steel material type conforming to the following requirements:
 1. A595, Grade A steel;
 2. base plates shall be fabricated from structural steel conforming to ASTM - A572, Grade 42 steel; and
 3. poles shall have no spliced joints.
- B. Fabricate pole caps from steel compatible with the pole shaft and attached to the shaft with a minimum of three (3) stainless steel set screws.

6-3.3.10.5 Fabrication

- A. Fabricate poles, handholes, fittings, accessories and base plates by methods conforming to AISC specifications, except as specified herein.
- B. The following tolerances shall be used during fabrication:
 1. tubular pole diameter – within 1.5 mm of the design diameter and shall be within 1.5 mm of perfect round;
 2. pole wall thickness – within plus 10%, but not less than the design thickness;
 3. pole straightness – within 1.5 mm per 1.5 m of pole length; and
 4. base plate tolerances shall be as follows:
 - a. bolt circle diameter: +1.5 mm, -0 mm;
 - b. hole diameter: +1.5 mm, -0 mm; and
 - c. location of Holes: ± 1.5 mm along the bolt circle diameter.

6-3.3.10.6 Pole Identification

- A. Provide pole identification plates similar to those currently being used on the Valley Line LRT Stage 1.
- B. Locate pole stationing labels at a height such that they can be easily read by a Driver travelling in either direction.

6-3.3.10.7 Pole Painting

- A. Paint the poles in accordance with the SUI requirements in Section 2-9.8 [*Overhead Catenary System*] of this Schedule and the Design Guide.
 1. The painting process shall be suitable for steel-galvanized poles.
- B. Ensure that painted OCS poles are supplied from the manufacturer in a finished condition.

1. Any paint damage requiring field touch-up painting shall conform to the manufacturer specifications.
- C. The finished coating shall have a Design Service Life of a minimum of 15 years, with no visible paint peeling, blistering, cracking or surface corrosion evident or occurring within that period.

6-3.3.11 Cables, Conductors, Wires and Ropes

- A. This Section 6-3.8.8 [*Cables, Conductors, Wires and Ropes*] covers the supply of the OCS cables, conductors, wires and ropes.
- B. Splices shall not be used in new cables, conductors, wires and ropes.
 1. With the exception of the OCS messenger and contact wires, where connecting to the existing system, splices may be used as accepted by the City.

6-3.3.11.2 Warranty

- A. Provide a Manufacturer Warranty for the cables, conductors, wires and ropes unconditionally guaranteeing that such material will be free from defects for a minimum of five (5) years.

6-3.3.11.3 Material

- A. Provide cables, conductors, wires and ropes materials with a composition, quality and purity, such that the finished product has the properties and characteristics described in this Schedule and the referenced standards.
 1. All cables, conductors, wires and ropes of the same design shall be uniform size and shape.
- B. All cables, conductors, wires and ropes shall be of the same material composition and diameter as the Valley Line LRT Stage 1.

6-3.3.11.4 Performance

- A. The physical, mechanical and electrical properties of the cables, conductors, wires and ropes shall conform to the requirements of this Schedule and the pertinent provisions of all standards referenced in Section 6-3 [*Overhead Catenary System*] of this Schedule.
- B. All cables, conductors, wires and ropes shall have a minimum Design Service Life as defined in, as defined in Section 1-2.9 [*Design Service Life*] of this Schedule, under Valley Line LRT's environmental and operating conditions.

6-3.3.12 Fittings and Hardware

- A. Provide OCS fittings and hardware material composition similar to the Valley Line LRT Stage 1.

6-3.3.12.2 Support and Registration Assemblies

- A. Materials
 1. Provide OCS support and registration assemblies' material composition similar to the Valley Line LRT Stage 1.
 2. All components used in the support and registration assemblies shall be of sufficient strength and durability to withstand the design loads, with a minimum factor of safety of 2.5 relative to operating conditions.

3. The assembly material shall be strong and light in weight and reliable to ensure minimum Design Service Life, as defined in Section 1-2.9 [*Design Service Life*] of this Schedule.
 4. The cantilever and support assemblies shall be of a proven arrangement and tested design, have been used on other overhead electrified rail systems and have demonstrated an acceptable performance history and in-service life.
 5. Cantilever support assemblies shall meet the SUI requirements in Section 2-9.8 [*Overhead Catenary System*] of this Schedule and the Design Guide.
- B. Installation Requirements
1. Locate cotter pins and nuts on each cantilever on the same side of the structure to assure uniformity along the line, and ease of maintenance and inspection by facing maintenance personnel approaching in the direction of normal Train travel.
 2. Orient assemblies fitted with pins, cotters, bolts and nuts where possible in such manner as to lock these components together by gravity if the pins or nuts should become detached under service conditions.
 3. Grease components employing a hinge or swivel with an approved grease before assembly of the rubbing surfaces, as recommended by the OCS manufacturer/supplier.

6-3.3.12.3 Insulators

A. Materials

1. Provide OCS insulator composition similar to the Valley Line LRT Stage 1.

6-3.3.12.4 Pole Mounted and Pad Mounted Disconnect Switches

- A. Provide pad mounted disconnect switch assemblies (DSW) within Utility Complexes at the TPSS locations as a means to disconnect OCS line sections from one another to enable connection and disconnection of adjacent electrical circuits.
1. DSW assemblies shall be remotely operated under no-load conditions.
 2. Local controls, located in lockable enclosures, shall be provided for maintenance activities.
 3. DSW assembly for use in Maintenance and Storage Facilities may be a 2-pole type switch with the positive blade grounding in the open position.
- B. Ground mats are required at all DSW operating handle locations.
- C. DSW assemblies shall be suitably rated switches to connect/disconnect two (2) adjacent electrical sections of OCS.
- D. If pole mounted switches are used at crossover locations, include a motorised/manually operated handle in pole mounted switches mounted approximately 1.2 m above a hard-standing surface and ground mat, coupled to operating gear mounted on the pole that is attached to the switch unit.
- E. General
1. The outdoor type pole mounted DC disconnect switch shall be a single-throw, no-load break and non-fusible air switch, with motorised/manual operator.
 2. Comply with the applicable requirements given in ANSI C37.34 and Z55.1, ASTM B187, NEMA 250, SG 5, ICS 1, and ICS 2.

- a. Ensure that the pole mounted disconnect switches in NEMA 3R non-metallic, outdoor type enclosure are acceptable.
- 3. Ensure that all exposed unit outdoor switches are capable of operation with a 5 mm thick covering of glazed ice on the external switch mechanism and operating rods.
- 4. Bolt cable terminations using cable lugs.
 - a. Lugs, unless otherwise indicated, shall be tin plated copper, long-barrel, compression type, two-hole, with NEMA hole sizes and spacing and complying with UL 486A for voltages up to 35 kV.
 - b. Insulate lug terminations with insulated sleeves.
- F. Provide switches rated for 1000 V DC continuous (825 V DC nominal) operation with 3.7 kV, RMS, minimum insulation level.
 - 1. Continuous current ratings shall be 2000A without exceeding a 50 °C rise above a maximum ambient temperature of 40 °C.
 - 2. Switches shall have a momentary current withstand rating of not less than 100 kA RMS for 50 ms.
- G. Two Pole Switch Operation
 - 1. Ensure that two (2) pole switches are switching both positive and negative polarities of their connected circuits.
 - a. In the normally closed position, the positive pole shall connect to the positive supply. In the 'open' position, the positive pole shall connect to a grounded connection.
 - b. The positive switch pole shall operate in a break-before-make sequence, with component clearances factory set to mitigate the risk of electrical flashover in the known conditions of service and environment.
 - c. The negative switch pole shall be connected in the closed position to the traction current return path. In the 'open' position this pole shall be connected to a grounded connection.
- H. Manufacture
 - 1. Ensure that the moving and stationary contact surfaces are silver plated copper.
 - a. All other current-carrying parts shall be of high conductivity copper or copper alloy. Contacts shall be self-aligning, wear- compensating, and with initial wiping action.
 - 2. Ensure bus conductors are of a high conductivity electrical grade copper.
 - 3. Manual Operation of Disconnect Switch
 - a. Furnish each pole mounted or wall mounted switch with an insulated operating rod, with an operating handle mounted at a suitable height from ground level on the OCS pole.
 - i. Furnish operating handles with heavy duty lugs to accept padlocks in the fully open and closed switch positions. Indicate switch positions with "OPEN" and "CLOSED" signs, or easily visible indicators or markings.
 - ii. Configure the switch operating rod and handle such that the operating pipe is in its lowest position and the handle is down in the "OPEN" position.

- b. House each switch in an enclosure and shall be equipped with pivot mounted, permanently attached, insulated spade handle that swings away from the switch. Allow the design for closing of the enclosure door with the switch in the open or closed positions. Ensure the operating handle is capable of withstanding stresses of multiple opening and closing.
- c. Hot-dip galvanized steel or stainless steel all non-current carrying metal parts. All external enclosure fasteners and hinges shall be stainless steel.

4. Cable Termination

- a. Furnish the line and load side that disconnect switch terminals with silver-plated copper buses complying with ASTM B187, to accommodate the number and size of copper cables.
 - i. The switch terminals shall have provision for NEMA drilled (2-hole or 4-hole) cable terminal lugs. Factory supplied, and installed cable openings shall be provided for all cable sizes/openings and shall be fitted with weatherproof cable bushings for all entries and exits.

5. Switch Enclosures

- a. Ensure that non-metallic fiberglass switch enclosures are of a ventilated, raintight, tamperproof design suitable for outdoor application.
 - i. The enclosure shall have a gasketed, heavy duty hinged door with padlockable handle, catch, full length hinge (one sided) and hooded ventilation openings with screens.
- b. Provide one specified outdoor type padlock with each cabinet (enclosure), all keyed alike.
- c. Provide a dead front operating handle and inside the box for each switch. The switch position shall be visually indicated by the handle alignment with "OPEN" and "CLOSED" plates.
- d. Ensure that the enclosure is of sufficient size to accommodate the switch, internal linkages and operating gear, cabling and terminations without electrical shorting or damage due to chafing on the feeder cable insulation.
 - i. All maintainable components shall be readily accessible through the door opening, and sufficient space shall be provided for the manipulation of required tools.
- e. Equip the exterior face of the cabinet with a switch data/nameplate and a "Danger - High Voltage" warning label permanently attached to the cabinet.
- f. Ensure that the enclosure is a minimum of 5 mm thick polyester with a glass to resin ratio of 40 to 60 and is equipped with a drain hole in the base.
 - i. Resin shall be fire retardant polyglass or equal as accepted by the City.

6. Padlocks

- a. Provide each pole mounted disconnect switch operating handle with an outdoor type, heavy duty, keyed padlock having a hasp diameter of 50 mm minimum.
- b. All padlocks shall be keyed alike.
- c. Provide two (2) keys to the City for each padlock.

6-3.3.12.5 Section Insulators

- A. Provide section insulators on the OCS to achieve electrical isolation while allowing physical continuity for the passage of a pantograph.

- B. Bridging type section insulators shall be used for sectionalizing purposes and continuous current collection.
- C. Provide non-bridging type section insulators at the entrances to the Gerry Wright OMF Building B and Lewis Farms Storage Facility;
 - 1. The non-bridging type section insulators shall ensure the electrical isolation (not bridging) of adjacent sections of OCS during all phases of pantograph passage.
- D. Provide OCS section insulator material composition similar to the Valley Line LRT Stage 1
- E. Locate section insulators in positions where the Track design does not require the LRV to draw a load on passage in particular where the LRV is accelerating from stop at stations and stops during normal right-hand running operations.

6-3.3.12.6 Surge Arrester

- A. Provide and install surge arrester assemblies at locations including:
 - 1. OCS poles with positive feeder cable risers;
 - 2. OCS poles with pole mounted disconnect switches;
 - 3. OCS poles which are on either side and/or under all overhead bridges crossing the LRT alignment; and
 - 4. on poles at a maximum spacing of every 300 m.
- B. Each surge arrester shall be suitable for OCS pole mounting and supplied with accessories.
- C. The OCS surge arrester shall be equivalent to Valley Line LRT Stage 1's system arrester (Elektoline ref. 285126) and subject to acceptance by the City.
- D. Achieve each grounding installation a recommended maximum grounding resistance of 5 Ohms or as specified by the surge arrester manufacturer for the type of unit supplied, if less than 5 Ohms.

6-3.3.12.7 Balance Weight Terminations

- A. Performance Requirements
 - 1. Maintain the balance weight anchor assemblies (BWA) constant tension in the conductors notwithstanding changes in ambient, solar or current heating temperatures. As the catenary conductors change in length due to changes in conductor temperature, the balance weights unit/stack shall be free to rise and fall.
 - 2. Operate the BWA freely under all climatic conditions within the auto-tensioned limits specified and function freely when a weight differential of plus/minus 10 kg is applied directly to the stack.
 - a. Do not interfere the BWA assembly cable and wire rope terminations with the pole, brackets and/or small part steelwork throughout the entire vertical range of up and down movement of the assembly.
 - 3. Ensure that all wire ropes are non-rotating stainless steel.
 - 4. Provide compact weights allowing for the required total vertical movements to occur between the required temperature range.

5. Ensure that the BWA have a minimum design minimum Design Service Life, as defined in Section 1-2.9 [*Design Service Life*] of this Schedule, and do not require periodic maintenance or inspection at intervals of less than 12 months.
 - a. The design shall permit field disassembly and reassembly of an in-place unit by maintenance personnel.
 6. Design the assemblies and component parts for ease of maintenance, replacement, assembly and disassembly which shall be accomplished with a minimum of special tools. Component parts shall be individually identified for this purpose.
 7. Incorporate assembly provisions for adjustment due to wire elongation or creep.
 8. Ensure that all balance weight assembly materials and equipment design are service proven in LRT Systems. They shall be suitably designed for the purpose for which they are intended. Ensure that they are totally compatible for the loads and climatic conditions.
- B. General
1. Operate the catenary system balance weight anchor assembly at a nominal pulley ratio of 1:3.
 2. Use caged element needle bearings for the pulley assembly. Permanently seal the bearings to prevent the ingress of moisture or other contaminants, or the loss of lubricant. Provide grease nipples to permit field replenishment of lubricant during maintenance.
 3. Balance weights are to be housed inside the poles.
 4. Fabricate balance weights with cast iron.
 5. Weight sets may be either one casting or made up from individual castings.
 - a. If individual castings are used, they shall be of an interlocking design to prevent slippage. The assembled stack of weights, and as compact as possible. Maximum weight for an individual casting shall be 20 kg.
- C. Ensure that the tolerance on weight of the complete balance weight stack is -0 kg, + 10 kg.
- D. Ensure that all external ferrous parts are stainless steel or hot-dip galvanized in accordance with the appropriate ASTM specification.
1. Any ferrous parts, which are not stainless steel or cannot be galvanized, shall be painted with an approved epoxy coating with colour to match ANSI #61, light gray.
- E. Ensure the manufacturer's name or trademark and year of manufacture are clearly and permanently imprinted on each tensioning device.

6-3.3.12.8 OCS Jumpers

- A. Ensure that continuity jumpers in auto-tensioned contact wire are of a length and configuration appropriate to the differential movement of the conductors.
 1. Generate the formula to be used to establish the lengths of the jumpers, based on actual field measurements.
- B. Install jumpers to avoid conflicts with the uplifted pantographs, adjacent cantilevers, cross contact bridges and hangers.

- C. Ensure that the cut end of jumpers does not project more than 25 mm through the connection clamps. Wrap the ends of all jumpers or fit with a barrel crimp to prevent fraying.
 - 1. Electrical taping of the ends of jumpers is prohibited.
- D. Install connection clamps as in accordance with manufacturer's recommendations.
 - 1. Before fitting the connector clamps, clean and wire-brush the conductors to ensure a good electrical connection beneath the clamp and lubricate with a conductive grease as recommended by the manufacturer.
- E. The connector bolts shall be torqued to the manufacturer's recommendations using a calibrated torque wrench.
 - 1. Mark all bolted clamps and connections after final torquing to indicate completion and provide maintenance personnel with indication of loosened bolts and nuts.

6-3.3.12.9 Section Insulators

- A. Provide OCS section insulators equivalent to Valley Line LRT Stage 1's system arrester and accepted by the City.
- B. Do not cut section insulators into contact wires until the full tension length has been adjusted, and balance weight anchors are operating normally.

6-3.3.13 OCS Installation

6-3.3.13.1 Summary

- A. Energize and double insulate all OCS equipment at a nominal 750 V DC.
 - 1. At any support a minimum of two (2) levels of electrical insulation, with at least 1.8 m separation between energized and grounded ends, shall be provided between the contact wire and a line pole or other grounded structure.
- B. Any uninsulated metalwork located within 600 mm of an OCS conductor or support shall be screened using insulating material as described in Section 6-3.3.15 [*Safety Screens*] of this Schedule.

6-3.3.13.2 Installation Tolerances

- A. Ensure final installed OCS conforms to the dimensional requirements within the following tolerances:
 - 1. Contact wire height, at support ±25 mm;
 - 2. Contact wire height, at a bridge ±10 mm;
 - 3. System Height ±50 mm;
 - 4. Hanger length ±5 mm;
 - 5. Contact wire stagger at registration ±25 mm;
 - 6. Messenger to contact wire lateral displacement at support ±25 mm;
 - 7. Vertical separation between crossing messenger wires ±100 mm; and
 - 8. Wire tension ±100 N.

6-3.3.13.3 The Rail Level Marker Pins

- A. After each OCS pole has been installed and the tracks have been adjusted to their final alignment and level, drive rail level marker pins into the faces of poles at a height of 300 mm, above the adjacent rail.

6-3.3.13.4 Grounding and Bonding

- A. Ensure that conductors for grounding and bonding are ASTM B8, Class B stranded annealed copper.
- B. Ensure that bolts, washers and stop nuts for connectors and clamps are of a high-copper alloy, Everdur, Durium, Duronze or silicone bronze. Ferrous hardware shall not be acceptable.
- C. Provide ground rods that are:
 - 1. medium carbon steel core, copper clad by the molten weld casting process with conductivity of not less than 27% of pure copper. The minimum thickness of the copper on the cylindrical portion of the rod shall average not less than 0.010 inch;
 - 2. not less than 3/4-inch diameter and 10-foot length. One end shall be suitable for compression couplings or threaded for threaded extension couplings; and
 - 3. compression or threaded bronze type couplings, UL listed for the purpose.

6-3.3.14 Signage

- A. Install electrification warning signs after the poles have been installed.
- B. Warnings signs shall look the same as the Valley Line LRT Stage 1.
- C. Provided and install the following types of OCS signage on all new or modified OCS poles:
 - 1. Pole station labels;
 - 2. "Danger - Live Wire";
 - 3. "Danger - Hi-Voltage"; and
 - 4. "No Trespassing".

6-3.3.15 Safety Screens

- A. Provide CEC compliant screening or fencing in areas where the OCS wires pass within a 3 m radial clearance from an accessible space, including any adjacent building, bridge or structure, to prevent exposure to live parts.

6-3.3.16 Testing

- A. During Commissioning, as a minimum, demonstrate that applicable procedures specified in the ANSI, IEEE, or NEMA standards have been completed.
- B. The required tests are categorized as follows:
 - 1. factory design tests shall be conducted by or under the supervision of the equipment manufacturer to demonstrate compliance with specified design requirements;

- a. these tests shall be performed on production components, assemblies and subsystems and shall be performed on the highest level of assembly that shall allow demonstration of design compliance; and
 - b. design tests are limited to the number of units needed to demonstrate design compliance, typically one or two;
2. factory production tests shall be conducted by or under the supervision of the equipment manufacturer and include all efforts necessary to demonstrate that the unit to be delivered operates within specified limits and is in compliance with design requirements;
 - a. production test requirements may vary from an inspection and functional demonstration for a simple component to a full system functional demonstration of an assembly;
 - b. production tests shall be performed at the OCS manufacturer's facility prior to shipment of the OCS equipment to the field;
 - c. these tests are routinely performed at the ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation; and
 3. field acceptance tests shall demonstrate that each installed OCS segment is functionally ready for LRV testing and cosmetically ready for revenue service;
 - a. field tests include measurement, mechanical, clearance, electrical and energization tests.
- C. LRV tests shall demonstrate clearances to pantograph and LRV body, and operation at maximum permissible speed without loss of contact or physical interference with a pantograph by the OCS.

SECTION 6-4 – TRAFFIC SIGNALS

6-4.1 INTRODUCTION

- A. This section sets out the Design and Construction Requirements for Traffic Signal Equipment and Traffic Control Devices to be provided at designated intersections along the LRT Corridor, and the requirements for Transit Signal Priority so as to safely and efficiently manage the interaction between competing modes of transportation at Grade Crossings.

6-4.2 APPLICABLE CODES STANDARDS AND REGULATIONS

- A. Without limiting Section 1-1.7 [*Reference Documents*] of this Schedule and except as otherwise specified herein, the Traffic Signal Equipment and all associated infrastructure shall comply with the following codes, standards and regulations, to the extent applicable:
 - 1. NBCAE, provided that any Traffic Signal electrical facilities, infrastructure and systems that are not subject to the NBCAE shall comply with Section 6-5 [*Transportation Electrical Service Plan*] of this Schedule;
 - 2. Alberta Electrical Utility Code;
 - 3. Alberta Electrical Communications Utility Code;
 - 4. AREMA C&S Manual;
 - 5. Canadian Electrical Code Part I;
 - 6. Canadian Electrical Code Part II;
 - 7. Canadian Electrical Code Part III;
 - 8. Transportation Association of Canada Manual of Uniform Traffic Control Devices;
 - 9. Transportation Association of Canada Bikeway Traffic Control Guidelines for Canada; and
 - 10. US DOT Manual on Uniform Traffic Control Devices.
- B. The following guidelines should be applied in accordance with Good Industry Practice:
 - 1. TCRP Report 69 Light Rail Service Pedestrian and Vehicular Safety;
 - 2. TCRP Research Results Digest 84 Audible Signals for Pedestrian Safety in LRT Environments;
 - 3. TCRP Report 137 Improving Pedestrian and Motorist Safety Along Light Rail Alignments; and
 - 4. TCRP Report 175 Guidebook on Pedestrian Crossings of Public Transit Rail Services.

6-4.3 TRAFFIC SIGNAL EQUIPMENT

- A. Provide all new Traffic Signal Equipment at the locations listed in the tables in Section 6-4.3 C of this Schedule in accordance with City standards, *Valley Line LRT Specifications for the Supply of Cabinets and Intersection Control Equipment* and *Valley Line LRT Traffic Signal Construction and Maintenance Specifications*.
- B. Provide a Manufacturer Warranty for the Traffic Signal Equipment for a minimum of five (5) years.
- C. This section includes three (3) tables listing the locations where Traffic Signal Equipment is required:

1. **Traffic Intersections**, listed in **Table 6-4.3-1 [Traffic Intersections]** of this Schedule, shall include Road Traffic Signals conforming to City standards and this Section 6-4.3 [Traffic Signal Equipment] of this Schedule to control vehicle, bicycle and pedestrian movements. These intersections shall also include LRT Traffic Signals where a Grade Crossing is present. LRT Traffic Signal requirements are described in Section 6-4.3 [Traffic Signal Equipment] of this schedule. All locations listed in Table 6-4.3-1 [Traffic Intersections] of this Schedule shall be equipped with Traffic Controllers.
2. **Pedestrian Activated Signals Locations**, listed in **Table 6-4.3-2 [Pedestrian Activated Signal Locations]** of this Schedule, shall conform to the City standards and be activated by push buttons. These signals shall also include an LRT Traffic Signal where an LRT Grade Crossing is present. All locations listed in Table 6-4.3-2 [Pedestrian Activated Signal Locations] of this Schedule shall be equipped with Traffic Controllers.
3. **Pedestrian Crossings of LRT Locations**, listed in **Table 6-4.3-3 [Pedestrian Crossing of LRT Locations]** of this Schedule, shall be controlled by pedestrian signals with countdown timers with the pedestrian signal resting in “walk” when there is no LRV approaching. All locations listed in Table 6-4.3-3 [Pedestrian Crossing of LRT Locations] of this Schedule shall be equipped with Traffic Controllers or through an I/O device element of the TRPS.

Table 6-4.3-1: Traffic Intersections

No	Traffic Intersection Location	Priority	LRT Grade Crossing	Notes
1	Webber Greens Drive / Lewis Farms Site Access	N/A	No	
2	Webber Greens Drive / Future 199 Street	N/A	No	
3	87 Avenue / Ramp SB AHD	N/A	No	
4	87 Avenue / Ramp NB AHD	Partial	Yes	
5	87 Avenue / 189 Street	Full	Yes	
6	87 Avenue / 182 Street	Full	Yes	
7	87 Avenue / 178 Street	N/A	No	
8	87 Avenue / WEM Parkade Access (177A Street)	N/A	No	
9	87 Avenue / WEM Parkade Access (176A Street)	N/A	No	
10	87 Avenue / 175 Street	N/A	No	
11	87 Avenue / WEM Transit Centre (174 Street)	N/A	No	
12	87 Avenue / WEM Parking Access (173 Street)	N/A	No	
13	87 Avenue / 170 Street	N/A	No	
14	87 Avenue / 169 Street	N/A	No	
15	87 Avenue / 165 Street	N/A	No	
16	87 Avenue / 163 Street	Full	Yes	
17	87 Avenue / 159 Street	Full	Yes	

No	Traffic Intersection Location	Priority	LRT Grade Crossing	Notes
18	88A Avenue / Meadowlark Road	Full	Yes	
19	89 Avenue / Meadowlark Road	Full	Yes	
20	Meadowlark Road / 156 Street	Full	Yes	
21	92 Avenue / 156 Street	Full	Yes	
22	95 Avenue / 156 Street	Full	Yes	
23	97 Avenue / 156 Street	Full	Yes	
24	99 Avenue / 156 Street	Full	Yes	
25	100 Avenue / 156 Street	Full	Yes	
26	Stony Plain Road / 156 Street	Full	Yes	
27	Stony Plain Road / 153 Street	Full	Yes	
28	Stony Plain Road / 151 Street	Full	Yes	
29	Stony Plain Road / 149 Street	Partial (WB) Full (EB)	Yes	Note 2
30	Stony Plain Road / 145 Street	Partial (WB) Full (EB)	Yes	Note 2
31	Stony Plain Road / 143 Street	Partial (WB) Full (EB)	Yes	Note 2
32	Stony Plain Road / 142 Street	Partial	Yes	
33	Stony Plain Road / 102 Avenue	N/A	No	
34	Stony Plain Road / 139 Street	Full	Yes	
35	Stony Plain Road / 136 Street	Full	Yes	
36	Stony Plain Road / 134 Street	Full	Yes	
37	Stony Plain Road / 132 Street	Full	Yes	
38	Stony Plain Road / Sylvancroft Lane	Full	Yes	Note 4
39	Stony Plain Road / 127 Street	Full	Yes	Note 4
40	Stony Plain Road / 126 Street	Full	Yes	
41	Stony Plain Road / 124 Street	Full	Yes	

No	Traffic Intersection Location	Priority	LRT Grade Crossing	Notes
42	Stony Plain Road / 121 Street	Full	Yes	
43	104 Avenue / 118 Street	Full	Yes	
44	104 Avenue / 116 Street	Full	Yes	
45	104 Avenue / 114 Street	Full	Yes	
46	104 Avenue / 112 Street	Partial (WB) Full (EB)	Yes	Note 2
47	104 Avenue / 109 Street	Partial	Yes	Note 1
48	104 Avenue / 107 Street	Partial	Yes	Note 1
49	104 Avenue / 106 Street	N/A	No	
50	104 Avenue / 105 Street	N/A	No	
51	103 Avenue / 107 Street	Partial	Yes	Note 1
52	102 Avenue / 107 Street	Partial	Yes	Note 1
53	102 Avenue / 106 Street	Partial	Yes	Note 1
54	102 Avenue / 105 Street	Partial	Yes	Note 1
55	102 Avenue / 104 Street	Partial	Yes	Note 1
56	102 Avenue / 103 Street	Partial	Yes	Note 1
57	102 Avenue / 102 Street	Partial	Yes	Note 6

Table 6-4.3-2: Pedestrian Activated Signal Locations

No	Traffic Intersection Location	Priority	LRT Grade Crossing	Notes
1	87 Avenue / East of 189 Street	N/A	No	
2	87 Avenue / West of Aldergrove / Belmead Stop	N/A	No	
3	87 Avenue / East of 182 Street	N/A	No	
4	87 Avenue / WEM Parking Access (172 Street)	N/A	No	
5	88B Avenue / Meadowlark Road	Full	Yes	
6	156 Street South of Glenwood/Sherwood Stop	Full	Yes	
7	156 Street North of Glenwood/Sherwood Stop	Full	Yes	
8	156 Street / 100A Avenue	N/A	No	
9	Stony Plain Road / 155 Street	Full	Yes	
10	Stony Plain Road / 154 Street	Full	Yes	Note 3

No	Traffic Intersection Location	Priority	LRT Grade Crossing	Notes
11	Stony Plain Road / 152 Street	Full	Yes	Note 3
12	Stony Plain Road / 150 Street	Partial (WB) Full (EB)	Yes	Note 2
13	Stony Plain Road / 148 Street	Partial (WB) Full (EB)	Yes	Note 2
14	Stony Plain Road / 146 Street	Partial (WB) Full (EB)	Yes	Note 2
15	Stony Plain Road / 138 Street	Full	Yes	
16	Stony Plain Road / 133 Street	Full	Yes	Note 3
17	Stony Plain Road / Connaught Drive	Full	Yes	
18	Stony Plain Road / 129 Street	Full	Yes	
19	Stony Plain Road / 125 Street	Full	Yes	
20	Stony Plain Road / 123 Street	Full	Yes	
21	Stony Plain Road East of 124 Street Stop (122 Street)	Full	Yes	
22	Stony Plain Road / 120 Street	Full	Yes	Note 3
23	Stony Plain Road / 119 Street	Full	Yes	Note 3
24	104 Avenue / 117 Street	Full	Yes	
25	104 Avenue East of The Yards Stop (115 Street)	Full	Yes	
26	104 Avenue West of MacEwan Arts / 112 Street Stop (113 Street)	Full	Yes	
27	104 Avenue / 111 Street	Partial (WB) Full (EB)	Yes	Note 2
28	104 Avenue / 110 Street	Partial (WB) Full (EB)	Yes	Note 2, 3
29	104 Avenue / 108 Street	Partial	Yes	

Table 6-4.3-3: Pedestrian Crossing of LRT Locations

No	Crossing Location	Priority	LRT Grade Crossing	Notes
1	87 Avenue / East of 189 Street	Full	Yes	

No	Crossing Location	Priority	LRT Grade Crossing	Notes
2	87 Avenue / West of Aldergrove / Belmead Stop	Full	Yes	Note 5
3	87 Avenue / West of Aldergrove / Belmead Stop (Emergency Access)	Full	Yes	Note 5
4	87 Avenue / East of Aldergrove / Belmead Stop	Full	Yes	
5	87 Avenue / 182 Street	Full	Yes	
6	156 Street / 100A Avenue	Full	Yes	
7	Stony Plain Road West of 142 Street	Full	Yes	Note 5
8	Stony Plain Road / 142 Street	Full	Yes	Note 5
9	Stony Plain Road West of Grovenor / 142 Street Stop	Full	Yes	
10	Stony Plain Road East of Grovenor / 142 Street Stop	Full	Yes	Note 5
11	Stony Plain Road / 140 Street	Full	Yes	Note 5
12	107 Street North of NorQuest Stop	Full	Yes	
13	107 Street / 102 Avenue	Full	Yes	
14	Pedestrians Crossings within Lewis Farms Park and Ride	Full	Yes	Note 7

Notes:

1. *Intersections in Downtown shall have fixed time phasing. This is indicated as "Green Wave" on the Traffic Signal Timing Sheets, and shall be coordinated for the LRT, with no TSP, however provide detection loops to facilitate future TSP implementation;*
2. *intersection priority is different in each direction as indicated on the Traffic Signal Timing Sheets;*
3. *intersection designed with two (2) Pedestrian Activated Signals (west and east crosswalks). These two (2) signals shall be tied together for operation as indicated on the Traffic Signal Timing Sheets;*
4. *two adjacent traffic intersections (127 Street and Sylvancroft Lane) shall be tied together for operation as indicated on the Traffic Signal Timing Sheets;*
5. *two adjacent LRT crossings shall be tied together for operation as indicated on the Traffic Signal Timing Sheet;*
6. *intersection interfaces with Valley Line LRT Stage 1. The west crosswalk shall be reconstructed; and*
7. *exact number and location of crossings to be determined by Project Co.*

6-4.3.1 Not Used

6-4.3.2 Traffic CCTV Cameras

- A. The existing CCTV camera and radio transmitter at 87 Avenue / 170 Street intersection shall be maintained during construction on an existing or temporary pole, as described on the Traffic Signal Timing Sheets. The camera shall be re-installed as part of the Final Design and installation.

- B. To permit the future installation and operation, by Other Contractors, of CCTV cameras at the 87 Avenue / 178 Street traffic intersections, provide two (2) dedicated 50 mm embedded conduits between the Traffic Controller Cabinet to each Road Traffic Signal pole at the intersection.

6-4.3.3 Intersection Safety Devices (ISD)

- A. Existing Intersection Safety Devices (ISD) at the locations listed below shall be replaced as part of the Final Design and installation, as described on the Traffic Signal Timing Sheets. The existing ISD at the Stony Plain Road / 156 Street intersection shall be removed;
 - 1. 87 Avenue / 178 Street;
 - 2. 87 Avenue / 170 Street; and
 - 3. 104 Avenue / 109 Street.
- B. Project Co shall coordinate with the City for the design of the ISD equipment;
 - 1. design options for the ISD equipment include either an approaching or receding radar based system dependant on the intersection constraints as detailed by the City during Design.
- C. Project Co shall provide all necessary connections and power supply from the Traffic Controller to the ISD as described in the Accepted Final Design.
- D. Project Co shall configure the Traffic Controller for installation of ISD equipment;
 - 1. Project Co shall re-install the existing ISD interface panel into the new Traffic Controller cabinet as described in the Final Design.
- E. Project Co shall coordinate with the City for all handling of existing and new ISD equipment in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 - 1. the City shall procure, supply, install, and Commission all new ISD equipment;
 - 2. the City shall decommission and remove all existing ISD equipment, with the exception of the following:
 - a. the ISD interface panel within the existing Traffic Controller cabinet which shall be removed and re-installed by Project Co as part of Final Design and installation;
 - b. the existing ISD in-ground loops shall be removed and disposed of by Project Co; and
 - c. the existing ISD pole foundation shall be removed and disposed of by Project Co;
 - 3. notify the City at least 20 days in advance of any removal of Roadway which may compromise the existing ISD equipment;
 - a. within those 20 days, provide the City with access and such on-site assistance as may be reasonably requested in order to decommission the ISD equipment;
 - 4. notify the City at least 20 days in advance of any Traffic Signal Commissioning so that the City can install and Commission the new ISD equipment;
 - a. within those 20 days, provide the City with access and such on-site assistance as may be reasonably requested in order to Commission the ISD equipment;
 - 5. notify the City of any temporary roadway marking installation so that the City can configure the ISD equipment;

- a. at such time, provide the City with access and such on-site assistance as may be reasonably requested in order to configure the ISD equipment; and
- 6. final configuration of the ISD equipment shall be completed by the City after the final roadway markings are in place;
 - a. ISD equipment details shall be incorporated into the As Built drawings in accordance with information supplied to Project Co by the City.

6-4.3.4 Opticom Emergency Pre-emption Equipment

- A. Project Co shall configure the Traffic Controller for installation of Opticom emergency vehicle pre-emption equipment at all intersection locations listed in Table 6-4.3-1 [*Traffic Intersections*] and Table 6-4.3-2 [*Pedestrian Activated Signal Locations*].
- B. Project Co shall coordinate with the City for all handling of existing and new Opticom equipment on both temporary and Final Traffic Signal Equipment in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 - 1. the City shall procure, supply, install, and Commission all Opticom equipment;
 - 2. the City shall decommission and store all existing Opticom equipment;
 - 3. notify the City at least 20 days in advance of any Traffic Signal decommissioning and Commissioning to coordinate the handling of all Opticom equipment; and
 - 4. provide the City with access to the Traffic Controller, and such on-site assistance as may be reasonably requested in order to decommission or recommission the Opticom equipment.
- C. Opticom equipment details shall be incorporated into the As Built drawings in accordance with information supplied to Project Co by the City.
- D. Replace the existing emergency vehicle beacon at the entrance of the fire hall along 107 Street to assist authorized emergency vehicles to enter and exit the fire hall while controlling vehicular and pedestrian traffic, designed in accordance to MUTCD (Canada);
 - 1. beacon to be manually initiated by emergency vehicles; and
 - 2. Train will operate on a Line-of-Sight basis.

6-4.3.5 Vehicle Detection

- A. Provide vehicle detection with in-ground inductive loops. Detection is required on each side street lane and main street dedicated turning lanes as specified on the Traffic Signal Timing Sheets;
 - 1. additional detection, including queue detection, is required where specified on the Traffic Signal Timing Sheets; and
 - 2. installation shall follow the procedures in the *Valley Line LRT Traffic Signal Construction and Maintenance Specifications*.

6-4.3.6 Qualifications

- A. The following Traffic Signal Equipment installation tasks shall be performed by Project Co Persons having at minimum an IMSA Tech I qualification:
 - 1. installation of poles and pole bases;

2. cabinet base installation;
 3. backfilling;
 4. cabinet placement; and
 5. installation of cables.
- B. The following Traffic Signal Equipment installation tasks shall be performed by Project Co Persons having at minimum an IMSA Tech II qualification as defined in Section 10.9.3 [*Traffic Signal Maintenance Staff Qualifications*]:
1. cabinet prewiring;
 2. cabinet bench testing;
 3. termination of all cables; and
 4. testing and Commissioning of traffic signals.

6-4.3.7 Traffic Controller and Cabinet

- A. Subject to the following amendments, provide fully configured cabinets, in accordance with the document *Valley Line LRT Specifications for the Supply of Traffic Cabinets and Intersection Control Equipment* at the intersections specified in Tables 6-4.3-1 [*Traffic Intersections*], 6-4.3-2 [*Pedestrian Activated Signal Locations*], and 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule:
1. the Traffic Controller cabinet at each intersection shall be “TS2 TYPE 1 - 42CCT P2 CABINET ASSEMBLY” or “TS2 TYPE 1 – M CABINET ASSEMBLY”;
 2. The Traffic Controller at each intersection shall be an Econolite 1000 Cobalt controller fully interoperable with the City’s existing Centracs® traffic management system, whose specifications are contained in document *Centracs Software and System Specifications*;
 3. each cabinet shall be provided with minimum six (6) hour battery standby for all equipment other than the heater and fan such that full operation of the intersection shall be maintained in the event of a Utility power failure;
 4. each cabinet shall indicate Utility power failure alarm to the SCADA as described in Section 6-1.15 [*Security and Alarm System*] of this Schedule, including the location(s) of the affected intersection(s);
 5. each cabinet shall indicate low ambient temperature alarms to SCADA as described in Section 6-1.15 [*Security and Alarm System*] of this Schedule when the ambient temperature within the cabinet drops below -20°C, including the location(s) of the affected intersection(s);
 6. integrate each cabinet with the TRPS at all Grade Crossings;
 7. each cabinet layout shall include signal outputs to energize all LRT Traffic Signal fixtures at the intersections in Tables 6-4.3-1 [*Traffic Intersections*], 6-4.3-2 [*Pedestrian Activated Signal Locations*] and 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule with LRT Grade Crossings;
 - a. alternatively, elements of the TRPS may be used to drive LRT Traffic Signal fixtures at the intersections listed in Table 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule;
 8. each cabinet layout shall include one (1) Polara IN2 wire Navigator Central Control unit for every 12 audible pedestrian push button stations;

9. each cabinet layout shall be designed to accommodate future installation by Other Contractors of an IP switch with the following dimensions 156 mm (h) x 156 mm (w) x 130 mm (d). Provide a 24 VDC, 35 W power source for the future IP switch, energized from the standby battery;
 10. each cabinet layout shall include signal outputs to energize all Opticom equipment and incorporate any necessary equipment where applicable;
 11. each cabinet layout shall include signal outputs to energize the ISD equipment and incorporate the existing ISD interface panel where applicable;
 12. each cabinet layout shall incorporate termination of all conduits described in Section 6-1.5Y.1 [*Systems Duct Bank and Associated Infrastructure*] and Section 6-4.3 [*Traffic Signal Equipment*] of this Schedule; and
 13. cabinets shall not be required at intersections listed in Table 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] if controlled through an I/O device of the TRPS.
- B. Mount each cabinet on a precast concrete base as required in the *Valley Line LRT Traffic Signal Construction and Maintenance Specifications*.
- C. Each cabinet shall follow the following wiring and testing requirements:
1. Submit to the City all applicable wiring diagrams, Traffic Controller programming sheets, Traffic Controller database files, and cabinet layouts with the Final Design submission for the Traffic Signals as described in Appendix 4B [*Project Specific Submission Requirements*] for each new Traffic Controller cabinet (“**Final Traffic Controller Design Package**”);
 - a. Traffic Controller programming sheets shall be submitted in the supplied format;
 2. after acceptance of the Final Design, provide the City four (4) weeks notice prior to bench testing to allow the City to be present for witnessing, inspection, or additional testing, at its discretion in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 3. pre-wire each cabinet at a Project Co test facility, configured to operate per the applicable design, including timing, phasing and additional control logic;
 4. each cabinet shall be bench tested with the applicable programming such that a minimum of 48 continuous hours shall pass with no failures or errors;
 - a. if a failure or error occurs during bench testing, submit to the City a modified wiring design and/or control logic to remedy the failure or error (each, a “**Modified Wiring Design**”);
 - i. after City acceptance of the Modified Wiring Design, the 48 hour testing period shall restart with the modified wiring design; and
 - b. upon successful bench testing of each cabinet, the cabinet shall be installed as specified in the *Valley Line Traffic Signal Construction and Maintenance Specifications*.
- D. Provide an unmetered power feed to each Traffic Controller cabinet at the intersections listed in Tables 6-4.3-1 [*Traffic Intersections*], 6-4.3-2 [*Pedestrian Activated Signal Locations*] and 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule from the City’s electric Utility Company;
1. the power feed shall be compliant with the electric Utility Company’s Customer Connection Guide.
- E. Provide notice to the City when fibre optic connectivity between the main Data Centre and the applicable Traffic Controller is available and provide the City with access to the Traffic Controller in

order to establish data connectivity to the City Traffic Management Centre in accordance with Section 1-1.3 [*City Works*] of this Schedule.

- F. Project Co may, pursuant to the TAR process described in Section 1-4.2.6 A [*Traffic Accommodation Request*] of this Schedule, elect to pre-install temporary Traffic Controller cabinets to facilitate the construction schedule.
- G. Notify the City at least 20 days in advance of installing each Traffic Controller such that:
 - 1. for new signalized intersections, full signals shall be placed in “flashing” activation for 72 continuous hours on consecutive Business Days, beginning on a Monday or Tuesday, before being placed in “full” activation. An applicable “starburst” sign shall be posted by Project Co for three (3) weeks. “Flashing” activation is not required for existing traffic signals nor for pedestrian only signals;
 - a. advise the City two (2) weeks in advance of “flashing” activation and full activation to allow the City to be present for witnessing, inspection, or additional testing, at its discretion in accordance with Section 1-1.3 [*City Works*] of this Schedule;
 - b. the 72 hour “flashing” activation period is not required when Traffic Controllers are upgraded from temporary to permanent; and
 - c. if errors occur during the 72 hour “flashing” activation, deficiencies shall be address immediately;
 - 2. for existing signalized intersections with a phase change or a signal head change a “starburst” sign shall be posted by Project Co for three (3) weeks; and
 - 3. all Road Traffic Signal heads must be appropriately bagged or covered prior to activation to minimize confusion for motorists.
- H. Once the Road Traffic Signals are placed into full activation, immediately perform an onsite activation test to include:
 - 1. manufacturer recommended tests;
 - 2. vehicle detector test;
 - 3. pushbutton test;
 - 4. lamp inspection; and
 - 5. operational compliance with timing sheet designs.
- I. Provide documentation showing results from onsite activation.
- J. Upon full activation, Project Co shall provide the City with access to the Traffic Controller, and such on-site assistance as may be reasonably requested in order to confirm interfaces with the City Traffic Management Centre in accordance with Section 1-1.3 [*City Works*] of this Schedule.
- K. Within 15 days of full activation, Project Co shall prepare and submit all final applicable wiring diagrams, Traffic Controller programming sheets, Traffic Controller database files, and cabinet layouts (“**Full Activation Traffic Controller Design Package**”) for each Traffic Controller cabinet;
 - 1. the cabinet wiring diagram shall include, for all terminating points within the cabinet, references to every point with which is directly interconnected (double-ended); and

2. the cabinet wiring diagram shall include, for all control and auxiliary equipment, functional description and identification of input/output pin connections.
- L. An electronic version of the cabinet wiring diagram shall be provided for each unique cabinet type. These shall be in MicroStation. DGN format or AutoCAD .DWG format.
 - M. One (1) cabinet wiring diagram within a protective plastic envelope shall be provided within each cabinet. All wiring diagrams in the cabinet shall fit on one A1 sized sheet.
 - N. One (1) Traffic Controller programming sheet within a protective plastic envelope shall be provided within each cabinet. All programming sheets in the cabinet shall fit on one A1 sized sheet.
 - O. One (1) log book shall be provided within each cabinet to record all visits to the cabinet. The log book shall remain in the cabinet unless requested by the City.
 - P. Facilitate the integration of the Traffic Signal operations along 102 Avenue for Valley Line LRT Stage 1 and Valley Line LRT Stage 2 by performing modifications to the Traffic Controller at the following intersections in accordance with Section 1-1.4 [*Integration with Valley Line LRT Stage 1*] and Section 6-4.3.11 [*Traffic Signal Timing Plans*] of this Schedule:
 1. 102 Avenue / 101 Street;
 2. 102 Avenue / 100A Street; and
 3. 102 Avenue / 100 Street.

6-4.3.8 Traffic Signal Construction Requirements

- A. Traffic Signal Equipment includes but is not limited to the following categories:
 1. Traffic Controllers;
 2. LRT Traffic Signal heads, Road Traffic Signal heads, bike signal heads, backboards, LED signal modules, pedestrian signals with count-down timers;
 3. pedestrian push buttons, bike push buttons, audible signals;
 4. cantilever structures, poles, arms, davit extensions;
 5. active signs, passive signs, overhead signs;
 6. Utility power, standby power;
 7. vehicle detectors, detector loops; loop sealant;
 8. foundations, junction boxes, vaults, ducts, cabling; and
 9. all signal assembly materials consisting of stainless-steel strapping and buckles, anchor bolts, tenons, cover plates, grommets, arm flanges, hand holes, identification decals, base plates, fixture brackets, guywires, preforms, machine bolts, eye nuts, hex nuts, washers, saddle clamps, strain insulators, and davit arm hangars.

All designed in accordance with MUTCD (Canada) and the requirements set out in Section 6-4.3.4 [*Traffic Signal Intersection Design*] of this Schedule.

- B. Provide Traffic Signal Equipment per the requirements of the *Valley Line LRT Traffic Signal Construction and Maintenance Specifications*.

6-4.3.9 Traffic Signal Maintenance Requirements

- A. Project Co shall be responsible for maintaining and operating all Traffic Controller and Traffic Signal Equipment during the Construction Period. Requirements for maintenance are included in the *Valley Line LRT Traffic Signal Construction and Maintenance Specifications* and within Section 1-3.5 [*Maintenance During Construction*] of this Schedule. Requirements for operation are included in Section 1-4 [*Transportation Management*] of this Schedule.
- B. Provide maintenance manuals as outlined in the *Valley Line LRT Specifications for the Supply of Cabinets and Intersection Control Equipment*.

6-4.3.10 Traffic Signal Intersection Design

- A. Design all traffic intersections, including all Traffic Signal Equipment, in accordance with the requirements of this Section 6-4.3.5 [*Traffic Signal Intersection Design*] of this Schedule, which shall apply and prevail if in conflict with the requirements of MUTCD (Canada).

6-4.3.10.1 Signal Displays

- A. Provide at least two (2) Road Traffic Signal fixtures for each approach. For protected left or right turns, provide a single fixture with two (2) red indications along with a “no left/right turn on red” sign.
- B. For dedicated left turn bays with permissive left turns only, provide left turn fixtures for future provisions.
- C. Backboards shall be used on all primary fixtures and are permitted on secondary and auxiliary fixtures.
- D. Louvers shall be installed on signals when deemed necessary by an engineering review.
- E. 300mm LED lenses shall be used in all fixtures.
- F. Auxiliary fixtures shall be used to supplement the primary turn fixtures at wide or complex intersections.
- G. Overhead fixtures shall be mounted horizontally for through lanes, right turn lanes, and where a shared fixture is used for through and left turning traffic. Vertical fixtures shall be used where a separate fixture is provided for an exclusive turn lane with protected phasing, and for pole mounted secondary and auxiliary fixtures. “Left turn signal” and “Right turn signal” signs shall not be used.

6-4.3.10.2 Pedestrian and Audible Signals

- A. Pedestrian signals shall count down during the “flashing don’t walk” interval only.
- B. Pedestrian pushbuttons shall be provided with directional arrows in the direction of the crossing.
- C. Pedestrian audible pushbuttons shall be provided at all signalized intersections with LRT in accordance with the document *Audible Pedestrian Signal (APS) Design and Installation Guidelines*.
- D. The following intersections shall be programmed with automatically initiated pedestrian crossings and shall be provided with an exclusive audible signal pushbutton on the side of the pole parallel to and entering each crosswalk, with a sign above the pushbutton stating “Push Button for Audible Signal Only”. Configure the Traffic Controllers at these intersections to automatically initiate pedestrian calls on every traffic cycle through recall settings as specified in the Traffic Signal Timing Sheets.

1. 104 Avenue / 109 Street;

2. 104 Avenue / 107 Street;
 3. 104 Avenue / 106 Street;
 4. 104 Avenue / 105 Street;
 5. 103 Avenue / 107 Street;
 6. 102 Avenue / 107 Street;
 7. 102 Avenue / 106 Street;
 8. 102 Avenue / 104 Street;
 9. 102 Avenue / 103 Street; and
 10. 102 Avenue / 102 Street (relocated west crosswalk).
- E. The pedestrian Grade Crossings in Table 6-4.3-3 [*Pedestrian Crossing of LRT Locations*] of this Schedule shall be:
1. automatically initiated and provided with an exclusive audible signal pushbutton on the side of the pole parallel to and entering each crossing, with a sign above the pushbutton stating “Push Button for Audible Signal Only”; and
 2. configured, via the Traffic Controller and TRPS as specified on the Traffic Signal Timing Sheets, to:
 - a. automatically display a permissive pedestrian signal unless a Train is approaching the crossing. The permissive pedestrian signal must be displayed for a minimum of seven (7) seconds if a second Train is approaching the crossing;
 - b. provide adequate “flashing don’t walk” interval before displaying a pedestrian stop signal based on a pedestrian walking speed 1.1 m/s except at the following locations, where 1.0m/s shall be used;
 - i. Stony Plain Road West of 142 Street;
 - ii. Stony Plain Road / 142 Street;
 - iii. Stony Plain Road West of Grovenor / 142 Street Stop; and
 - iv. Stony Plain Road / 140 Street;
 - c. display an LRT-Stop signal in both directions of LRT travel whenever the corresponding pedestrian signal is not displaying a pedestrian stop signal; and
 - d. provide adequate buffer time between the start of the pedestrian stop signal and the arrival of the Train at the crossing.
- F. At all intersection locations listed in Table 6-4.3-1 [*Traffic Intersections*], except those listed in Section 6-4.3.5.2 D [*Pedestrian and Audible Signals*], and as indicated on the Traffic Signal Timing Sheets, the main street pedestrian crossing shall be automatically initiated and shall be provided with an exclusive audible pedestrian signal pushbutton on the side of the pole parallel to and entering each crosswalk with a sign above the pushbutton stating “Push Button for Audible Signal Only”;

1. configure the side street for pushbutton initiated pedestrian calls, as indicated on the Traffic Signal Timing Sheets, and provide a pushbutton on the side of the pole parallel to and entering each crosswalk with a sign above the pushbutton stating “Push Button for WALK (symbol only) Hold for Audible Signal”.
- G. For all locations listed in Table 6-4.3-2 [*Pedestrian Activated Signal Locations*] of this Schedule and as indicated on the Traffic Signal Timing Sheets, provide a pushbutton on the side of the pole parallel to and entering the crosswalk and provide a sign above the pushbutton stating “Push Button for WALK (symbol only) Hold for Audible Signal”, and configure the Traffic Controllers for pushbutton initiated pedestrian calls.

6-4.3.10.3 Bike Signals and Detection

- A. The following intersections shall include bike fixtures as indicated on the Traffic Signal Timing Sheets:
 1. 104 Avenue / 110 Street;
 2. 102 Avenue / 107 Street;
 3. 102 Avenue / 106 Street;
 4. 102 Avenue / 105 Street;
 5. 102 Avenue / 104 Street; and
 6. 102 Avenue / 103 Street.
- B. Bike detection shall be provided as indicated on the Traffic Signal Timing Sheets. Bike detection may include pushbuttons or in-ground detection loops as indicated on the Accepted Final Design.
- C. Bike signals and detection shall be designed in accordance with *Transportation Association of Canada Bikeway Traffic Control Guidelines for Canada*.

6-4.3.11 Traffic Signal Timing Plans

- A. Reference Traffic Signal Timing Sheets for all signalized intersections in Tables 6-4.3-1 [*Traffic Intersections*] and 6-4.3-2 [*Pedestrian Activated Signal Locations*] of this Schedule are provided;
 1. The reference Traffic Signal Timing Sheets include the information required for Project Co to undertake the Interim Design of the Traffic Signals and cabinet.
- B. The City shall provide the Traffic Signal Timing Sheets (with Transit Signal Priority) to Project Co for programming, testing and Commissioning based on the Final Design and in accordance with the Design Management Plan developed by Project Co as defined in Schedule 4 [*Design and Construction Protocols*];
 1. Final Traffic Signal Timing Sheets will be provided within 90 days of Acceptance of the Final Design.
- C. After the Construction Completion Date, the City may elect to perform modifications to the signal timing at all locations at its discretion, provided all of the signal timing constraints defined in Section 6-4.5 [*Transit Signal Priority*] of this Schedule are maintained.
- D. Signal timings prior to Construction Completion shall be programmed by Project Co as specified in an approved Traffic Accommodation Request as defined in Section 1-4.2.6 [*Traffic Accommodation Request (TAR)*] of this Schedule.

E. The City shall provide the Traffic Signal Timing Sheets for the following intersections on the Valley Line LRT Stage 1:

1. 102 Avenue / 101 Street;
2. 102 Avenue / 100A Street; and
3. 102 Avenue / 100 Street.

6-4.4 LRT TRAFFIC SIGNALS

A. Provide LRT Traffic Signals at all Grade Crossings consistent with the LRT Traffic Signals used in Valley Line LRT Stage 1. Where Track clearances provide a minimum 100 mm clearance between all outside edges of the LRT Traffic Signal and the Track Clearance Envelope, the LRT Traffic Signal shall be installed between the Tracks on a pedestal or OCS pole or at the end of a traffic cantilever arm. In all other cases, the LRT Traffic Signal shall be installed at the end of a traffic cantilever arm.

1. Provide LRT Traffic Signals at all Grade Crossings for bi-directional running.

B. Provide a minimum of two (2) LRT Traffic Signals for each direction of travel with one (1) pole placed on each side of the vehicular type Grade Crossings as shown in Figure 6-4.4.1 [Typical LRT Traffic Signal Configuration for Vehicular Crossing].

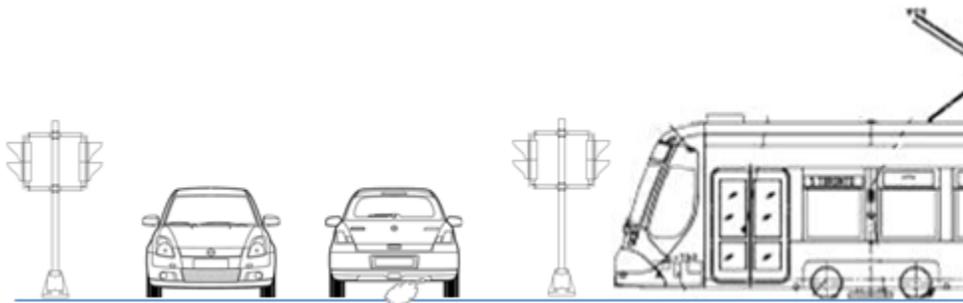


Figure 6-4.4.1: Typical LRT Traffic Signal Configuration for Vehicular Grade Crossing

C. For pedestrian only Grade Crossings, one of the following configurations may be used based on Hazard Analyses defined in Schedule 4 [Design and Construction Protocols]:

1. Minimum two (2) LRT Traffic Signal poles with one (1) on either side of the pedestrian crossing with a minimum one (1) LRT Traffic Signal on each pole facing the approach to the crossing as shown in Figure 6-4.4.2 [Typical LRT Traffic Signal Configuration for Pedestrian Crossing (Option 1)] of this Schedule; or

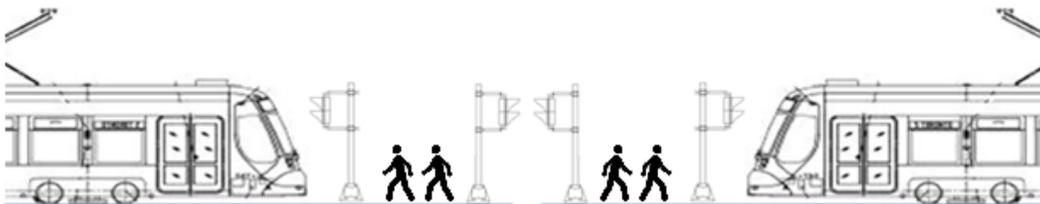


Figure 6-4.4.2: Typical LRT Traffic Signal Configuration for Pedestrian Crossing (Option 1)

2. Minimum one (1) LRT Traffic Signal pole and minimum one (1) pedestrian boundary sign pole on either side of the pedestrian crossing with a minimum two (2) LRT Traffic Signal on each pole

facing the approach to the crossing as shown in Figure 6-4.4.3 [*Typical LRT Traffic Signal Configuration for Pedestrian Crossings (Option 2)*] of this Schedule;

- a. For centre mounted pole situations, the LRT Traffic Signal pole will be mounted on the approach side with highest Train Speed and one (1) pedestrian boundary sign pole will be placed centre mounted on the opposite side; and
- b. When centre LRT Traffic Signal poles cannot be placed, a minimum of two (2) side mounted poles are required with one (1) pole mounted on the approach side in normal travel direction. In such situations a minimum of two (2) pedestrian boundary sign poles will be placed on the opposite side to the LRT Traffic Signal pole for reverse running.

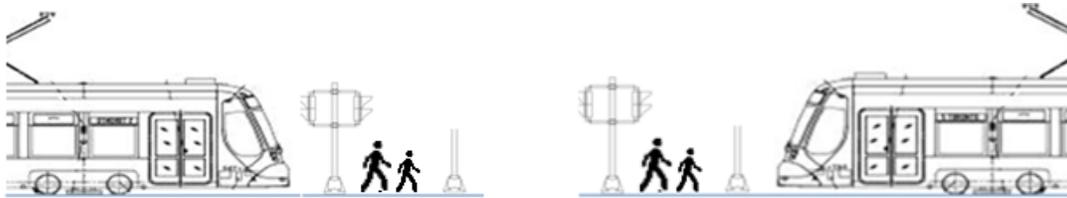


Figure 6-4.4.3: Typical LRT Traffic Signal Configuration for Pedestrian Crossing (Option 2)

- D. Where an LRT Traffic Signal could be misinterpreted by road traffic as a Road Traffic Signal, provide an additional passive sign to indicate that the LRT Traffic Signal is for LRT use only.
- E. Provide two (2) heads with each LRT Traffic Signal:
 1. the top head shall display a horizontal lunar bar aspect to convey a stop indication, ("**LRT-Stop**");
 2. the bottom head shall display a vertical lunar bar aspect to convey a proceed indication, ("**LRT-Proceed**");
 3. proceed signals shall be used in flashing mode to convey a prepare to stop indication, ("**LRT-Prepare-to-Stop**"); and
 4. Where applicable, provide a third LRT Traffic Signal head above the "LRT Proceed" aspect to display an 'R' aspect to convey acknowledgment of receipt of the Driver initiated Train routing request by the Traffic Controller.
- F. The LRT Traffic Signals shall be operated by the Traffic Controllers, with timing to be integrated with the TRPS, as described in Section 6-4.5 [*Transit Signal Priority*] of this Schedule and as indicated on the Traffic Signal Timing Sheets.
- G. Provide a consistent method of visually differentiating LRT Traffic Signals from Block Signals and repeater signals.
- H. The LRT Traffic Signal shall have sighting and conspicuity such that the LRT Traffic Signal, or a Vital repeater signal, can be seen at the Sighting Distance in advance of the LRT Traffic Signal, by a person having normal 6/6m vision, under normal daylight conditions.

6-4.4.1 Not Used

6-4.4.2 Grade Crossing Traffic Control Devices

- A. Traffic control at Grade Crossings shall be managed using only the following Traffic Control Devices each as defined in MUTCD (Canada) or, if not defined therein, as defined in MUTCD (US DOT):

1. tactile paving, passive signs and markings, including intersection pavement markings, railroad warning markings, pedestrian warning signs, "Railroad Ahead" warning signs, and regulatory traffic signs;
 2. striped channelization including median pedestrian refuges, enhanced crosswalks, vehicle channelization and Track Clearance Envelope markings;
 3. Traffic Signals, including Road Traffic Signals, LRT Traffic Signals, pedestrian signals with countdown timers, pedestrian audible signals, bike signals, protected left turn arrows, protected right turn arrows, LRT blank out signs, active no right turn signs, and second Train approaching signs;
 4. barrier channelization including pedestrian channelization, vehicle channelization, bike channelization, fencing, bollards and chains; and
 5. other pedestrian protection devices including flashers; pedestrian activated crossing signals, and swing gates.
- B. Where a Traffic Control Device is not defined in either MUTCD standard, such device shall be as defined by Good Industry Practice, as documented in the applicable APTA publications issued by the United States Federal Transit Administration.
- C. The specific device(s) required for safe and efficient traffic control at each Grade Crossing shall be determined on the basis of the applicable Grade Crossing Hazard Analysis as defined in Schedule 4 [*Design and Construction Protocols*].
- D. Provide active LRT blank out signs or no right turn signs on the traffic pole and/or cantilever arm nearest the turning lane at each Grade Crossings where road traffic may legally turn onto the Track. Active signs shall be monitored by the Traffic Controller and TRPS and failure modes determined on the basis of the Grade Crossing Hazard Analysis as defined in Schedule 4 [*Design and Construction Protocols*].

6-4.5 TRANSIT SIGNAL PRIORITY

- A. Provide Transit Signal Priority functionality to manage the interaction between LRVs, road traffic, cyclists and pedestrians, and in accordance to the Traffic Signal Timing Sheets.
- B. Configure all Grade Crossing Traffic Controllers to provide either Full Priority or Partial Priority, Transit Signal Priority as specified in Tables 6-4.3-1 [*Traffic Intersections*] and 6-4.3-2 [*Pedestrian Activated Signal Locations*] of this Schedule and on the Traffic Signal Timing Sheets provided by the City as described in Section 6-4.3.11 [*Traffic Signal Timing Plans*] of this Schedule:
1. Grade Crossing Traffic Controllers shall maintain their designated Transit Signal Priority configuration for bi-directional running and any single tracking event without reduction in Train speed.
- C. The TRPS shall work in concert with each Grade Crossing Traffic Controller, and subject to the requirements of Section 6.4.3.6 [*Signal Timing*] of this Schedule:
1. an advance notification, (the "**Check-in**"), to the intersection Traffic Controller to condition it to provide the Train with an LRT-Proceed. The Check-in time will be as shown on the Traffic Signal Timing Sheets provided by the City. The Check-in distance will be determined after the Final Design of the roadway has been accepted as specified in Schedule 4 [*Design and Construction Protocols*];

2. an arrival notification (the "**Check-in-B**"), to the Traffic Controller, to confirm the Train's arrival at the intersection. Failure of the Train to arrive at Check-in-B within 20 seconds after the LRT-Proceed aspect has been displayed shall permit the Traffic Controller to:
 - a. cancel the LRT-Proceed aspect by displaying an LRT-Prepare-to-Stop aspect;
 - b. subsequently display an LRT-Stop aspect;
 - c. initiate a new timing sequence to accommodate the passage of the Train through the intersection once notification is received of the Train's arrival at the Check-in-B point; and
 - d. the new timing sequence shall be calculated as though the notification had been received from the associated Check-in point, and a subsequent Check-in-B notification will not be necessary to confirm arrival; and
 3. an exit notification, (the "**Check-out**") once the rear of the Train is clear of the intersection. Upon receipt of the Check-out notification, the Traffic Controller shall cancel the LRT-Proceed aspect by displaying an LRT Prepare-to-Stop indication followed by an LRT-Stop aspect;
 - a. the Check-out point shall be placed at a distance from the nearest curb of the intersection to which they apply such that the rear of a two-car Valley Line LRT Stage 1 Train, regardless of the LRV orientations within the Train, has cleared the intersection.
- D. The Check-in, Check-out and Check-in-B notifications shall be provided by the TRPS through either a data, direct I/O, or loop interface to the local Traffic Controller.
 - E. Transit Signal Priority shall only apply to Trains. Movements of other On-Track Vehicles across intersections shall be governed by normal traffic sequencing without the application of Transit Signal Priority.
 - F. At intersections with an exclusive "LRT only" traffic phase (such as at intersections where the geometry of the Tracks are diagonal relative to the cross streets), provide a means of initiating a non-priority call for the LRT traffic phase:
 1. in the event of TRPS failure; and
 2. to permit On-Track Vehicles, other than Trains, to safely traverse the intersection.
 - G. The Traffic Controller at each Grade Crossing shall be configured to initiate a four (4) minute countdown timer each time a Train has cleared the intersection;
 1. a subsequent Transit Signal Priority request initiated by a Train travelling in the same direction as the previous Train shall not be serviced until expiration of this timer.
 - H. During the second Interim Design submission, provide an OpenTrack model and results using the stop probabilities provided by the City to show that the run time and single tracking headways can be achieved as described in the Operability and Maintainability Parameters and Section 1-2.1.2 [*Operational Design Parameters*] of this Schedule.
 - I. During the Final Design submission provide an OpenTrack model and results using the stop probabilities provided by the City (based on the Final Traffic Signal Timing Sheets) to show that the run time and single tracking headways can be achieved as described in the Operability and Maintainability Parameters and Section 1-2.1.2 [*Operational Design Parameters*] of this Schedule.

SECTION 6-5 TRANSPORTATION ELECTRICAL SERVICE PLAN

6-5.1 INTRODUCTION

- A. All electrical facilities, infrastructure, systems and sub-systems that are not subject to the NBCAE shall comply with this Section 6-5 [*Transportation Electrical Service Plan*].

6-5.2 TESP PROCESS FORM

- A. Develop a TESP process form to record the following information for each electrical installation that is not governed by the NBCAE (each, a “**TESP Process Form**”):
1. all applicable Final Designs, including all Design Data and relevant Design Certificates, that have been submitted to the City and accepted in accordance with Schedule 2 [*Submittal Review Procedure*];
 2. work coordination and modifications with Utilities;
 3. applicable meter applications, Utility Agreements and Project Approvals;
 4. applicable inspection and test procedures; and
 5. a final electrical inspection report, in accordance with Section 6-5.5 [*Final Electrical Inspection Report*] of this Schedule.

6-5.3 TESP DOCUMENTATION

- A. For each electrical installation that is not governed by the NBCAE, compile a TESP binder, which shall include (each, a “**TESP Binder**”):
1. the applicable TESP Process Form;
 2. any Canadian Electrical Code, Part 1 and Part 3 variances granted in accordance with Section 6-5.4 [*Application for Electrical Code Variance*] of this Schedule;
 3. a copy of all applicable electrical Project Approvals;
 4. a copy of applicable Utility Agreements;
 5. copies of all applicable inspection and test reports; and
 6. copies of metering applications (if applicable).
- B. The applicable TESP Binder shall be submitted to the City along with each applicable Construction Certificate submitted in accordance with Section 11.1 [*Construction Certificates*] of Schedule 4 [*Design and Construction Protocols*].

6-5.4 APPLICATION FOR ELECTRICAL CODE VARIANCE

- A. Where a variance to the CEC, Part 1 or Part 3 is required, Project Co shall submit a variance request to the City (each, a “**Electrical Code Variance Request**”). Each Electrical Code Variance Request shall include the following information:
1. date of request;
 2. Project Co’s name, along with the name of the entity submitting the variance request;
 3. CEC section to be varied;

4. details of requested variance;
 5. reason for requested variance;
 6. supporting documentation (proof of equal or better safety performance);
 7. address or legal description upon which the subject-matter of the variance is located;
 8. authority under which the requested variance may be issued; and
 9. signature of Project Co's Representative and of the Person submitting the variance request.
- B. Each Electrical Code Variance Request shall be submitted to the City, provided that the Review Period shall be extended to 30 days.

6-5.5 FINAL ELECTRICAL INSPECTION REPORT

- A. The final electrical inspection report shall be:
1. prepared and sealed by a Professional Engineer acceptable to the City, acting reasonably; and
 2. in the same form, and containing the same content and level of detail, as required for a final electrical inspection report under the NBCAE.

SECTION 6-6 – STREET LIGHTING SYSTEM REQUIREMENTS

6-6.1 INTRODUCTION

- A. Street Lighting shall be provided in accordance with Section 3-7 [*Street Lighting Requirements*] of this Schedule.

6-6.2 APPLICABLE CODES, STANDARDS AND REGULATIONS

- A. Ensure that the Street Lighting system and all associated infrastructure comply with the following codes, standards and regulations, to the extent applicable:
 - 1. Valley Line West LRT Road and Walkway Lighting Construction and Material Standards;
 - 2. Valley Line West LRT Road and Walkway Lighting Design Manual;
 - 3. Light Efficient Community Policy (C576); and
 - 4. Canadian Electrical Code.

6-6.3 DESIGN AND CONSTRUCTION REQUIREMENTS

- A. Provide all Street Lighting electrical infrastructure in accordance with the *Valley Line West LRT Road and Walkway Lighting Construction and Material Standards*, including but not limited to:
 - 1. Conduit;
 - 2. Wiring;
 - 3. Lighting control systems; and
 - 4. Receptacles.
- B. Acceptable products for use on the Project are included in *Valley Line West LRT Road and Walkway Lighting Construction and Material Standards*.
- C. Street Lighting shall be revenue metered, unless part of the City of Edmonton streetlight program, in accordance with Section 6-1.9.8 [*Lighting and Receptacle Metered Service*] of this Schedule.

6-6.3.2 Jasper Place Opportunity Area Specific Requirements

- A. Provide 120V GFI receptacles and necessary electrical systems to street tree beds within the Jasper Place Opportunity Area as required for secondary lighting so that the City can re-establish existing tree lighting, in accordance with Section 2-6.2 [*Right of Way Lighting*] of this Schedule.
- B. Existing City of Edmonton lighting control system within the Jasper Place Opportunity Area shall be maintained in accordance with Section 2-4.8 [*Jasper Place Opportunity Area Special Requirements*] of this Schedule.

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