Hampton Roads Transit Adjacent Construction Manual

March 2015

Version 1.0

Hampton Roads Transit
Adjacent Construction Manual

This document has been prepared to serve as a guideline for projects adjacent to the operating corridors or facilities of Hampton Roads Transit (HRT). This manual covers a wide range of potential construction conditions, but are not intended to replace specific engineering analysis, but intended to provide guidance and direction to protect HRT during the adjacent project work.

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HAMPTON ROADS TRANSIT

Version 1.0 March 2015

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P. PREFACE

P.1 Purpose

The Hampton Roads Transit (HRT) Adjacent Construction Manual ("The Manual) is prepared in the interest and for the guidance of those who propose construction activities adjacent to, beneath, on, or over existing HRT property, facilities, and/or operating rights-of-way. This Manual contains coordination and design requirements for joint development and adjacent construction projects, as well as sections pertaining to insurance, real estate, and as-built documentation.

The Manual outlines the design criteria and procedural requirements that shall be followed for submittal of project information to HRT and for construction in the vicinity of HRT systems and facilities. The guidelines provided herein provide an overview of design requirements. In general, HRT review and approval are required prior to project construction.

As a policy of HRT, all projects are reviewed to ensure that no adverse impacts will be caused to HRT operations, systems, and facilities, and to ensure the continued safe operation of all HRT services.

P.2 Contact References

HRT is a multi-modal agency that operates bus, light rail, ferry, carpool, and paratransit services throughout Hampton Roads. HRT's website is as follows:

HRT Web Address: http://www.gohrt.com

For construction coordination next to HRT, in general, the area on the border of any HRT right-of-way line is typically maintained by the agency's Engineering and Facilities Department. Formal submittals to HRT regarding adjacent construction should thus be directed to:

Mailing Address: Hampton Roads Transit
Engineering and Facilities Department
509 E. 18th Street
Norfolk, VA 23504
(Attn: Adjacent Construction)

HRT Information: (757) 222-6100

Customer Service: (757) 222-6036

For emergency use, the following contact numbers are associated with HRT Operations:

HRT Bus Dispatch, Northside:	(757) 222-6000, Ext. 6625
HRT Bus Dispatch, Southside:	(757) 222-6000, Ext. 6058
HRT Rail Operations Control Center:	(757) 222-6063
HRT Safety & Security Hotline:	(757) 222-6134

1. INTRODUCTION AND GENERAL PROCEDURES

1.1 Preliminary Overview

The HRT Adjacent Construction Manual describes the HRT review and approval process for:

- Proposed projects adjacent to HRT property and/or facilities that may impact existing HRT facilities
- Proposed projects adjacent to HRT owned or controlled property
- Joint development projects
- Other work on HRT property (e.g., utility crossings)

HRT will review plans and specifications for proposed construction adjacent to or on HRT property and joint development projects to ensure that HRT facilities and operations are not damaged or affected by the proposed project work. The review includes impacts during construction activities; e.g., traffic control and temporary shoring work. In addition, factors such as station platform access, future platform expansion, and impact on HRT systems outside of its right-of-way are considered during the review process.

Proposed work will be reviewed to determine whether the proposed construction falls within HRT's Zone of Influence (ZOI) as defined in Appendix 1 of this Manual, and whether the project will have an impact on HRT facilities or revenue operations.

It is a general practice of HRT to review the design for construction of projects adjacent to HRT property on a case-by-case basis.

Design and construction on or adjacent to HRT property should be in conformance with appropriate sections of the HRT Manual of Design Criteria; Hampton Roads District Planning Commission Construction Specifications (4th Ed. City of Norfolk or other jurisdictional modifications); and any applicable criteria such as Norfolk's Right-of-Way Excavation & Restoration Manual or City of Chesapeake Public Facilities Manual.

HRT has specific clearances and utility crossing requirements, particularly for work around The Tide light rail line. These requirements are provided in Appendices 2 and 4.

Most HRT operations and facilities are located adjacent to public rights-of-way. Review and approval by HRT of proposed work for contractors, developers, or other external agents will typically be performed as part of the applicable jurisdictional permit process. In this case, it is typically not necessary for a contractor or developer to provide separate submittals to HRT.

HRT does not currently charge a fee or require reimbursement for its internal review and inspection of work adjacent to its right-of-way. The physical work on HRT property may be subject to reimbursement of costs (see Appendix 4), depending on the location, agreement, or contract under which the work is covered.

Regardless of the type of work, HRT requires that the external owner, developer, contractor, or agency, herein referred to as the Applicant, submit a site specific work plan (SSWP) for approval by HRT.

The general submittal procedure for adjacent construction and joint development projects can be summarized as follows:

- Applicant submits design and SSWP to the HRT Engineering and Facilities Department, either directly or through the jurisdiction's permit application process.
- Sufficient drawings, details, and specifications shall be provided to permit evaluation of whether the work is within the ZOI of HRT and of the sufficiency of proposed mitigation measures.
- To assure proper project coordination, Applicant shall designate one (1) person as primary point of contact to represent the project.
- The HRT Director of Engineering is generally responsible for the review of adjacent construction review work by HRT, unless the impact also involves land use, planning, ADA, real estate, maintenance, operations, or safety & security issues. These impacts will require approval by additional HRT departments, and the Applicant should allow sufficient time in its schedule for this task or tasks.
- HRT will advise the Applicant or jurisdiction in writing of its review findings under one of the following categories:
    1) No Impact. Letter confirming no impact.
    2) Impact. Letter confirming impact and requirements for approval of construction. This generally requires an additional submittal of information.
    3) Approval. Letter confirming approval of proposed work, with required coordination and conditions during construction.

Work within HRT property, particularly any construction affecting service-critical facilities such as The Tide light rail, will require a far greater level of coordination, including involvement with the HRT right-of-way access program, right of entry/flagging procedures, and insurance requirements. This will be covered in greater detail elsewhere in this Manual.

1.2 Engineering Submittals

The Applicant shall field verify, document, and design its proposed project relative to existing HRT facilities and utilities in accordance with the applicable sections of this Manual.

To obtain HRT as-built records, the Applicant must submit a completed Document Request Form (Appendix 3). Requests should be sent to HRT in writing.

The Applicant should provide at least one (1) hardcopy of drawings, calculations, and supporting documents to HRT, and one copy of all submittals in electronic (.pdf) format. The engineering submittal shall clearly show the spacial relationship between the Applicant's project and HRT facilities.

A construction sequence and heavy equipment plan shall be submitted, indicating the position of major construction equipment, particularly within the ZOI, and/or crane positions operating within the potential to foul HRT right-of-way, pedestrian, or vehicular access areas.

1.3 Submittals - General

The following provisions provide general guidelines for SSWP submittals by the Applicant to HRT.

Project Design: General plans of the project showing relative proximity of the work specific to HRT impacts and interests. Specific detailed plans of the work are to be provided.

Support of Excavation, Monitoring, and Contingency Plans: Allow sufficient time for review and approval of plans.

Construction Equipment: A general plan indicating the positioning of construction equipment operating in the ZOI, or potentially impact HRT right-of-way, facilities, operations, pedestrian, and vehicular access areas.

Survey Plats: Where required, and in coordination with jurisdictional requirements, submittal of a sealed survey plat is necessary for permanent easements, property ownership transfer, and work at or within HRT right-of-way lines (including temporary construction easements).

Preconstruction Surveys and Monitoring Plans: Submit as necessary.

Calculations and Submittals: Submittals shall include design calculations, material and catalog cut information, installation procedures, and applicable material safety data sheets (MSDS).

Insurance: Insurance policies and certificates of insurance shall be submitted, including applicable HRT protective liability insurance requirements.

Schedule: Submittal shall include a contemporaneous construction bar chart specific to impact on HRT facilities, right-of-way, and/or coordination efforts. The project bar chart should clearly show work activity impact to HRT facilities and adjacent construction support requirements from HRT as required. Submittal of electronic scheduling media (e.g., Primavera, MS Project, etc.) in lieu of hardcopy/pdf submittals is not permitted.

Other Material: As requested by HRT.

1.4 HRT Right-of-Way Access

Depending on the nature and extent of impact to HRT, access to the right-of-way may be necessary. In addition to work specifically within HRT right-of-way, such as pipe crossings, access may be required for pre- and post-construction inspections, monitoring, and surveying existing facilities.

HRT has different access policies for work adjacent to its bus facilities, parking areas, The Tide light rail line, and administrative facilities, reflecting different operational characteristics of each type of site.

For access to any portion of The Tide right-of-way, which includes right-of-way associated with the light rail track, yard, shop building, station, traction power, and signal facilities, a combination of HRT right-of-way training and access procedures are applicable to the work. HRT has a Standard Operating Procedure (SOP 101.13) for rail access and work within the rail right-of-way, which is provided in Appendix 4 and falls under the authority of the HRT Rail

Operations Department and Department of Technical Services/Systems Maintenance. Provisions of SOP 101.13 supersede the guidelines of this Manual for work within The Tide right-of-way.

Rail access procedures described by SOP 101.13 are required in addition to SSWP requirements.

Flag protection will be required for any work where HRT revenue operations, facilities, structures, or customers are at risk with adjacent construction field activities. Requests for a flag protection are included as part of HRT rail access requests.

Insurance requirements for all work on HRT property are determined by the HRT Risk Management Department; work on adjacent property is generally covered under the property owner's or jurisdiction's specific requirements.

1.5 Field Monitoring

Monitoring of temporary support of excavation structures shall be required for all excavations within the ZOI of HRT structures (Appendix 1), or as determined during design review.

The Applicant shall develop a plan to monitor affected HRT structures, where required, and shall monitor conformance with approved staging plans.

Monitoring of the inside or surface of HRT facilities will be necessary when the adjacent excavation and construction will possibly cause movement or changes in loads on an adjacent HRT facility. HRT reserves the right to place construction inspection personnel on site to observe the effects of the Applicant's project construction on HRT facilities.

1.6 Project Closeout

The Applicant shall advise HRT in writing when project construction adjacent to HRT is complete, and ensure that any HRT punch list items have been addressed. As-built documentation is required for all permanent modifications on, above, or below HRT property and facilities. Geo-referenced as-built documentation shall be submitted to HRT in the format required by the permitting jurisdiction and in accordance with Section 7 of this Manual.

1.7 Additional Review Notes

If uncertainty or disagreement exists with regard to possible impacts that a project may have on HRT facilities prior to formal submittal of documents to HRT or for permit, it is recommended that the Applicant contact HRT for a pre-construction conference to determine assessment of construction impact.

The Applicant should allow no less than 21 calendar days for each HRT review of submittals. Reviews are conducted in the order received. Allow 21 additional calendar days for each successive review. Incomplete applications or submittals will delay the review process and may lead to the return of submittal documents. The Applicant is responsible to ensure that its applications and submittals comply with HRT requirements.

HRT project approvals remain in effect for a 120 day (four calendar month) period. If field construction does not begin within 120 days after HRT approval, design plans and submittals

must be validated as to any updated HRT requirements with regard to construction, coordination, and communication. If validation is not or cannot be provided within this time frame, the Applicant must resubmit plans and other submittals for review and approval prior to the start of construction.

2. DESIGN REVIEW PROCEDURES

2.1 Design Submittal

Required submittals are to be transmitted to HRT via the following address:

Hampton Roads Transit
Engineering and Facilities Department
509 E. 18th Street
Norfolk, VA 23504
(Attn: Adjacent Construction)

2.2 Review Procedures

Design work will be reviewed based on the assumption that the design will meet all applicable codes adopted in the jurisdiction of construction, HRT Design Criteria, and other applicable standards.

Permits, where required, shall be the responsibility of the Applicant.

Monitoring of temporary support of excavation structures for adjacent construction shall be required for excavations located within the HRT Zone of Influence (ZOI), defined in Appendix 1 of this Manual, and as deemed to be required by HRT. The extent of monitoring will vary by project depending on each project's specific impact on HRT facilities and operations.

Drawings, plans, and calculations approved by HRT and changed by the Applicant must be resubmitted for approval.

2.3 Submittals, Criteria, and Guidelines

Drawings and other information required in submittals to HRT should include the following:

- Civil Drawings: Site plans showing all existing conditions, including buildings and foundations, parcel limits, demolition areas, excavation limits, erosion and sediment control, distances from HRT facilities, and utilities.
- Architectural Drawings: Plans showing buildings and new project layout work, including applicable plans, elevations, and sections.
- Structural Drawings: Plans showing foundations and structure plans, elevations, sections, and column loads.
- Utility Drawings: Plans showing new, abandoned, and relocated utilities.
- Geotechnical Report: Report including all boring logs, soil remediation, and foundation requirements.

Designs for the protection, support, and underpinning of existing HRT structures shall be fully evaluated for the effects caused by the adjacent construction using working stress analysis. The stresses and deflections induced on existing HRT structures, short-term and long-term, shall be provided. Soil parameters and other pertinent geotechnical criteria contained herein shall be analyzed for differential pressure loading caused by dewatering operations during the adjacent construction.

The Applicant shall maintain, protect, and assume responsibility for the safety, stability, and integrity of all adjacent HRT structures that may be affected by the work.

The Applicant shall submit dimensioned horizontal and vertical clearances between the adjacent construction project and HRT structures, tracks, roadways, parking areas, and utilities. HRT easement and right-of-way limits must be clearly identified on all site plans. Project encroachments, whether temporary or permanent, shall be specifically identified.

Details of any proposed modifications to HRT facilities, roadways, utilities, parking areas, and busways shall be provided. Submittals shall include sections and details showing the interface of existing and proposed facilities.

Provide cross sections with existing and proposed elevations, and limits of grading work in relation to property lines. Where grading changes are required on HRT property, provide dimensions and square footage of the area required for construction easements.

Hydrologic and hydraulic calculations showing impacts on HRT drainage are required if stormwater drainage from proposed development discharges into the existing HRT drainage system. Stormwater discharge must be reviewed and approved by HRT in advance. Appropriate sediment and erosion control measures should be included upstream of the discharge point onto HRT property.

Where modifications to HRT utilities are required by adjacent construction, submit cross sections, plans, profiles, specifications, and design calculations for review. Details for maintaining utility services to HRT facilities shall be shown when these utilities are impacted. This includes both HRT utilities and the service feeders to these utilities.

Where construction impacts an HRT rail or bus facility entrance, and public access to rail platforms and bus loading/unloading areas are affected, the Applicant shall submit plans for necessary pedestrian and vehicular traffic circulation for areas around HRT. Where construction is adjacent to or above HRT or public areas, protection shall be required over all pedestrian and vehicular areas. Requests for temporary relocation of bus stops or bus shelters shall be clearly shown on the plans. Barricades and signage necessary to direct the public through the construction zone shall be required. Lighting shall be required as part of all overhead construction structures.

Provide construction protection details to preclude impacts on HRT landscaping, street furniture, pylons, bus shelters, bus stops and signage, light rail stations, and light fixtures. Temporary displacement of bus stop facilities will require review by HRT Bus Operations Planning. The current version of HRT bus shelters cannot be moved as a single unit, and disassembly of these units is somewhat involved. The Applicant should protect HRT bus shelters in lieu of relocating the structures whenever possible.

When a gas line installation is proposed under HRT track or other facility, provide all safety measures to be taken, including sleeves and safety jackets, to protect HRT facilities in the event of gas leaks and/or explosion.

3. DESIGN REQUIREMENTS

3.1 Design Intent

Previous work performed by HRT may not necessarily be in conformance with the current HRT Manual of Design Criteria or its appendices. It is the Applicant's responsibility to obtain as-built construction documents from HRT, where available, to understand the design intent of existing facilities to accurately assess the impact of proposed construction on HRT structures, facilities, and utilities.

3.2 Structural Criteria and Zone of Influence (ZOI)

Structural evaluation of the adjacent construction shall be based on the HRT Manual of Design Criteria; excerpts are provided in Appendix 6 for reference. This Criteria includes structural loading induced by the light rail vehicle.

HRT facilities are considered to be affected by the adjacent construction when the proposed excavation and construction are within the HRT Zone of Influence (ZOI), defined in Appendix 1. Existing HRT foundations, structures, shelters, piles, retaining walls, and underground utility lines are considered to be part of HRT facilities.

If the proposed construction is located within the ZOI, the design and construction of the work shall conform to the more restrictive provisions of either the HRT Design Criteria or the applicable jurisdiction.

When the structure adjacent to HRT is required to support or provide resistance to re-establish the long term loading on HRT structure(s), adjacent construction shall be designed for appropriate loadings. In case of uncertainty as to HRT requirements, the Applicant shall contact HRT for clarification before commencement of design.

For construction proposed within the ZOI, the following analyses shall be included in Applicant structural submittals:

- Diagrams illustrating the pressures used in the design, including long term/existing pressures on HRT facilities. Illustrate the variation of existing earth pressures due to various construction phases. A structural evaluation will not be required if the proposed pressures and loads on HRT structures are within the limits of original structure design conditions.
- If the proposed pressures and loads on HRT structures fall outside the limits of original structure design conditions, then a structural analysis will be required to verify that the anticipated earth pressures will not cause overstressing and cracking. The analysis must be submitted for HRT review and approval. HRT may, at its sole discretion, waive such an analysis based on the variation of pressures and loads acting on the affected structure.
- The design for the excavation support system shall include consideration of a deep seated slope stability analysis of sheet piles and retaining walls.

If necessary, or if required by HRT, an analysis shall be provided of existing HRT structure for anticipated loads. Provide details of any proposed construction, dewatering, or groundwater drawdown planned during the adjacent construction.

Settlement analysis of existing HRT facilities shall be performed if foundations are proposed in subsurface strata of loose or substandard material with a thickness of over 5.0 feet.

If laid back slopes are used at the top of an excavation support system, and if they are steeper than 1.0 vertical to 1.75 horizontal, a slope stability analysis shall be provided.

3.3 Support of Excavation

The design of the temporary structures shall be the responsibility of the Applicant. This section presents minimum design and construction requirements to facilitate HRT review of excavation support submittals.

Temporary structures may be designed with laid back slopes as long as the soil loads are taken as equivalent to the full height of the excavation from the subgrade line to the original surface elevation of the soil before excavation.

If design criteria or methods given in any of the reference standards differ with a criteria or method explicitly stated in this Manual, the more restrictive of the standards shall apply.

Means and methods for support of excavation impacting HRT shall be submitted for approval by HRT.

3.4 Shop and Project Drawings

Calculations shall be provided for all components of the structural support system required for adjacent construction impacting the ZOI for HRT. The calculations and drawings shall be sealed by a Professional Engineer registered in the Commonwealth of Virginia. The calculation submittals shall include the following:

- A concise statement of the problem and the purpose of the calculation.
- Input data, applicable criteria clearly stated assumptions and justifying rationale.
- References to articles, manuals, and source material must be furnished with all calculations.
- References to pertinent codes and standards.
- Sufficient diagrams, sketches, or drawing references for the work to be easily understood by an independent reviewer.
- Source or derivation of any equations introduced into the calculations.
- Numerical calculations shall be presented in an orderly and legible format, all in English units.
- Results and conclusions.

Include construction sequencing and methods on the design submittal. For major support systems, show details and procedures for rakers, tiebacks, struts and bracing. The details of wedging or jacking should be such as to maintain tight contact for all bracing members.

Drawings shall include the following:

- Number and title of the drawing
- Drawing date
- Name of project
- Plan scale
- Applicant name
- Clear identification of contents and work location
- HRT right-of-way or easement lines
- Title and number of referencing specification sections
- Professional Engineer's seal and signature, where applicable
- Fabrication or erection drawings
- Construction material list on or directly adjacent to HRT property
- Schedules
- Manufacturer's drawings
- Wiring and control drawings, if applicable
- Catalog cuts and descriptive product literature
- Performance test data
- Material samples, as required

When specialized computer programs are used to perform calculations, a description of the program shall accompany the computations. This description shall indicate that the program is appropriate for its applicable design use.

3.5 Construction Limitations - General

The following construction activities are not permitted within the specified limits of existing HRT facilities without HRT approval:

- Excavation under HRT structures, including access to underpinning
- Tunneling, jacking, or boring under HRT structures
- Excavation within 10.0 feet of HRT structure face, or work within ZOI limits, is prohibited unless an approved excavation support system conforming to the requirements of this Manual is installed to protect HRT facilities.
- Overhead equipment shall not operate less than 12.0 feet from the HRT light rail catenary wire or poles.
- Pile driving within 25.0 feet of HRT structures, or to centerline of at-grade or embedded track.
- Blasting within 100.0 feet of HRT structures without prior approval of HRT. A blast-monitoring program shall be provided to verify compliance with approved plans and criteria. In general, peak particle velocity (PPV) at HRT structures from any blast event shall not exceed 2.0 inches per second, as per U.S. Army Corps of Engineers

Publication ETL 1110-1-142, Engineering and Design – Blasting Vibration Damage and Noise Prediction and Control (ref. www.usace.army.mil).

3.6 Construction Adjacent to HRT At-Grade Tracks and Facilities

Work to install pipe casings, conduits, micro-tunnels, and other facilities under HRT tracks shall normally be done continuously. If the facility is to be installed near the surface, where ground borne vibrations or settlement may be a problem, then the work will be restricted to non-revenue hours.

A subsidence detection plan and detailed tunneling/boring schedule will be required prior to proposing any such operation to HRT. The Applicant shall provide a detailed description and design of the underground crossing.

A geotechnical or soils report with a proposed dewatering plan shall accompany the plan submitted for an underground crossing of HRT operating right-of-way, or excavation adjacent to HRT at-grade tracks and right-of-way. Any ground improvements, such as flowable fill grout, necessary for the underground crossing shall be specified in the geotechnical or soils report.

No drainage, either surface or subsurface, is to be diverted into HRT drainage systems from adjacent facilities without calculations verifying no quantitative increase in stormwater runoff inflow to HRT facilities from existing conditions. Written approval by HRT is required for these diversions, regardless of impact.

When construction is adjacent to HRT surface tracks and will impact fencing, railings, or bollards, details shall be provided for proposed changes, whether temporary or permanent, that are required to accommodate the project.

Specific protective measures will be required for project activities that impact the operating right-of-way. These measures may include protective screening and overhead protections, as well as restrictions on crane placement and movements. Requirements will be addressed on a project specific basis.

3.7 Boring or Jacking under HRT Right-of-Way

This section is based on the assumption that the proposed tunneling is smaller than 8.0 feet in cross-sectional area. Tunnels larger than 8.0 feet in cross-sectional area will require a preliminary proposal and presentation to HRT for approval prior to final design. Any work on The Tide light rail shall conform to the provisions in Appendix 4 (HRT SOP 101.13).

General submittal requirements for proposed work under HRT right-of-way are as follows:

- Plans and specifications for the proposed tunnel shall be submitted for review and approval in advance of construction.
- Monitor HRT track or subgrade movement during the underground crossing or excavation work in according with monitoring plan developed in compliance with this Manual.
- As a minimum, subsidence detectors are required along the centerline of the proposed tunnel. Any heaving or subsidence of the HRT is not permitted. Submit existing survey data of applicable HRT surface elevations prior to start of work.

- A contingency construction plan is required to allow track adjustment for any movement caused by the work. Track tolerances shall be in accordance with HRT Track Standards. In addition, any movement shall be within the monitoring thresholds established in Section 4.3 of this Manual.
- For temporary excavations associated with crossing work, such as jacking pits or tunnel headers, adjacent to HRT underground structures (e.g., foundations and piles) within the ZOI, provide an excavation support system in accordance with the provisions of this Manual.

3.8 Excavation Adjacent to HRT Tracks and Facilities

Excavation support systems adjacent to at-grade HRT tracks shall be designed if any portion of the work is within the ZOI.

Batter piles that require the pile to lean toward or over HRT right-of-way shall be driven during non-revenue hours. Plumb and batter piles that lean away from HRT right-of-way may be driven during non-peak revenue hours. HRT flagman or representative, at HRT discretion, will be required for all pile augering within 25.0 feet of HRT structures or centerline of track.

Fixed leads are required for all pile driving where fouling or encroachment onto HRT property is possible.

The Applicant shall be held responsible for any damage to HRT structures, including loss of revenue operations due to detrimental impact from the adjacent construction. This would include, but not limited to, restoring track, structures, buildings, and pavements to new construction standards, and reimbursement to HRT for alternative service in the event of disruption to scheduled revenue service.

3.9 Construction Adjacent to HRT Aerial Track Structures

For excavations adjacent to HRT aerial structures, an excavation support system conforming to the requirements of this Manual must be provided if the facility or construction is located within the ZOI.

If required, structure movement shall be monitored during excavation in accordance with an approved monitoring plan developed in accordance with the requirements of Section 4 of this Manual. The Applicant will be held responsible financially for any damage to HRT structures, including any loss of revenue operations due to detrimental impact from the adjacent construction, restoration, and alternative service in the event of disruption to scheduled revenue service.

3.10 Structures Over HRT Right-of-Way

Design loads for structures over HRT right-of-way must satisfy jurisdictional codes, including wind loads.

New structures designed for vehicular traffic must have adequate provisions and strength to prevent structure failure, and where pedestrian access is permitted, guard against objects and debris from entering HRT right-of-way.

For structures over The Tide light rail tracks, the structure must provide adequate clearance or accommodation of the traction power overhead contact system (i.e., catenary wires). Guidance for vertical and horizontal clearances from HRT light rail facilities are provided by the HRT Design Criteria (Appendix 6).

3.11 Certification and Documentation for Demolition

Submit a copy of request for discontinuance to all utility companies affected by demolition work, along with any certificates of service termination. The Applicant must also ensure that HRT facilities are not impacted by demolition activities whether due to adjacent utility damage or temporary service discontinuation.

3.12 Civil Criteria

Refer to HRT Manual of Design Criteria (Appendix 6) for submittal of surveys, property documentation, sitework, and fencing requirements.

Underground utilities on HRT property being proposed for abandonment shall be either removed or filled with permanent flowable fill. This requirement generally follows local jurisdictional practice, and shall be identified on all design plans.

3.13 Mechanical Criteria

Existing services to HRT facilities, including potable and fire water piping, fire stand pipes, pump stations, discharge pipes, storm structures, and sanitary sewers, are not to be interrupted nor disturbed without written approval from HRT. The Applicant must ensure that future access to HRT utilities is maintained.

Modification of existing HRT mechanical systems and equipment required by new utility connections shall be permitted only with HRT approval, provided:

- The Applicant submits design calculations, drawings, specifications, catalog cuts, and other information necessary to fully describe the proposed modification.
- If the Applicant wishes to permanently enclose any HRT exhaust or ventilation units, the enclosure must be designed with appropriate clearances and openings to accommodate the air circulation volumes equal to the design capacity of the particular ventilation shaft.

Hot or foul air, fumes, smoke, steam, etc. from adjacent, new, or temporary facilities and equipment shall not be discharged within 25.0 feet of any HRT doorways or ventilation intake structures.

3.14 Electrical and Communication Criteria

No interference with existing HRT ductbanks or overhead lines for electrical service shall be allowed for:

- 34.5 kVAC primary service from Dominion Virginia Power to light rail traction power substations.
- 750 VDC positive feeds and negative returns between light rail substations and operating tracks.

- 480 VAC service to buildings and select light rail station platforms
- 240 VAC service to service buildings, signal and communication houses, typical light rail station platforms, and park & ride lighting
- 120 VAC service to bus shelters and ancillary facilities

If ductbanks are affected by the adjacent construction, all information related to that impact must be submitted to HRT and/or the utility company for review and approval.

For other ancillary work affecting HRT (e.g., power or water supply outage), a request must be submitted to HRT, and any such outages must be approved. Except for emergency situations, the Applicant must comply with any HRT restrictions on service outages.

No interference with existing HRT ductbanks or overhead lines shall be allowed for:

- Incoming telecommunication services to HRT facilities
- HRT train control and communications cables

3.15 Fencing and Railings

HRT operates an electrified light rail system, and other major HRT facilities include energized areas that are generally protected by fences or other barriers. The Applicant shall maintain adequate construction clearance from these facilities at all times.

Any fence modifications must be reviewed, approved, and coordinated with HRT. The Applicant must clearly delineate any proposed changes to HRT fencing in its submittals. Note the grounding and bonding measures below.

3.16 Grounding and Bonding of Structures

Grounding of fencing, wayside furniture, service equipment, bus shelters, and other facilities shall be performed where required by HRT. Grounding of facilities is generally required in the vicinity of The Tide light rail corridor, as most conductive materials on the light rail property are subject to significant induced voltage.

Bonding for stray current and cathodic protection shall be in accordance with HRT Manual of Design Criteria (Appendix 6).

3.17 Lighting Standards

For proposed temporary or permanent modifications, lighting criteria shall conform to HRT Manual of Design Criteria provisions for all construction.

Temporary lighting modifications shall be maintained by the Applicant.

Requirements for temporary and permanent lighting modifications impacting HRT property will be conveyed in HRT design reviews and any applicable permits.

3.18 Corrosion Protection

The Applicant must be aware that The Tide light rail line is powered by 750 VDC current, with

traction power return through the running rails. Direct current can enter the earth through unintentional leakage and may flow through or discharge from underground metallic structure elements (i.e., steel reinforcing, pipelines, grounding systems, etc.) that are in contact with any electrolyte, including earth. The Applicant shall investigate any HRT wayside sites for stray current and provide mitigation where necessary. This may include bonding of structures in close proximity to the HRT right-of-way.

Guidelines for bonding for stray current and cathodic protection shall be in accordance with HRT Manual of Design Criteria (Appendix 6), and from the National Association of Corrosion Engineers (www.nace.org).

Casings, pipes, tunnels, sleeves, and similar structures subject to corrosion, when installed under any HRT right-of-way or facility, will require corrosion protection. The proposed corrosion protection scheme shall be submitted to HRT for approval and specifically indicated as a proposed corrosion protective measure. Underground structures running adjacent to HRT right-of-way may be subject to similar corrosive forces and required similar protective measures. HRT accepts no liability for stray current damage to these external wayside facilties.

3.19 Certification of Design, Installation, and Monitoring

The Applicant will provide written certification that designs, installations, and monitoring are completed and implemented per approved drawings and plans.

4. MONITORING, INSTRUMENTATION, AND CONTINGENCY PLANS

4.1 General

The Applicant is required to design, submit for approval, and implement a monitoring program where required by HRT.

Selection, design, installation, reading, and documentation of the monitoring program are to be developed and sealed by a licensed Virginia Surveyor or Engineer. Results of the monitoring program are to be submitted to HRT for verification. It is the responsibility of the Applicant to document and convey compliance of the proposed monitoring system in accordance with HRT requirements.

Instrumentation and monitoring of HRT structures, utilities, and track may be required to ensure that structural or functional inadequacy does not develop as a result of the proposed adjacent construction. Monitoring is performed by measurement of displacement, deformation, strain, stress, crack width, joint separation, water leakage, new cracking, or a combination of these items. If changes are observed, the frequency of monitoring will be increased. If the changes exceed established threshold limits, the Applicant shall implement contingency and repair measures.

The Applicant will be required to submit a written plan for monitoring HRT facilities for movement and structural adequacy. The plan will contain contingency measures listing the immediate remedial action to be taken in the event movement reaches the established threshold limits and/or damage is observed.

All instrumentation, monitoring work, documentation, reports, and any contingency measures required as a result of adjacent construction shall be the sole responsibility of the Applicant for the adjacent construction project.

4.2 Monitoring Stages

Stage 1, Initial Pre-Construction Monitoring: Stage 1 requires a survey of conditions within the HRT structure or facility, and obtaining a reading at established monitoring points. The first stages of monitoring shall be performed before construction or excavation begins in the ZOI. The applicant should provide at least two (2) initial readings, and provide HRT with a preconstruction survey, a summary report, and photographs of initial conditions.

Stage 2, Project Monitoring: Stage 2 includes monitoring during demolition, excavation, and construction, and will be performed at approved intervals, normally once a week. Monitoring frequency will be increased for critical or settlement-prone activities such as tunneling. Stage 2 monitoring may be stopped at HRT discretion when construction activity reaches at-grade level or concrete acquires sufficient design strength.

Stage 3, Post-Construction Monitoring: Stage 3 includes final survey monitoring after substantial completion to determine changes in alignment of condition of HRT facilities. In addition to structural monitoring, record photographs and a final alignment survey of the tracks are required for comparison with initial survey data.

The Applicant shall provide a final condition assessment report, including measurements, after

construction. Remedial or corrective measures shall be taken if any deviations or damage occurs as a result of the adjacent construction.

4.3 Monitoring Thresholds and Limits

The following represents threshold values to be used for monitoring and implementation of contingency measures and are provided as a guide in assisting the Applicant in preparing project specific structural monitoring tolerances.

Level 1 requires an increase in monitoring frequency, and serve as an alert that change (displacement, crack widening, etc.) is occurring.

Level 2 requires remedial action. When Level 2 values are reached, the Applicant shall stop work in the ZOI and any other work considered to be causing excessive movement.

Limiting Threshold Values:

HRT Structure	Level 1 (Threshold Limits)	Level 2 (Remedial Limits)
Track/Rail, including Embedded Track Structures (Horizontal and Vertical)	0.0625” (1/16”) in any 31’ length, but not to exceed a total of 0.25” (1/4”) from existing at any location	0.125” (1/8”) in any 31’ length, but not to exceed a total of 0.50” (1/2”) from existing at any location
Station Platforms (Horizontal and Vertical)	0.125” (1/8”) in any 31’ length, but not to exceed a total of 0.25” (1/4”) from existing at any location	0.125” (1/8”) in any 31’ length, but not to exceed a total of 0.50” (1/2”) from existing at any location
Other Structures (Horizontal and Vertical)	0.25” (1/4”), unless otherwise noted	0.50” (1/2”), unless otherwise noted
Change in Structure Crack Width	0.02” (0.5 mm)	0.04” (1.0 mm)
Pier Supporting Aerial Structure (Horizontal and Vertical)	0.125” (1/8”)	0.25” (1/4”)
Blast Vibration at HRT Structure		2.0 in./sec. peak particle velocity
Support of Excavation Wall	0.25” (1/4”) at top between supports, 0.125” (1/8”) at top bracing, after bracing pre-loading	0.50” (1/2”) at top between supports, 0.375” (3/8”) at top bracing, after bracing pre-loading
Support of Excavation Heel Block	0.125” (1/8”), after bracing pre-loading	0.25” (1/4”), after bracing pre-loading

An instrument checklist for monitoring recordation is provided below:

Monitoring Plan Instrumentation Checklist

Total station instrument type (circle one):	conventional total station	robotic total station
Total station manufacturer and model:	_____	
Instrument angle accuracy (circle one):	.5" 1" 2" 3"	
Instrument EDM accuracy (circle one):	1 mm 2 mm 3 mm (fill in) ppm +/-_____	
Dual compensator (circle one):	yes no	
Instrument and tribrach centering accuracy (circle one):	1 mm	2 mm 3 mm
Instrument location (circle one):	forced centered platform	tripod
Monitoring prism type (circle all that apply):	stick on target	model # _____
	mini 360	model # _____
	full size 360	model # _____
	mini circular	model # _____
	full size circular	model # _____
Level instrument type (circle one):	automatic level	digital level
Level instrument manufacturer and model:	_____	
Level rod type (circle all that apply):	invar without struts	model # _____
	invar without struts	model # _____
	semi-precise single piece	model # _____
	semi-precise sectional	model # _____
	semi-precise folding	model # _____

Description of other monitoring equipment:

_____
_____
_____
_____
_____
_____
_____
_____

4.4 Contingency Plan

The need for implementing a contingency plan will be established by HRT during review of submittals. If required, the Applicant shall submit a contingency plan with the details of the corrective action to be taken in case of emergency involving the following:

- Ground or structure movement exceeding the threshold limit values
- New or expanded cracking in concrete structures
- Excessive opening of joints

Corrective actions necessary, or repairs required, to HRT structures and facilities due to adjacent construction shall be the responsibility of the Applicant.

If monitoring measurements reach or exceed Level 1 values, HRT will be notified within 24 hours. The Applicant will increase the frequency of monitor if a trend exists, as directed by HRT.

When monitoring measurements reach or exceed Level 2 values, the Applicant will immediately notify HRT, stop all construction activities, and implement the approved contingency measures. When monitoring readings have stablilized, after corrective measures have been completed, construction activities may be resumed with HRT approval.

Examples of contingency measures to protect HRT facilities from deformation or change in condition are:

- Maintaining additional supply of steel bracing to support temporary excavation systems at additional points or levels.
- Maintaining equipment on site for compensation or compaction grouting to stabilize the HRT structure or track.
- Retaining a provisional supply of backfill on site.

The Applicant has the sole responsibility for the provision of monitoring until HRT agrees in writing that monitoring activities may be terminated.

5. SAFETY, OPERATIONAL REQUIREMENTS, AND COMPLIANCE

5.1 General

The Applicant shall review HRT Track Access Procedures prior to proposing any work on the Tide light rail right-of-way, or any work that will interfere with light rail operation. These procedures (Appendix 4) include provisions for right-of-way training and track access permits.

For work on HRT property outside of light rail operating tracks and facilities, an access permit is not required. HRT will advise the Applicant as to any restrictions or permits applicable to the work.

Prior to scheduling any work in the ZOI, including work immediately adjacent to, on, over, or under HRT right-of-way, the Applicant shall request and conduct a pre-construction field meeting with HRT. These meetings are typically held at the site, and notification of such a meeting request shall be scheduled a minimum of fourteen (14) days in advance of construction.

5.2 Safety, Construction, and HRT Operational Considerations

The Applicant must initiate and complete all access forms, arrange for HRT flag protection, and coordinate any operational or utility outages prior to scheduling work on HRT property. Depending on the nature of the work, an allowance of thirty (30) days advance notice should be provided to permit HRT to schedule personnel, support equipment, and to adjust HRT operations and maintenance to accommodate the Applicant's request to the greatest extent possible.

Applicant's personnel shall conform to HRT's safety rules and procedures while working within HRT right-of-way. Any excavations or openings shall be adequately barricaded or covered as per OSHA and jurisdictional standards.

The Applicant is required to submit a construction sequence and equipment staging plan for all work that will impact HRT facilities. The plans shall include necessary maintenance of traffic plans or plans required by local jurisdictions. The Applicant shall maintain both vehicular and pedestrian traffic as required by HRT, applicable right of way permits, and approved plans.

The Applicant shall install and maintain any temporary safety signage, barricades, warning lights, and fences placed on HRT property during construction.

5.3 Operational Requirements

Access to HRT bus and rail facilities shall not be obstructed. Projects that require work on or adjacent to HRT operations shall develop specific construction procedures and work sequencing to meet the following minimum requirements:

- Construction activities must be planned, scheduled, and carried out in a manner that will afford HRT patrons and the general public a clean, safe, and orderly access to and from HRT facilities during revenue hours.
- Construction activities that involve the use of overhead equipment and suspended loads over pedestrian areas must be performed during non-revenue hours, or as directed by

HRT.

Non-revenue hours vary by the type of HRT operation (bus, rail, ferry) and location.

5.4 Overhead Protection

Overhead protection shall be provided whenever there is a possibility of overhead fall hazards from construction material, personnel, dunnage, etc. Overhead protection is required on or around HRT stations, building entrances, bus stops, right-of-way, elevators, and any other public or employee access to HRT facilities. Installation of appropriate overhead protection shall be performed during non-revenue hours.

Structural design criteria for overhead protection:

- The design live load for all shields shall be at least 150 pounds per square foot. The design wind load on temporary structures shall be 20 pounds per square foot on both the windward and leeward sides of the structure, and a total of 40 pounds per square foot in any one direction. The roof of the shield shall be designed for an uplift wind pressure of 25 pounds per square foot.
- The shield must be constructed of fire retardant materials. Construction material shall not be stored on the completed shield. The roof of the shield shall be watertight.

Lighting design criteria for overhead protection:

- Lighting in public areas and HRT facilities must be provided under temporary shields to an illumination level of ten (10) foot-candles at walking surfaces. Power for and maintenance of temporary lighting shall be by the Applicant.
- Temporary power outage to HRT facilities will require temporary lighting to existing levels. Electrical staging plans shall be submitted for HRT approval. Facility lighting criteria is available upon request by HRT.

Construction barricades shall be provided around all temporary construction areas and HRT property to prevent public access in accordance with local and OSHA standards. Temporary barricades or fences shall be a minimum of 6.0 feet in height, and secured and maintained to withstand wind loads and public vandalism.

Temporary sidewalks or other pedestrian walkways that will be in use more than 10 days shall be constructed of four (4) inch thick Portland cement concrete or asphalt concrete, placed and finished for pedestrian traffic. Temporary sidewalks shall be a minimum of five (5) feet wide, or as required by local code. All modified or temporary pedestrian access paths shall be ADA compliant.

5.5 Overhead Protection, Operating Tracks

Construction that requires work over, under, or adjacent to HRT at-grade or aerial light rail track segments shall be performed during non-revenue hours with a supervisory HRT power outage, or with a work plan otherwise approved by HRT.

Work may be approved to be performed during revenue service hours, with conditions such as constructing a temporary protective shield to protect the HRT right-of-way and facilities in accordance with design loads specified in this Manual. Temporary shields shall be constructed

during non-revenue hours, or other supervisory power outage and access approved by HRT.

Equipment used for sheeting and shoring shall be positioned and oriented so that equipment or sheeting is precluded from overturning or falling onto HRT right-of-way. Soldier piles must not be swung over HRT right-of-way or within twelve (12) feet of traction power overhead lines. Auger or pile driving equipment shall be oriented parallel to the HRT right-of-way and set up to prevent piles or equipment from falling into or otherwise fouling HRT tracks.

Construction cranes shall not swing over HRT operating right-of-way or within twelve (12) feet of traction power overhead lines. A quadrant lockout or other positive means of preventing crane operation within HRT right-of-way shall be provided and included in construction procedures submittals.

Where an HRT flagging is required, such as for work in or immediately adjacent to light rail tracks, the Applicant shall make a formal request for flag protection in accordance with HRT right-of-way access program procedures. Costs associated with flagging protection shall be borne by the Applicant.

5.6 Other HRT Facilities

Access from public streets to HRT access roadways, emergency exits, and pedestrian walkways shall be maintained at all times.

Use hand excavation in the vicinity of signal and communication lines, traction power lines, or utility feeder lines to HRT facilities.

Flammable liquids shall not be stored over, under, or within 25.0 feet horizontally of any HRT facility. Underground tank installation within 100.0 feet of HRT track and facilities shall have structural protective encasement of the tank and be designed to current applicable codes. Abandoned underground tanks within 100.0 feet of HRT facilities shall be removed and disposed of properly.

5.7 Americans with Disabilities Act (ADA) Compliance

The Applicant shall comply with the rules and regulations found in 49 CFR, Part 37, Transportation Services for Individuals with Disabilities (ADA Act), ADA Accessibility Guidelines (ADAAG), and local jurisdictional codes in temporary and permanent construction.

5.8 Demolition

For construction adjacent to HRT stations and bus stops, HRT facilities shall be protected from dust generated by demolition. Demolition adjacent to an active HRT station or bus stop shall be performed during non-revenue hours.

The Applicant must provide a complete demolition plan for HRT review and approval as part of the permitting process. HRT, at its discretion, may require the Applicant to check the structural adequacy of existing HRT facilities due to the impact effects of the excavation.

5.9 Safety and Security Provisions

HRT provides several levels of safety and security throughout its various operations and

facilities. The main functions of the HRT safety and security provisions are as follows:

- Protect patrons and other pedestrians from HRT operating vehicles (fence/bollard barriers, signage, railings, signals, pavement markings)
- Protect HRT property from intrusion, vandalism, and theft (fencing, signage)
- Protect vehicular traffic from HRT operating vehicles (barriers, signage, signals, gates, pavement markings)
- Prevent illegal trespass (fencing, signage)
- Enhancing safety and security at HRT facilities (lighting, signage, cameras)

Where construction impacts the effectiveness of existing safety and security devices, or creates an additional potential hazard (e.g., substandard clearance distance to temporary fencing), these adverse conditions must be identified and mitigated.

The Applicant shall identify impacts and mitigation in its submittals, pre-construction meeting direction from HRT, or a combination of both.

Work on HRT right-of-way is subject to HRT policies and procedures regarding safety and security, generally provided as part of HRT's right-of-way training and access procedures.

HRT's Department of Safety and Security generally provides input into the review of adjacent construction submittals and is the agency authority on requirements for non-structural protection of the project on behalf of HRT.

6. REAL ESTATE AND INSURANCE REQUIREMENTS

6.1 General Requirements

The Applicant shall clearly depict HRT right-of-way, property, and easements on design plans submitted for review. Where HRT facilities are located on public right-of-way, the limits of that right-of-way shall be identified.

Real estate matters at HRT are handled through its General Counsel, as are any agreements, memorandum of understandings, and other legal documentation and instruments.

HRT may grant permits, easements, and other rights to the Applicant on a case-by-case basis. In many cases, HRT operations are located on public property and function under specific operating agreements and compacts that supersede the provisions of this Manual. HRT will advise the Applicant of any applicable agreements during its review of proposed projects.

Use of HRT property on a temporary or permanent basis is generally evaluated and coordinated by HRT's Department of Planning and Development.

A real estate occupancy request, supporting documentation, and property plat to be recorded in the jurisdiction of record shall be submitted for all temporary and permanent occupancy requests that impact HRT property. Impact is considered to include any property interest (including structural tieback installations) and access by the Applicant. HRT requires payment of fair market value for any property interest conveyed, and reimbursement for costs associated with the review of requests for permits, easements, and other rights. Property requests include the following items:

- New installations on HRT property.
- New underground utilities within HRT underground easements.
- New installations over HRT facilities that encroach into HRT air space and upper limits of applicable surface and aerial easements.
- Provision of escorts for on-track structure monitoring of HRT facilities.
- Temporary support of excavation systems on HRT property.
- Overhead protection structures that impact HRT property.
- Storm drainage runoff directed onto HRT property from new construction.
- Temporary access by construction personnel, equipment, or devices.
- Encroachment onto HRT surface, access, or temporary construction easements.
- Placement of temporary erosion devices or construction site grading areas.
- Modification of HRT fences, barriers, and railings.
- Encroachments into HRT underground easements form underpinning of structures or soil anchoring systems (e.g., tiebacks).

The Applicant shall plan and coordinate project design and construction on and adjacent to HRT facilities in advance of any property use considerations. HRT guidelines identified in other sections of this Manual may require structural monitoring or pre- and post-construction surveys

of HRT facilities. Such impact and structural monitoring typically necessitate access to HRT right-of-way for the design, survey, installation, and execution of such monitoring programs.

Requests for new installations on HRT property that require HRT to incur maintenance, security, or other costs will normally be denied, unless the requesting party agrees and demonstrates financial capability to pay such costs.

Submittal of all documents to HRT shall be coordinated with the agency's Department of Records Management.

6.2 Procedures and Approval Process

Once the design review phase has been completed by HRT, and plans are approved, the Applicant is required to complete and submit necessary real estate documentation.

The completed real estate documents, agreements, and plat shall be submitted to HRT for review, approval, and signature.

Real estate requests that permanently impact HRT real property and easements (exclusive or non-exclusive) will generally require supportive documentation for property. Plan submittals for real property use shall include, at a minimum:

- Certified survey plat or exhibit prepared, signed, and sealed by a licensed Virginia surveyor, suitable for recordation, that clearly defines property interrelation to HRT property and facilities. The certified plat should represent a survey of the impacted HRT property and include all necessary measures for a real estate appraisal by HRT: Proposed total areas, easement lengths, easement widths, upper and lower easement limits, etc.
- Certified legal property descriptions with metes and bounds, signed and sealed by a licensed Virginia Professional Land Surveyor.
- Deed Book and Page Number of parcels identified on the plat, with applicable legal descriptions.
- Confirmation of survey closure, with tie-in to existing HRT survey control.
- Clarification of specific maintenance responsibilities and future access to such permanent structures.

Conveyances governed by HRT's Board of Commissioners, including any jurisdictional agreements, and leases/permits which are specifically entered into for the purpose of generating revenue for HRT will be handled in accordance with the procedures included in those agreements.

6.3 Real Estate Responsibility

Documentation of impact to HRT real property shall be the responsibility of the Applicant, who shall plan, develop, and coordinate HRT real estate interests resulting from the proposed work or operations.

The Applicant shall coordinate permit requests with HRT and applicable jurisdictions. It is preferable and more efficient for the Applicant to coordinate all impacts to HRT real property

from joint or adjacent construction in one (1) real estate impact and HRT right-of-way access permit under one (1) applicant. This requires advance planning and coordination on the part of the Applicant prior to interface with HRT.

6.4 Indemnification and General Insurance Requirements

The Applicant is responsible for complying with all applicable indemnification and insurance requirements for work activities impacting HRT.

Any on-site work which could cause or potentially cause impact to HRT facilities or operations shall not begin without proper insurances in place. HRT is to be named as additional insured on all insurance relative to joint and adjacent construction work.

For adjacent construction work on public property, jurisdictional insurance requirements generally prevail. HRT insurance requirements prevail for any work on HRT right-of-way. For work on private property adjacent to HRT, insurance requirements will generally be determined as part of the jurisdictional permit application process.

HRT insurance requirements for the work shall be reviewed and determined on a case-by-case basis during permitting phases of the project. HRT requirements are based on scope, involvement, and risk exposure to HRT, as well as applicable operating agreements with jurisdictions (e.g., Light Rail Operations and Maintenance Agreement, HRT/City of Norfolk).

Copies of applicable insurance policies and certificates of insurance shall be forwarded to HRT as soon as the Applicant is informed of the requisite insurance coverages for the project.

Contact may be made directly with HRT's Risk Management Department at (757) 222-6000, Ext. 6158 for any specific insurance issues/requirements/questions when working on, over, below, or adjacent to HRT facilities.

6.5 Insurance Responsibility

The Applicant shall keep all insurance policies and certificates of insurance current with HRT during the full duration of the project.

All policies applicable to HRT shall contain a special cancellation provision which read as follows:

> *HRT has a direct interest in the maintenance of this insurance, and it is agreed that this insurance will not be cancelled, materially changed, or not renewed without at least thirty (30) calendar days prior written notice to HRT.*

At least two (2) weeks prior to the expiration of the original policies or any renewals, evidence of renewal or replacement policies of insurance, with the same terms and limits as expiring, shall be delivered to HRT.

7. AS-BUILT DOCUMENTATION AND CLOSEOUT

7.1 As Built Documentation General Requirements

During construction, the Applicant shall maintain a record set of contract drawings annotated to illustrate changes incorporated as work progresses.

As-built drawings shall be prepared on provided by the Applicant for HRT record. As-built records will be required for new facilities, structures, utilities, property rights related to HRT structures, property rights related to the adjacent construction/joint development project. As-built drawings will include recordation of impacts within HRT's zone of influence (ZOI).

Drawings, plans, and calculations approved by HRT, if revised by the Applicant, shall be resubmitted for approval.

As-built documentation shall include, but not be limited to, the following:

- Depths of foundations in relation to survey data.
- Horizontal and vertical locations of underground electrical and utility facilities.
- Field changes of dimensions and details.
- Revisions resulting from change orders.
- Construction left in place, such as temporary support systems, and concrete left outside neat lines of permanent structures, including notes defining types and locations of items.
- Any applicable Operations and Maintenance manuals, required if HRT is to maintain such facilities or equipment upon completion of the project.

7.2 As Built Drawings

The Applicant shall submit one set of as-built prints for review and approval not later than two (2) weeks after final acceptance of the work, or as required by jurisdictional construction permit requirements.

Completed as-built drawings shall bear the signature of an officer of the Applicant's organization, certifying compliance with as-built conditions, using a stamp with the following information:

AS BUILT

Date: _____

I certify that this drawing accurately depicts the work as constructed

Signed – Officer of the Applicant

Applicant's Printed Name and Company

7.3 Submittal Criteria

Construction impact to HRT property and easements shall be documented in as-built records, submitted as follows:

- One (1) set of hardcopy as-built drawings.
- One (1) set of drawings as .pdf (portable document format) files.

Documents shall be delivered to HRT Records Management, with appropriate transmittal form or letter, for distribution and filing.

7.4 Project Closeout

HRT will notify local jurisdictions when necessary completion of Applicant's responsibilities required by HRT has been achieved.

The Applicant shall contact HRT once all engineering, field support, and interface (including post-construction surveys) functions are completed within the HRT's zone of influence (ZOI).

HRT will issue a closeout letter to the Applicant and/or jurisdiction representing technical, physical, fiscal, and administrative closeout of the project.

A. APPENDICES

A.1. Appendix 1 - HRT Zone of Influence
A.2. Appendix 2 - Utility Zone for Underground Clearances
A.3. Appendix 3 - Document Request Form
A.4. Appendix 4 - SOP 101.13, Work Performed on The Tide ROW
A.5. Appendix 5 - HRT Right of Way Temporary Work Permit Form
A.6. Appendix 6 - HRT Manual of Design Criteria, Ver. 1.1, Various Section Excerpts
A.7. Appendix 7 - Abbreviations and Glossary

A.1 Appendix 1 - HRT Zone of Influence

1.0 DESIGN CRITERIA

1.1 Geotechnical Criteria and Zone of Influence

The depth and slope of an excavation, and groundwater table level will control the overall stability and movement of an open cut. On the basis of the generalized shallow subsurface soil conditions and groundwater table levels, the following guidelines should be adhered to:

Excavation Parameters NOT requiring an Engineered Plan:

A. The maximum depth of the open cut does not exceed 6 feet in depth.

B. If the proposed excavation is outside of the LRT Zone of Influence. Zone of Influence is generally considered as:

   1. If the proposed excavation is within 6 feet (horizontal / plan dimension) of an LRT facility/trackage.
   2. An envelope starting at the lowest point of the underground excavation continuing upward at a forty five (45) degree angle from the horizontal at the vertical projection of the outside limits of the LRT structure/trackage (See Figure 1).

C. The side slope of the cut is constructed at a 2:1 (Horizontal: Vertical) incline or flatter. This is applicable for cuts that are parallel or perpendicular to the LRT rails.

D. The depth of the open cut does not extend below the static groundwater table level by more than 12 inches.

E. No dewatering required in order to maintain a dry working area inside the excavation.

A detail of the excavation parameters is further outlined on the attached plan, Figure 2.

Excavation Parameters that WILL require an Engineered Plan:

Conditions not meeting the previously outlined parameters or criteria will require an engineered excavation plan and/or shoring plan developed by a registered professional engineer in the Commonwealth of Virginia, including any dewatering requirements.

Furthermore, the following conditions will trigger the requirement of an engineered excavation plan:

A. Any vertical cuts.

B. Dewatering adjacent to rail lines may have an adverse impact on the lines.

Accordingly, any dewatering activities must be approved by a professional engineer, indicating that no settlements will occur at the rail lines as a result.

1.2 LRT At-Grade Trackage and/or Facilities

This section applies to the following LRT track conditions:

- Retained Section, Ballasted Track (See Figure 3)
- Ballasted Track (See Figure 4)
- Station Platform, Embedded Track (See Figure 5)
- Embedded Track (See Figure 6)
- Station Platform, Ballasted Track (See Figure 7)

1.2.1 General Construction Adjacent to LRT At-Grade Trackage and/or Facilities

A. Work to install casings, drive tunnels and micro tunnels or construct other facilities under LRT tracks shall normally be done continuously. If the facility is to be installed near the surface where ground borne vibrations or projected settlement / heave may be a problem, then the work will be restricted to nonrevenue hours.

B. A subsidence detection plan and a detailed tunneling schedule will be required prior to scheduling any such operation adjacent to LRT structures. Provide detailed description and design of underground crossing (tunneling, micro-tunneling etc.).

C. A geotechnical or soils report with a proposed dewatering plan shall accompany the plan submitted for an underground crossing of the LRT at grade operating right-of-way, or excavation adjacent to the LRT at-grade trackage or operating right-of-way. Any ground improvements, like grouting, necessary for the underground crossing should be specified in the geotechnical / soils report.

D. No drainage, either surface or subsurface, is to be diverted into LRT drainage systems from adjacent facilities without calculations to verify that the LRT facilities will not be overloaded. Specific approval by LRT is required for these diversions.

E. When construction is adjacent to LRT surface trackage and will impact the LRT security fence, details shall be provided for the proposed modifications to the LRT security fencing required to accommodate the project. The drawings shall include the details of temporary and permanent intrusions into or occupancy of LRT's right-of-way. LRT will require that the right-of-way is protected at all times and any modifications to current right-of-way fencing will be completed during non-revenue hours. LRT will also require that all fencing (temporary or permanent), which protects the operating / energized right-of-way, will meet the standards and specifications provided in the LRT's Manual of Design Criteria.

F. Specific protective measures will be required for project activities which may impact the operating right-of-way. These measures may include protective screening and overhead protections, as well as, restrictions on crane placement and movements. Requirements will be addressed on a project specific basis.

1.2.2 Excavation Adjacent to LRT At-Grade Trackage and/or Facilities

Excavation support systems adjacent to surface sections/at-grade trackage of light rail shall be designed when trackage is located partially or entirely within the LRT zone of influence.

1.3 Excavation Adjacent to LRT Trackage/Structures on Retained Fill

A. For excavations adjacent to LRT structures on Mechanically Stabilized Earth (MSE) Walls, an appropriate excavation support system must be provided, when the facility/trackage is located partially or entirely within the LRT zone of influence.

B. For MSE wall structure foundations that fall partially or entirely above the adjacent excavation influence lines, underpinning shall be provided. Underpinning for LRT MSE Wall structures must be extended to bear at least ten (10) feet below the zone of influence line. Structure movement shall be monitored during excavation in accordance with a monitoring plan developed in compliance with Section 1.5 of this report.

1.4 Monitoring Plans

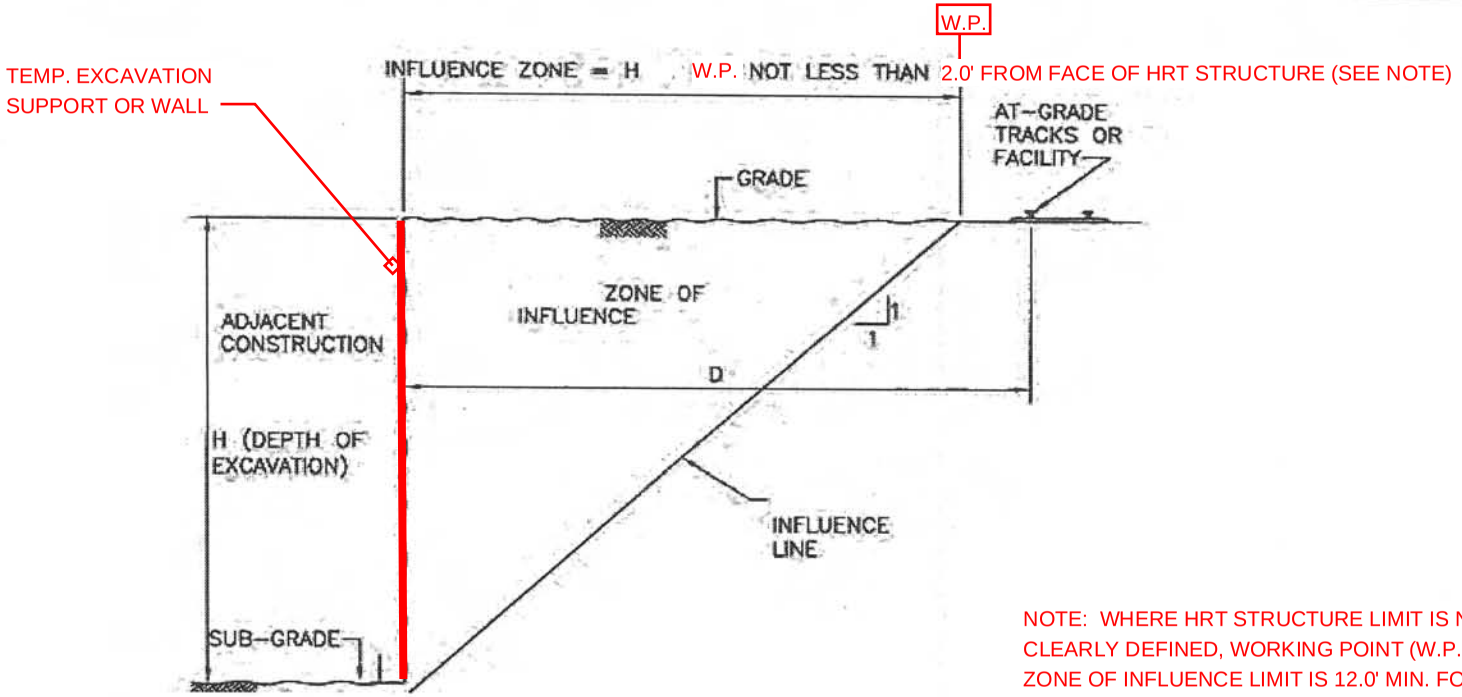
Instrumentation to monitor the existing rail lines (in the form of surveying or other approved methods) should be implemented by the contractor to verify that the excavations have not impacted the rail lines. The monitoring and/or surveying should be performed at pre-construction time, at time of work completion (post construction), and at a future time within 3 years of completion of work (post post construction); all at the discretion of the City of Norfolk Department of Public Works personnel.

1.5 General Requirements:

A. All backfill material should consist of suitable structural fill, placed and compacted in accordance with the requirements of the municipality in which the work is being performed.

B. In case of emergency repairs, open cuts requiring an engineered plan must be performed under the observations of a registered professional engineer.

FIGURES



NOTE: WHERE HRT STRUCTURE LIMIT IS NOT CLEARLY DEFINED, WORKING POINT (W.P.) FOR HRT ZONE OF INFLUENCE LIMIT IS 12.0' MIN. FOR OPEN BALLASTED TRACK AND 8.0' MIN. FOR EMBEDDED TRACK, MEASURED FROM TRACK CENTER LINE.

FIGURE 5 –STATION PLATFORM, EMBEDDED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

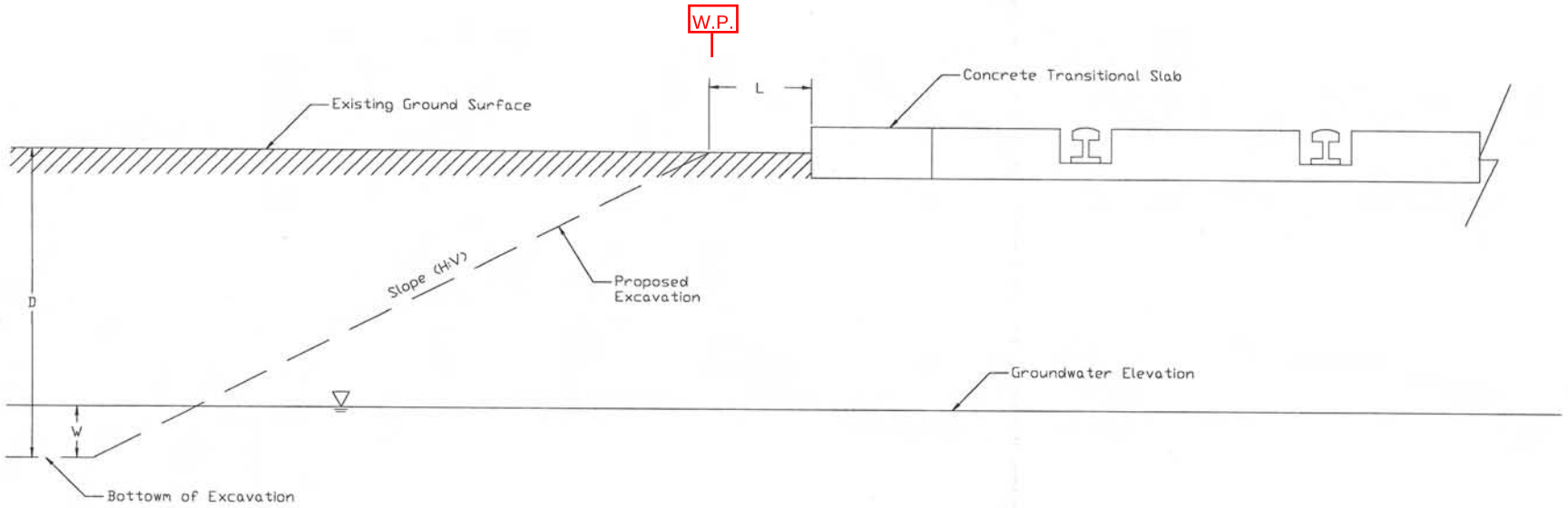
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

PLOT BY: MM

CLIENT: City of Norfolk, Department of Public Works



Excavation Criteria NOT requiring Engineered Plan must satisfy all requirements below:

L ≥ 2 feet
D ≤ 6 feet
W ≤ 12 inches
Slope = 2:1 (H:V) or flatter

If any one of these criteria is not met, then an Engineered Plan will be required.

GET Solutions, Inc. Geotechnical · Environmental · Testing	EXCAVATION PARAMETER DETAIL	Project No. VB10-290G	LEGEND	Date 11/23/2010
	Utility Trench Excavation Criteria LRT Alignment Norfolk, Virginia	Drawn By Chris Caton, E.I.T.		Scale As Shown
		Edited By na		Figure No. 2

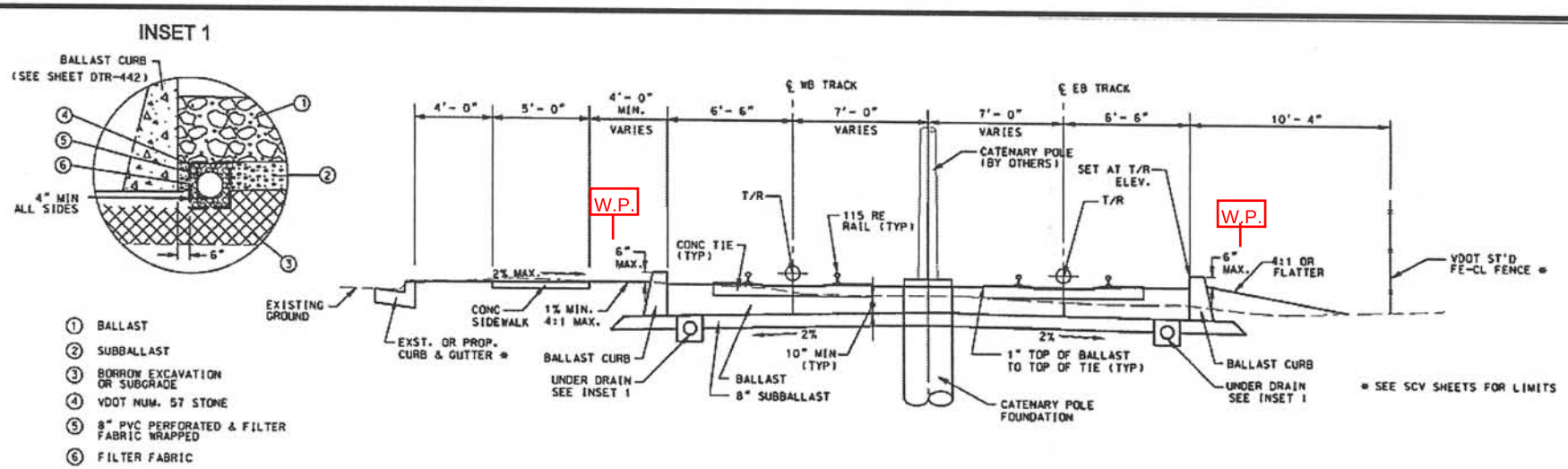


FIGURE 3 – RETAINED SECTION BALLASTED TRACK (not included: driven pile overhead structures)

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

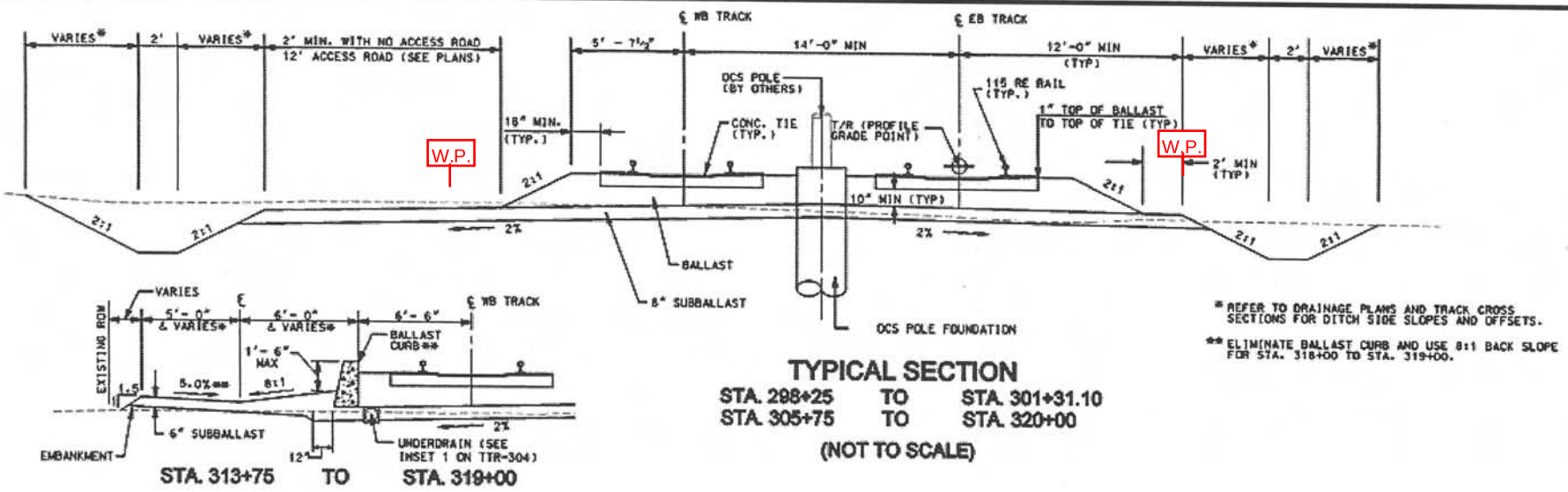
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

CLIENT: City of Norfolk, Department of Public Works

PLOT BY: MM



TYPICAL SECTION

STA. 298+25 TO STA. 301+31.10
STA. 305+75 TO STA. 320+00

(NOT TO SCALE)

STA. 313+75 TO STA. 319+00

FIGURE 4 –BALLASTED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

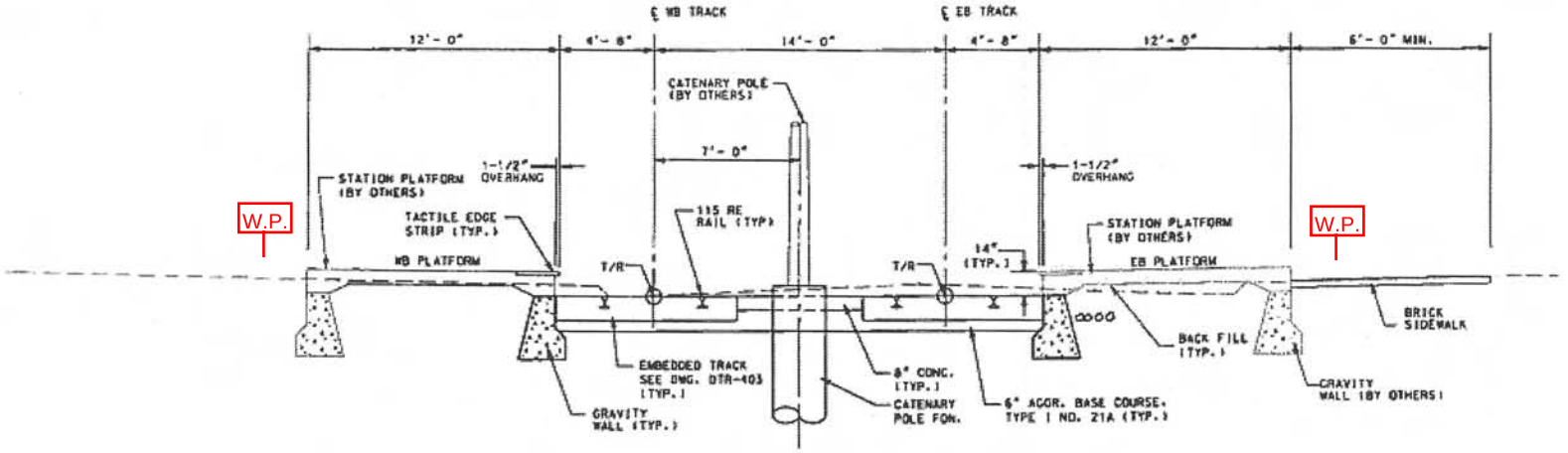
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

CLIENT: City of Norfolk, Department of Public Works

PLOT BY: MM



TYPICAL SECTION
STA. 141+70 TO 142+60
STA. 180+25 TO 181+15
NOT TO SCALE

FIGURE 5 –STATION PLATFORM, EMBEDDED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

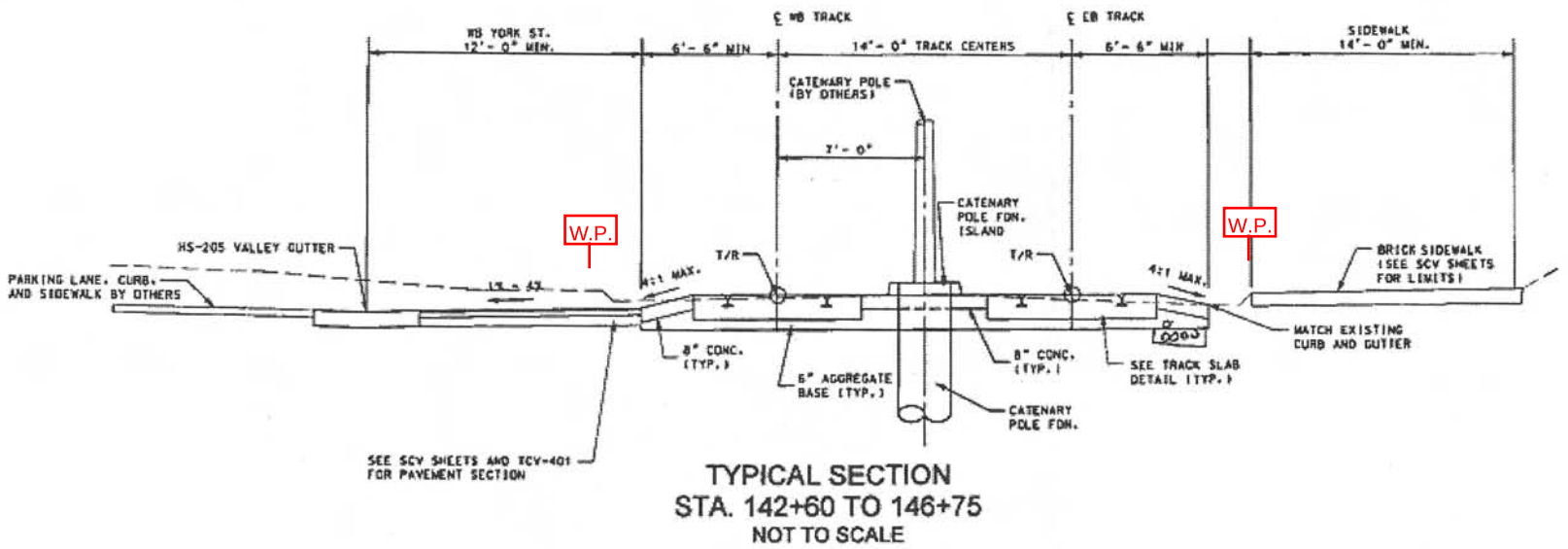
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

CLIENT: City of Norfolk, Department of Public Works

PLOT BY: MM



TYPICAL SECTION
STA. 142+60 TO 146+75
NOT TO SCALE

FIGURE 6 –EMBEDDED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

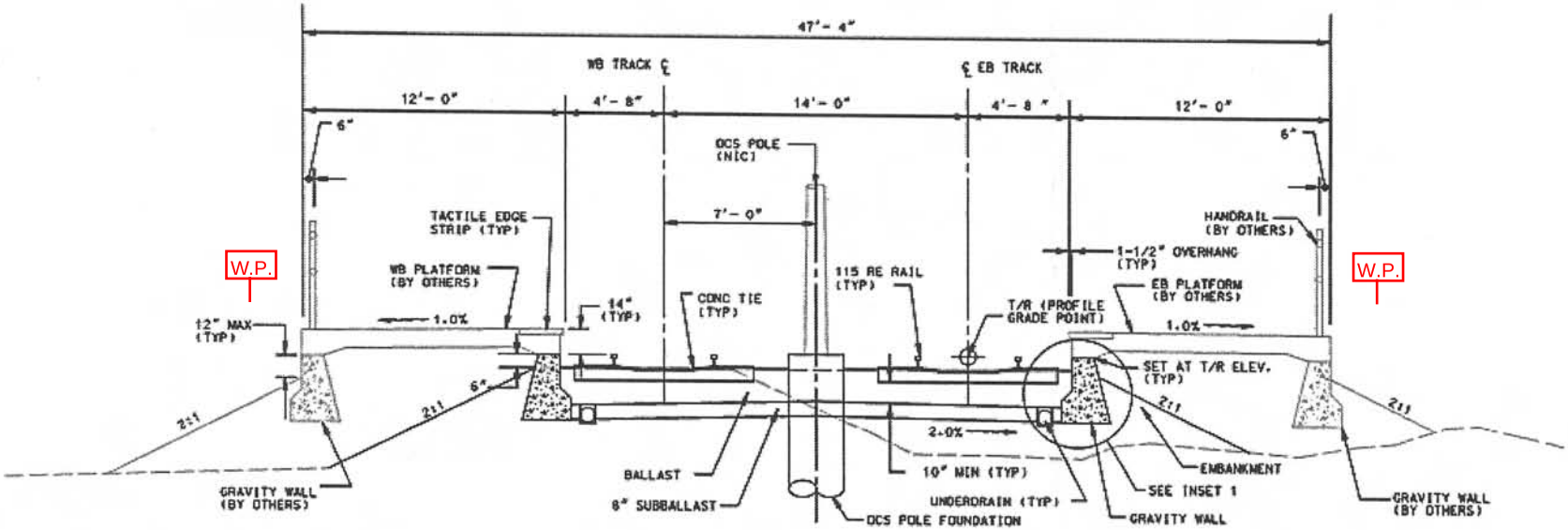
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

PLOT BY: MM

CLIENT: City of Norfolk, Department of Public Works



TYPICAL SECTION

STA. 301+31.10 TO STA. 304+01.10

STA. 358+31.43 TO STA. 359+01.43

(NOT TO SCALE)

NOTES: 1. ALL TRACK WORK, RAIL, TIES, BALLAST & SUBBALLAST ARE SHOWN FOR INFORMATIONAL PURPOSES TO AID IN THE ESTABLISHMENT OF GRADING LIMITS.

2. STATION LIMITS ARE BASED OFF EB TRACK ALIGNMENT

3. T/R = TOP OF RAIL

FIGURE 7 –STATION PLATFORM, BALLASTED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

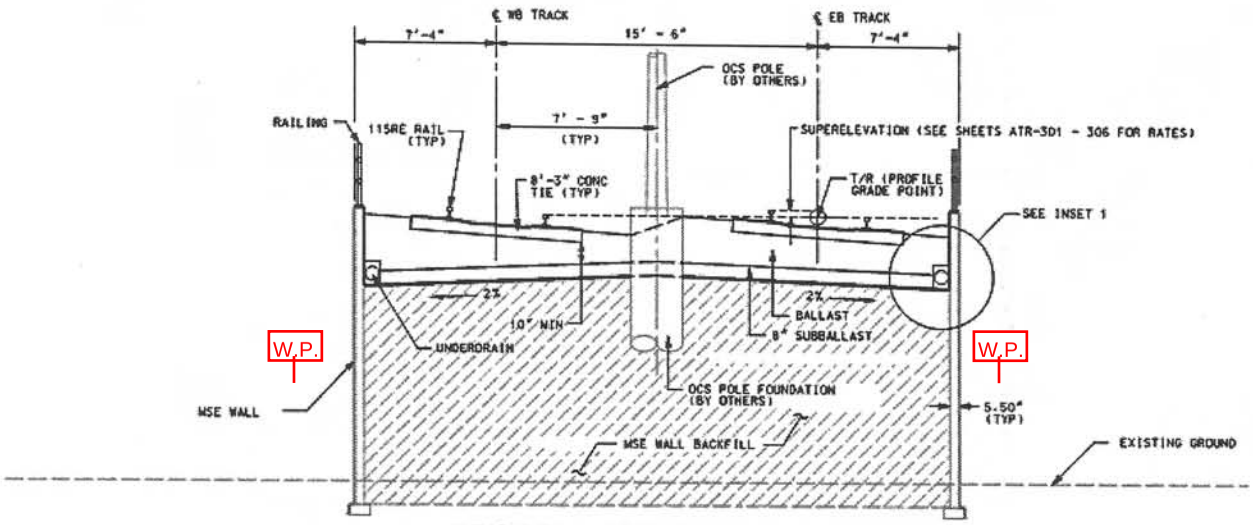
SCALE: As Drawn

DATE: 10/12/2011

PROJECT NO: VB10-290G

CLIENT: City of Norfolk, Department of Public Works

PLOT BY: MM



TYPICAL BALLASTED TRACK W/MSE WALL
SUPERELEVATED SECTION
(NOT TO SCALE)

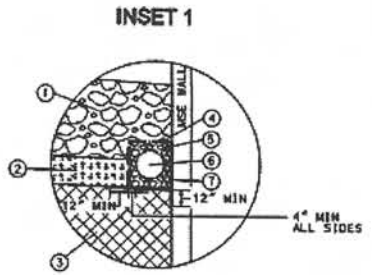


FIGURE 8 –RETAINED FILL, BALLASTED TRACK

PROJECT: Light Rail Transit (LRT) Excavation Construction Manual
LRT Alignment
Norfolk, Virginia

SCALE: As Drawn

DATE: 10/12/2011

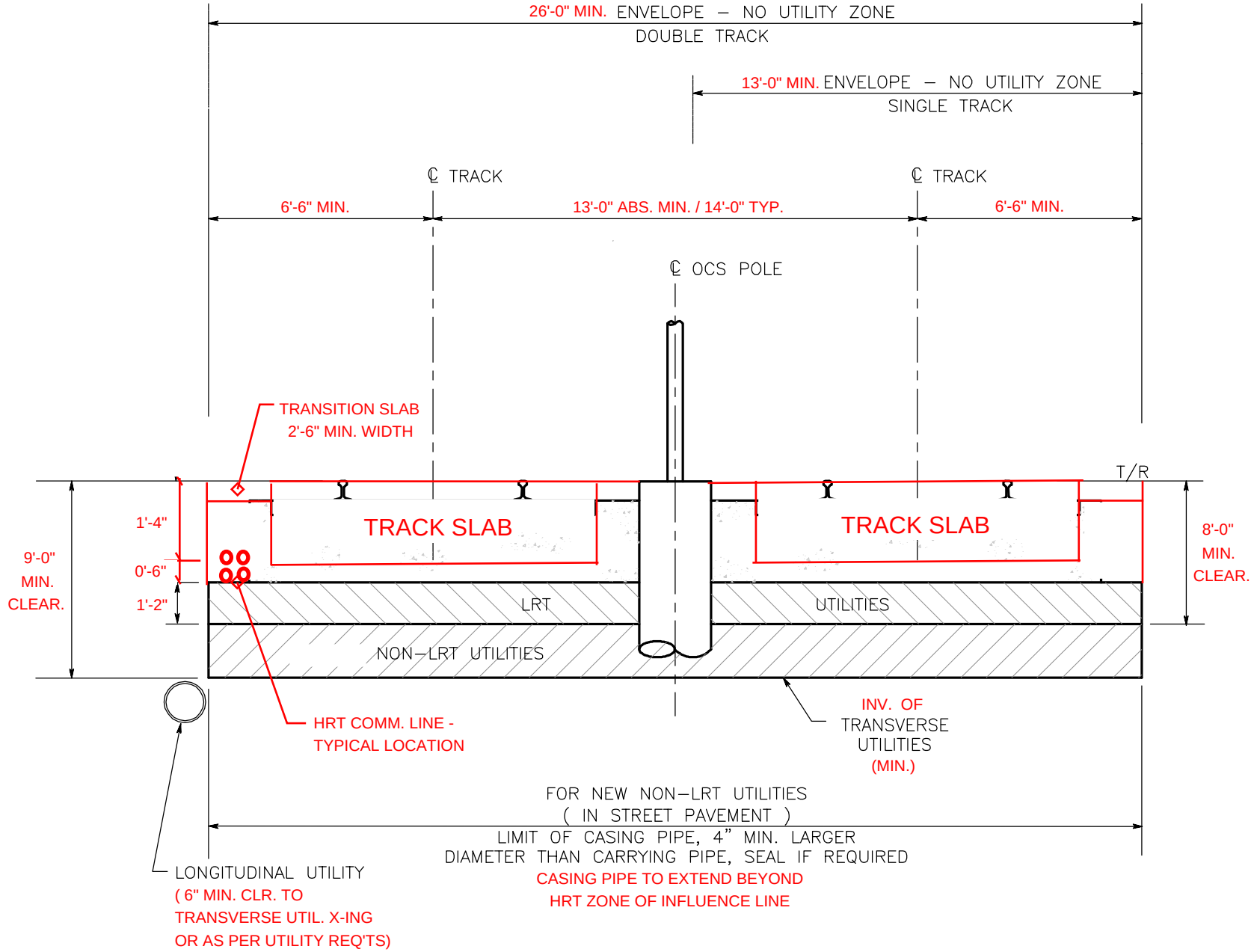
PROJECT NO: VB10-290G

CLIENT: City of Norfolk, Department of Public Works

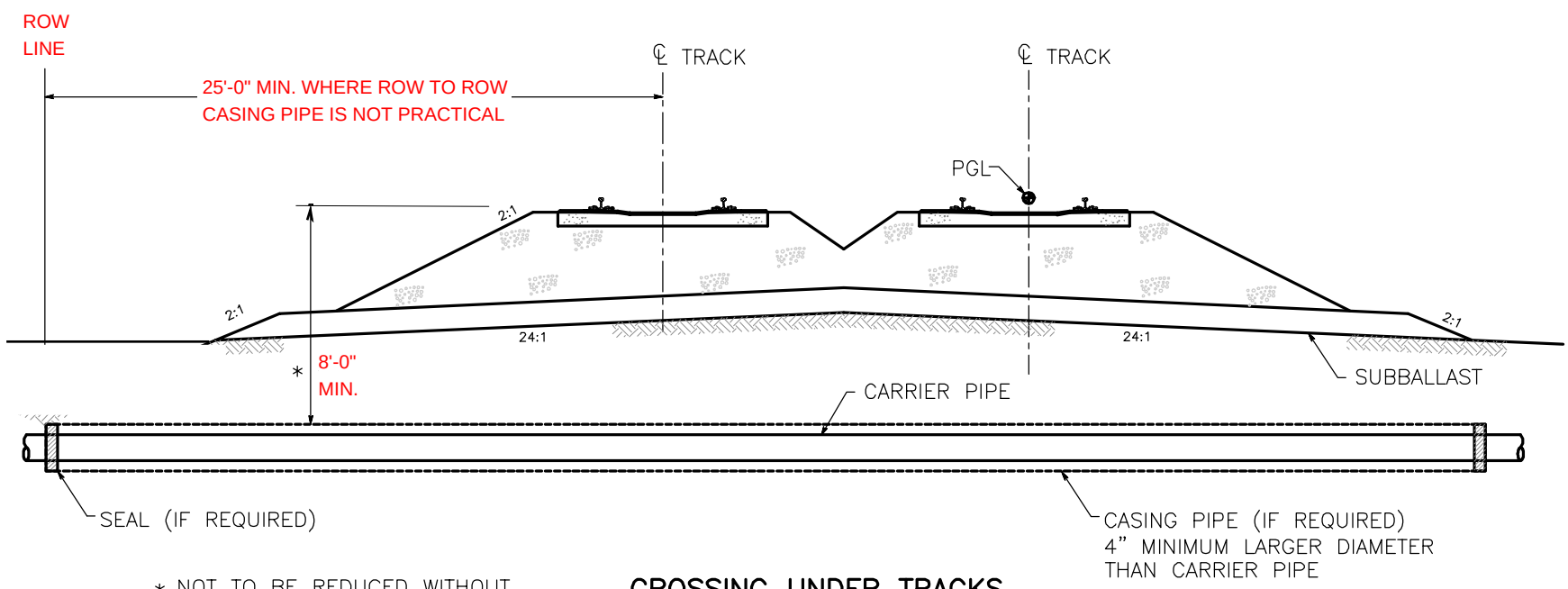
PLOT BY: MM

A.2 Appendix 2 - Utility Zone for Underground Clearances

LRT EMBEDDED TRACK
UTILITY ZONE FOR
UNDERGROUND UTILITIES



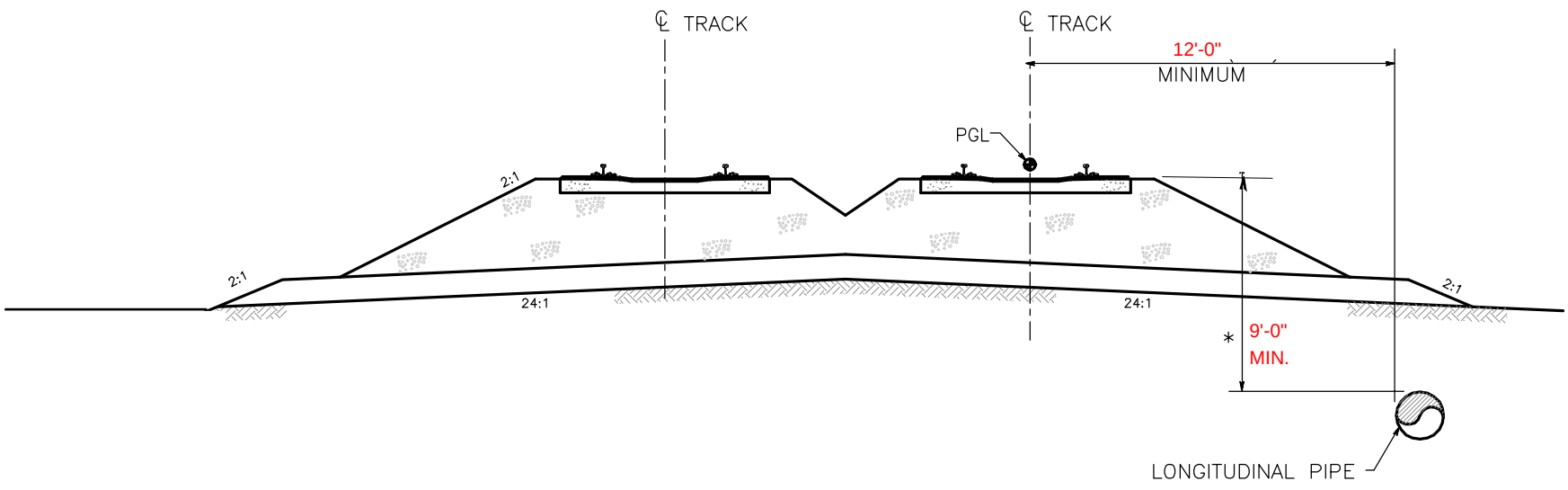
TYPICAL UTILITY CROSSING, OPEN BALLASTED TRACK SECTION



* NOT TO BE REDUCED WITHOUT PRIOR APPROVAL
(REF. HRT SOP 101.13)

CROSSING UNDER TRACKS
SCALE: 1"=7'-0"

TYPICAL UTILITY LOCATIONS, OPEN BALLASTED TRACK SECTION



* NOT TO BE REDUCED WITHOUT PRIOR APPROVAL
(REF. HRT SOP 101.13)

ADJACENT TO LRT
SCALE: 1"=7'-0"

A.3 Appendix 3 - Document Request Form

HAMPTON ROADS TRANSIT

Request Form for SSI Documentation

SENSITIVE SECURITY INFORMATION

Warning: This record contains Sensitive Security Information that is controlled under 49 CFR parts 15 and 1520. No part of this record may be disclosed to persons without a "need to know", as defined in 49 CFR parts 15 and 1520, except with the written permission of the Administrator of the Transportation Security Administration or the Secretary of Transportation. Unauthorized release may result in civil penalty or other Action.

Date of Request: _____

HRT Employee Requesting Information: _____

Department: _____ Phone Extension _____

Name of Requestor: (external request): _____

Name of HRT contact person : (external request): _____

Company / Organization Name: : (external request):

_____

Contact Information (address / telephone / e-mail) _____

_____

Purpose of Request / "Need to Know" Justification: _____

_____

Description of Items Requested (specific information needed on drawing number, contract number, etc. for infrastructure as built requests): _____

_____

_____

Approval Signature of HRT Safety & Security Personnel: _____

Date of Approval for Release of Information: _____

Revision 3: Effective 03/21/2013

A.4 Appendix 4 - SOP 101.13, Work Performed on The Tide ROW

Rail Operations

1850 East Brambleton Avenue, Norfolk, Virginia 23504

Operating	Procedure	SOP #	Date:	Page 1 of 12
Operations	Department	101.13	June 2009	
Title: **WORK PERFORMED ON THE TIDE RIGHT OF WAY**				

Classifications: **OCC – Controller/Dispatcher – Maintenance of Way - Contractors**

Other Departments: **Real Estate – Operation – Safety - Risk Management - Engineering & New Systems Development**

Issued by:

James E. Price
Rail Operations Officer

PURPOSE AND SCOPE

The purpose of the following requirements is to maintain a safe environment and efficient transit system for The Tide customers, employees and Contractors when work is being performed on The Tide Right-of-Way (ROW).

The following procedures must be followed and all requirements fulfilled before permission will be granted to any individual or group requesting access to The Tide Right-of-Way (ROW) to perform work. This includes all work on, under, above, or adjacent to The Tide Right-of-Way that has the potential to impact train operations. The Tide Right-of-Way is defined as HRT owned property along The Tide's Light Rail System, including main line tracks, yard track, shop tracks, and stations. Work performed on the Right-Of -Way outside of the alignment or area where trains operate that **will not** impact train operations, e.g. park and ride lots etc., is excluded from the scope detailed in the following procedures.

This procedure is applicable to Contractors and HRT Employees.

The Tide Land Maps defining HRT property lines and a The Tide Alignment Schematic are available from the Maintenance Of Way (MOW) Department upon request.

ATTACHMENTS/EXHIBITS

EXHIBIT A: The Tide - Contractor Right-of-Way Temporary Work Permit.

DEFINITIONS

Flag Person is a Level 2 qualified Contractor or HRT Employee that is assigned as a dedicated flagger to protect work crews, personnel, and equipment working on or near the tracks to ensure safe passage of trains as described in SOP 103.04.

Fouling a Track means placement of an individual, material or equipment in such proximity to the track that the individual, material or equipment could be struck by a moving train or on-track equipment, or in any case is within 8' 6" from the centerline of nearest track.

Lookout is a Level 2 qualified HRT employee who is qualified to provide warning to ROW workers of approaching trains or on-track equipment. Lookout should be equipped with the necessary equipment to warn ROW workers of approaching trains, as well as flagging equipment to be used if it is necessary to warn approaching trains. The Lookout's sole duty is to look for approaching trains or on-track equipment and provide advanced warning to employees before arrival of the trains or on-track equipment.

No Clearance Zone areas along The Tide Right of Way where there **is not** 8' 6" clearance from centerline of nearest track to nearest fixed object, e.g. wall, fence, bridge, steep embankment. Within these areas it **is not** possible for personnel to safely clear from fouling train movement. These areas are designated with reflective **No Clearance** signs on the right-of-way and by markings on The Tide Alignment Schematic.

Operating Right-of-Way (ROW) is the area within twenty (12) feet of the centerline of any track on the main line or yard.

Pilot is a Level 3 qualified HRT employee assigned to facilitate track car or on-track equipment movement when the operator or driver is not qualified on the physical characteristics or rules of the portion of the alignment over which movement is to be made. The pilot will be responsible for the safe movement of on-track equipment for the work crew to which they are assigned.

Right-of-Way (ROW) is land, property and interests therein, acquired by the Agency.

Train Detection is a procedure by which a worker acquires ROW access safely by seeing approaching trains and leaving the track before the train arrives at the location at which they are working and which may be used only under certain conditions authorized by OCC.

GENERAL REQUIREMENTS FOR ACCESS TO THE TIDE RIGHT-OF- WAY

- To access The Tide ROW all Contractor and HRT Employees must have a minimum of Level 1 Safety Training and each work group must be accompanied by at least one person that is Level 2 qualified to serve as a flag person or lookout.
    - ❖ For unforeseen work for short durations, The Tide Operations may authorize unqualified persons access to the ROW if accompanied by a qualified HRT Lookout.
- The work crew must have in their possession a copy of an approved work permit describing the work being performed. Contractor must also meet all additional requirements for ROW access described within this SOP and the referenced documents. Prior to the start of any proposed work

the Contractor must submit a The Tide - Contractor Right-of-Way Temporary Work Permit, and HRT Employees must submit a HRT Personnel Right of Way Work Permit. If HRT requires a detailed work plan, that plan must be approved prior to permit submittal. Once the work plan is approved, the permit can be submitted.

- ❖ For unforeseen work for short durations, The Tide Operations can authorize access to the ROW without an approved work permit.

- ❖ Work permits are not required for LRV equipment maintenance performed on the mainline or in the yard & shops.

- Operators of track cars or on-track equipment must be Level 3 qualified, unless a qualified HRT Pilot accompanies them. In that situation, the Operator must be at a minimum, Level 1 qualified.

- A HRT Level 3 qualified pilot must accompany Contractor track cars. The pilot is responsible to ensure the Contractor's track car and on-track equipment is operated in compliance with HRT operating and safety rules. The contractor requirement for the HRT pilot can be waived by HRT, if it has been determined that the Contractor's operator has sufficient experience with HRT operating and safety rules.

ROW SAFETY TRAINING QUALIFICATIONS

- The following table summarizes the required ROW Safety Training necessary before any Contractor or HRT Employee will be allowed to perform any work on the ROW. Annual recertification is required for Level 1, 2 &3 Training.

Work or Duties	**Training Required**
Any work within The Tide Right-of-Way	Level 1
Flagging to protect work crews, personnel and equipment in the Right-of-Way	Level 1, and Level 2
Operating a track car on The Tide	Level 1, Level 2, and Level 3

- If HRT employees are not qualified at a minimum Level 2 (Flagging and Radio Use), they must be escorted by another employee qualified to Level 2.

The Safety Department and OCC will maintain a list of ROW Safety Trained qualified persons and their level of qualification (e.g. Level 1, 2, or 3). An updated list will be kept on file in OCC. Dates, times and locations of Training class can be obtained by contacting The Tide Operations.

HRT REQUIREMENTS FOR CONTRACTOR

- Contractor must, if requested by HRT, submit a detailed work plan to The Tide Operations to be reviewed and approved by The Tide Rail Operations, Maintenance of Way, and Safety. After acceptance of the work plan, Contractor will obtain, through the procedure defined in this SOP, an approved **EXHIBIT A: The Tide - Contractor Right-of-Way Temporary Work Permit** before any work can be performed and they must have their The Tide approved Permit available at all times on the work site.

- Contractor may be required to reimburse HRT for all expenses as defined in EXHIBIT B: HRT Permit Fee Schedule. **HRT reserves the right to waive fees at its sole discretion.**

- Method of payment from Contractor to HRT will be determined by HRT. All HRT expenses for a particular Contractor shall then be accumulated under the associated permit number.

- Contractor will complete annual required ROW Safety Training as described in **Section V - ROW SAFETY TRAINING QUALIFICATIONS**. Annual recertification is required for Level 1, 2 &3 Training.

- Contractors will immediately stop any work that deviates from their approved Right-of-Way Temporary Work Permit or detailed work plan submitted. The Tide Rail Operations should be contacted and must approve any alternate work procedures.

- Contractor work activities can be terminated immediately by The Tide Operations, Maintenance of Way or Safety, at any time without notice. Typical conditions under which this may occur include, but are not limited to:
    - ❖ Failure to comply with any of the requirements identified in this SOP or other documents referred to within.
    - ❖ Safety related reasons.
    - ❖ Operations schedule-related reasons.
    - ❖ If work in progress deviates from the written work proposal approved by The Tide.
    - ❖ Flag person(s) not available.
    - ❖ Contractors' work interferes with the constant, continuous use of the tracks, property and facilities of The Tide system, its employees, its customers or other Contractors working within the right-of-way.
    - ❖ Accidents, injuries, near misses, or vehicle damage.
    - ❖ The Tide rule violations

- All on track equipment (including Hi-Rail Vehicles) must meet Federal Register 49 CFR, Part 214

standards, related to Roadway Maintenance Machine Safety. Contractor will be required to submit a list of qualified operators and which Roadway Maintenance Machines that they are qualified to operate on The Tide Rail System. The Contractor will provide, for The Tide's approval, documentation of their training and qualification process.

- Contractor must satisfy all safety requirements including, but not limited to, those found in Exhibit G: The Tide Rail Operations Rule Book. Copies are available upon request from the MOW Department.

- Under no circumstances will Contractor access tracks with vehicles, equipment, or machinery, without explicit written permission of The Tide. Each individual working on the ROW is responsible to supply their own personal protective equipment, including a reflective safety vest, hard hat, safety glasses, and work shoes with less than ½ inch heels (open toe or heel shoes are prohibited).

- These requirements should be followed for excavations:
  - ❖ Excavations to either side of tracks must be at least **twelve feet** (12) from the centerline of track.
  - ❖ Excavation under, between or within the track structure or the removal of ballast is prohibited unless approved by The Tide Rail Systems department.
  - ❖ Under-track cable installations must be directionally bored using the following procedures.
  - ❖ A minimum depth of 8 feet below top of ties shall be maintained at all times or 8 feet below flow line of ditch, whichever is greater, must be maintained to top of conduit(s).
  - ❖ Conduit schedule Fiberglass Reinforced Epoxy (FRE) or equivalent is required.
  - ❖ Excavations within 5 feet of either side of buried The Tide signal, power, and communication cables must be performed by hand digging and with MOW personnel present at the dig site.
  - ❖ When cable work is being performed parallel to The Tide right-of-way, cables shall be laid at the same depth as The Tide cables. The location of the cables shall be between The Tide cables and the property line, **not** towards the track.
  - ❖ If cable locates are required, the procedures for Virginia must be followed.

    Note: *Any deviation from these requirements will only be allowed with written consent from The Tide Rail System.*

- Over-track crossings will be considered on a case-by-case basis. All over-track crossings must comply with both National Electric Safety Code (NESC) clearances and any of The Tide requirements imposed.

- Contractor shall only enter The Tide Right-of-Way with an approved Work Permit, unless otherwise approved by The Tide Operations.

Rail Operations

1850 East Brambleton Avenue, Norfolk, Virginia 23504

Operating Procedure		SOP #	Date:	Page 6 of 12
Operations	Department	101.13	June 2009	
Title: **WORK PERFORMED ON THE TIDE RIGHT OF WAY**				

- Work performed by a Contractor on The Tide Right-of-Way within 12 feet of the centerline of a main line or yard track will require a Temporary Restriction to be issued on the Daily **Operating Clearance.**

- If the Contractor is performing work outside of 12 feet of the center line of any main line or yard, and it is possible for equipment e.g. boom, or hoisted equipment etc, to foul the operating ROW or has potential of making contact with the catenary, a temporary restriction will be required.

- The temporary restriction will require a dedicated flag person to provide flag protection for the work crew(s). Speed Restriction Signs will need to be posted to identify the work zone to approaching trains. Refer to *SOP103.04 BLUE FLAG PROTECTION* for more information on flagging requirements.

- In the event that the Contractor disturbs, or modifies The Tide's property in any manner, the Contractor must restore the property to the same condition it was in before the Contractor performed work. Such restoration must be to the satisfaction of the Director of Transportation and the Director of Rail System. Contractor will be billed for all work required to restoring property to original condition.

- Contractor must comply with all applicable federal, state, and local laws, regulations, and standards affecting their work.

- As a limitation to any rights or licenses that may be granted to the Contractor, The Tide reserves the right to use and maintain its entire property. This includes The Tide's right to construct, maintain, repair, renew, use, operate, change, modify, or relocate railroad tracks, roadways, station platforms, signal, communication, fiber optics, power, or other wire lines, pipelines and other facilities upon, along or across any or all parts of its property. All or any of the above mentioned use and maintenance may be done at any time or times by The Tide without liability to the Contractor or to any other party for compensation or damages.

- The Contractor is required to comply with The Tide's Exhibit D "Insurance Specifications for The Tide Contractors"

- The Tide reserves the right to fully investigate all Contractor accidents, injuries, near misses, or vehicle damage and the Contractor and its employees agree to comply and assist The Tide in all aspects of these investigations. This includes, but is not limited to, drug and alcohol testing, employee interviews, written reports, and requests for documentation.

- Contractor employees who work on The Tide ROW will be required to comply with the HRT Drug and Alcohol Policy

Rail Operations

1850 East Brambleton Avenue, Norfolk, Virginia 23504

Operating	Procedure	SOP #	Date:	Page 7 of 12
Operations	Department	101.13	June 2009	
Title: **WORK PERFORMED ON THE TIDE RIGHT OF WAY**				

CONTRACTORS PROCEDURE TO ACCESS THE TIDE R.O.W.

- Contractor will request a Right-of-Way Work Permit packet of information from:

  Control Center Manager
  The Tide Rail Operations
  3404 Mangrove
  757-222-6063
  rowworkpermits@hrtransit.org

- The Tide Rail Operations will distribute *SOP101.13 WORK PERFORMED ON THE TIDE RIGHT OF WAY* with Exhibit A to the Contractor.

- Contractor then submits their Permit Application Fee and The Tide Contractor Right-of-Way Temporary Work Permit (Exhibit A). All other required documents should be submitted a minimum of 14 days prior to their proposed start date. This may include a detailed work plan and project drawings, indemnification agreement and required insurance coverage as described in the Description of Insurance Specifications (Exhibit D).

- The Tide Rail Operations distributes Permit and detailed work plan if required, to Real Estate, Risk Management and Safety Departments for approval and facilitates a pre-project planning meeting with Contractor(s).

- The Tide Rail Operations contacts Contractor with approval and necessary requirements for Level 1-3 safety training. Permit numbers are assigned by The Tide Operations as described in *SOP101.12 PERMIT NUMBERS & TRACK ALLOCATION*.

- Contractor completes required safety training:
  - ❖ Level 1 Training: Persons working on or next to The Tide Right-of-Way.
  - ❖ Level 2 Training: Flagging and Radio Use.
  - ❖ Level 3 Training: Track Car Operation and Operating Rules

  Notes:
  Contractors are required to be trained at a minimum of Level 1 to enter ROW. All work performed by the Contractor on the operating ROW must be protected by a qualified flag person. An unqualified Contractor may be authorized to enter the alignment by Operations if escorted by a HRT Lookout.

  Operators of track cars or on-track equipment on The Tide light rail system must be qualified to Level 3, unless they are to be piloted by a qualified HRT Pilot (in this case,

the Operator will be Level 1 qualified at a minimum). A Tide Level 3 qualified Pilot is required to direct the operation of Contractor's track cars and on-track equipment, unless otherwise approved by The Tide.

- Contractor **track cars must be piloted by a Tide Pilot qualified to Level 3 of safety training**. The pilot will communicate with OCC and control the movement of track cars or group of track cars assigned to a single work crew. The Tide Pilot will be responsible for the safe movement of the on track equipment or track cars. The Tide Pilot requirement may be waived by HRT if it is determined that the operator has sufficient training and experience on The Tide alignment to safely operate track cars and on-track equipment, and the Operator is Level 3 qualified.

- Contractor submits Right-of-Way Temporary Work Permit (Exhibit A) with permit number no later than **Tuesday, 5:00pm,** prior to the week the work will be accomplished. Permit must be resubmitted every week during the length of the proposed project.

  Note: *If there is a HRT recognized holiday on Wednesday, the work permits are due on Monday, 5:00pm.*

  Note: *If the project proposal changes significantly, a new Tide Right-of-Way Temporary Work Permit (Exhibit A) must be submitted. A new Permit Number will be assigned after the Permit is approved.*

- Contractor or a Tide Designee is required to attend weekly Track Allocation meeting scheduled for Wednesday with The Tide Operations and Maintenance of Way to respond to questions regarding proposed work. The Contractor's Tide Designee may represent the Contractor at this meeting if previously arranged.

  Note: *When the week includes a HRT recognized holiday on Wednesday, the Track Allocation Planning meeting is scheduled for Tuesday.*

- All work requests are subject to The Tide Approval

  Note: *Scheduling of work activities is subject to availability of Maintenance of Way, Operations and Safety personnel, as well as the effect it will have on customer service based on the impact the proposed work has on service quality and train schedules.*

Peak Operating Periods

- Generally work requiring a temporary restriction will be allowed only during non-peak operating times. Non-Peak operating times are of Monday – Friday: 9:00 AM to 3:30 PM and 7:30 PM to the end of revenue service and all day on Saturday and Sunday.

- Some work will be restricted to the after revenue service hours of 12:00 AM to 5:00 AM.

- The Tide Project Manager or The Tide Rail Operations will provide the Contractor with a copy of their approved temporary permit (Exhibit A), which must be available on the project site at all times during work activities to confirm permission to occupy The Tide Right-of-Way.

- Contractor must contact OCC and request permission prior to accessing the ROW. OCC has authority over all activity along the ROW at all times.

- Once work is complete, and the work area is cleared of materials, equipment, tools, and personnel, the Contractor must contact OCC to confirm that they are clear of the ROW.

- HRT provides Contractor an invoice for appropriate fees upon completion of the work or on a monthly basis as necessary.

- Contractor submits payments to the HRT Accounts Receivable.

HRT EMPLOYEE REQUIREMENTS AND PROCEDURE FOR ACCESS TO RIGHT-OF-WAY

- This procedure is to be used by all HRT Departments to receive temporary permit access to The Tide's Right-of-Way.

  - ❖ Submit completed Exhibit A: Tide Personnel Right-of-Way Work Permit to The Tide Rail Operations.

  - ❖ Permits reviewed and approved at weekly Track Allocation meeting by The Tide Operations and Maintenance of Way.

  - ❖ The Tide Rail Operations publishes the Final Track Allocation for the following week and all revisions.

  - ❖ For unforeseen work such as emergencies or to perform minor corrections or routine inspections, OCC can authorize a Tier 2 Qualified HRT Employee to access the track without an approved permit.

  - ❖ Work performed by an employee on the Operating ROW within 12 feet of the center line of an in service main line or yard track will require a Temporary Restriction be issued on the Daily Operating Clearance. Exceptions to the temporary restriction requirement for employees can be granted under the conditions listed in Item 6.

  - ❖ The temporary restriction requires a dedicated flag person be utilized to provide flag protection of the work crew(s). Speed Restriction Signs may need to be posted to identify the work zone to approaching trains. Refer to SOP 103.03 for more information on flagging requirements.

- ❖ Work performed by Tier 2 qualified Tide employee does not require the issuance of a Temporary Restriction if one of the following Train Detection schemes is used:

- ❖ *Worker(s) Using Train Detection to Clear the Operating ROW 15 seconds Prior to Arrival of Train.* Train approach warning shall be given in sufficient time to allow worker(s) to move to and occupy a prearranged place of safety outside of the Operating ROW (more than twelve (12) feet from the centerline of any track on the main line) not less than 15 seconds before a train moving at maximum authorized speed can pass the location of the worker(s).

- The following four conditions must be met:
  - ❖ Where worker(s) are performing minor corrections or routine inspections.
  - ❖ Where no power tools or equipment are being used in hearing range of the worker(s).
  - ❖ Where worker(s) are performing tasks that allows them to be attentive to train movement.
  - ❖ Where the ability of the worker(s) to hear and see approaching trains is not impaired by background noise, lights, precipitation, fog, passing trains or other obstructions or physical conditions.

    If all four conditions cannot be met, a Lookout must be assigned to provide the worker(s) warning of approaching trains.

- Trains can pass the location of the worker(s) at maximum authorized speed if worker(s) have cleared outside the Operating ROW.

- *Worker(s) Use Train Detection to Clear From Fouling a Track 15 seconds Prior to Arrival of Train.* Train approach warning shall be given in sufficient time to allow worker(s) to move to and occupy a prearranged place of safety so that employee(s) or equipment are not fouling any in-service track (more than 8’ 6" from the centerline of nearest in-service track) not less than 15 seconds before a train moving at maximum authorized speed can pass the location of the worker(s).

- The following four conditions must be met:
  - ❖ Where worker(s) are performing minor corrections or routine inspections.
  - ❖ Where no power tools or equipment are being used in hearing range of the worker(s).
  - ❖ Where worker(s) are performing tasks that allows them to be attentive to train movement.

- ❖ Where the ability of the worker(s) to hear and see approaching trains is not impaired by background noise, lights, precipitation, fog, passing trains or other obstructions or physical conditions.

If all four conditions cannot be met, a Lookout must be assigned to provide the worker(s) warning of approaching trains.

- Trains must pass the location of the worker(s) at restricted speed if worker(s) have cleared so that they are not fouling the track, but have not cleared off of the Operating ROW. OCC must contact a minimum of the next two approaching trains on the affected track before authorizing work or movement in this area. If work is for an extended time period, OCC will notify approaching trains as necessary to protect the workers.

- **Working in a No Clearance Zone.**

WARNING
Areas marked as NO CLEARANCE do not provide sufficient space for worker(s) to move to and occupy a prearranged place of safety so that employee(s) or equipment are not fouling any in-service track (more than 8' 6" from the centerline of nearest in-service track) not less than 15 seconds before a train moving at maximum authorized speed can pass the location of the worker(s).

- **No Clearance Zone** is an area along the Operating ROW where there is not 8' 6" clearance from centerline of nearest track to nearest fixed object, e.g. wall, fence, bridge, steep embankment. Within these areas it is not possible for personnel to safely clear from fouling train movement. These areasare designated with reflective "No Clearance" signs on the Operating ROW and by markings on The Tide Alignment Schematic.

To access a No Clearance Zone, a temporary restriction must be issued for BOTH tracks.

- For unforeseen or emergency situations, OCC can authorize entry into No Clearance Zones for short durations without the issuance of a temporary restriction, but the following steps must be taken:

- ❖ Train operation must be temporarily stopped on the track(s) in the area where the worker(s) will be located.

- ❖ Normal Train operation in the affected area cannot resume until OCC is advised by the worker(s) that they are no longer fouling the track on which the train will operate.

- ❖ Trains must pass the worker(s) at restricted speed, if personnel remain within the Operating

ROW.

A.5 Appendix 5 - HRT Right of Way Temporary Work Permit Form

Exhibit A

Permit #:

HRT - Right of Way Temporary Work Permit

This permit must be submitted by 5:00 P.M. on Tuesday prior to the work week requested

email to: rowworkpermit@hrtransit.org (If unable to email) Fax to: 757-222-6049

Operations Control Center 757-222-6063

Rail Transportation 757 222- 6000 ext. 6659

Company: _____ **Date:** 12/31/12

Requester: _____ **Email Address:** _____

Office: _____ **Cell:** _____ **Fax:** _____ **(In Lieu of Email Address)**

Contractor's HRT Contact: _____

Description of work to be performed and equipment and tools to be used:

Will personnel or equipment be within **12ft.** from center of nearest track **at anytime?**	Yes ☐ No ☐	If within 12ft a HRT Qualified Flag Person will be required	HRT ☐ Self ☐
Will work or equipment be within **10ft.** of the closest overhead catenary wire **at anytime?**	Yes ☐ No ☐	Will any excavating be performed (by hand or machine)?	Yes ☐ No ☐
Is the work described above being performed under a **HRT contract?**	Yes ☐ No ☐	If excavating is being performed Dig Number must be provided	

Dates Work Performed:	**Start Date:**		**Finish Date:**						
Enter Time in 24hr. Format:	**Start Time:**		**Finish Time:**						
Work Location by MP:	**From MP:**		**To MP:**						
Track to be Accessed:	**Track 1 Eastbound** ☐	**Track 2 Westbound** ☐	**Both Tracks** ☐	**Embeded Track** ☐	**Yard Track** ☐				

I understand that before entering the HRT Right-of-Way, and prior to the start of any work, permission must be obtained from Operations Control Center **(OCC)** via a HRT issued portable radio on the appropriate Operations channel for my work location. I understand all workers and equipment must remain 12ft. or more from the center of the nearest track at all times, if at anytime 12ft. cannot be maintained a restriction is required and the Contractor is responsibile for having a HRT Certified Flagperson present with speed boards in place. **If HRT radio fails OCC should be reached by phone at 757-222-6063**

HRT Maintenance of Way Use Only

Operation's:	Insurance Approved?	Yes ☐ No ☐	Training Completed? Yes ☐ No ☐		Initial:
Signal:	Cable Locate Required?	Yes ☐ No ☐	**Barricade** ☐	**Track Vehicle** ☐	Initial:
Comm:	Cable Locate Required?	Yes ☐ No ☐	**Cones** ☐	**Stop Signs** ☐	Initial:
Traction Power:	Power Down Required?	Yes ☐ No ☐	**Derails** ☐	Hand Tools ☐	Initial:
Rail Fac. Maint:	Flagperson Scheduled?	Yes ☐ No ☐	**Ground Strap** ☐	Power Tools ☐	Initial:
Track:	Work is Approved?	Yes ☐ No ☐	**PPE** ☐	☐	Initial:

HRT Operations' Use Only

Operations:	**Restriction** Yes ☐ No ☐	**Speed Signs** Yes ☐ No ☐	**Track Out of Service** **Track # 1** ☐ **Track # 2** ☐ **Norfolk Yd.** ☐ **Test Trk** ☐	
	Moving Crew Yes ☐ No ☐	**Single Track** Yes ☐ No ☐	_____ **Operation Authorization Signature**	**Date**

A.6 Appendix 6 - HRT Manual of Design Criteria, Ver. 1.1, Various Section Excerpts

SECTION 3
TRACK ALIGNMENT AND CLEARANCES

Introduction

The primary assumption behind this Section is that the physical system design must physically and safely accommodate revenue service vehicles. The primary assumption for track alignment and vehicle clearances is that these items shall be designed for the current light rail vehicle utilized at Hampton Roads Transit (HRT), the Siemens S70.

This Section covers the engineering design of light rail track alignment and clearances.

3.1 GENERAL

The track alignment criteria for HRT is established herein to optimize safety, passenger comfort, operations, and reduced maintenance by utilizing accepted engineering practice and the experiences of the Tide light rail. The track alignment requires consideration of efficient train operations and the flexibility of future operational improvements without requiring major infrastructure expenditures for maintenance.

Where possible, the track alignment shall be designed to accommodate a maximum authorized speed (MAS) of 55 mph, or more accurately, a civil design speed of 60 mph to account for 10% overspeed during operations. Physical constraints along various portions of the system, together with other design limitations, may preclude achievement of this design speed objective.

Both MAS and Design Speed shall be shown on the Design Plans. For a proposed MAS greater than 25 mph, the Design Speed shall be 5 mph more than the MAS. For a proposed MAS of 25 mph or less, the Design Speed shall be equal to the MAS.

In addition to track alignment geometry, this Section covers clearance criteria to be used in the design of LRT corridors, particularly minimum dimensions required to insure proper clearances between the transit vehicle, transit structures, and any other wayside obstructions.

Where the LRT operates within or adjacent to surface streets without a separation barrier or minimum 12.0’ buffer zone, measured from the track centerline, the maximum design speed for the track alignment shall be limited to the legal speed of the parallel street traffic, but shall not exceed 35 mph. The various general operating conditions of tracks anticipated on the LRT system are covered in Section 2.

Although physical corridor constraints, together with other possible design limitations, may preclude achievement of the maximum 55 mph operating speed, each curve along the track alignment shall be designed for the maximum feasible “civil speed” to assure flexibility for future speed improvements, to decrease long term maintenance, and to enhance ride quality.

For the purpose of establishing general clearance requirements, Figure 3-1 shows the static and dynamic envelopes for HRT's light rail vehicles (LRV's). The construction clearances shown on Figure 3-2 shall be used as a physical envelope, with additional clearance allowance for operating safety, to ensure no spacial interference between vehicles and wayside installations.

The horizontal control for HRT work shall be based on the Virginia State Plane Coordinate System of 1983 (NAD/83, HARN). Note that project coordinates used for the preliminary Norfolk LRT and other HRT construction work utilized other legacy control systems such as the VDOT metric coordinate base.

Vertical control shall be based on U.S. Coast & Geodetic Survey Sea Level Datum, 1988 General Adjustment (NAVD/88).

Designs requiring physical interfaces with previous work shall include appropriate coordinate translations and conversions to current project survey control criteria.

Refer to Section 15.5 for more specific survey criteria.

When viewing the track alignment in the direction of increasing stationing, the track on the right side is to be designated as Track No. 1 and the left side as Track No. 2. In general at HRT, Track No. 1 is either the Northbound (NB) or Eastbound (EB) Track. Where tracks are extended from existing tracks, stationing and track nomenclature shall be carried forward from previous work.

Routes that do not intersect with another existing LRT route shall require coordination of project specific stationing origin and convention with HRT. Stationing protocol shall remain independent of any subsequent milepost system which may be established for operations. At present, the Tide light rail has an initial milepost signage system in place, but it is not used for current operations or maintenance purposes.

Track alignment shall be stationed independently along the centerline of the designated Track No. 1 and shall serve as the basic control for locating all other system facilities along the route.

Independent stationing for the designated Track No. 2 shall be required only in cases where the tracks are neither parallel nor concentric, where parallel tracks require separate profiles, or where tracks are on separate structures. Where track curvature results in different stationing at the end of a curve, the designated Track No. 2 shall be mathematically equated to Track No. 1 stationing at the spiral to tangent point (ST) of the curve which extends at the farthest ahead station.

Track No. 2 stationing shall not be used to locate adjacent structures unless it is impractical to use Track No. 1 stationing and offset references.

Yard tracks shall have individual stationing from a common point at the primary connection to the main track.

Curve geometry and coordinates shall be defined for all tracks.

Horizontal alignment and curve data shall be calculated and defined to the following accuracy:

- Coordinates: 4 decimal places
- Stationing: 2 decimal places
- Curve and Spiral Elements: 2 decimal places
- Angles and Bearings: Nearest tenth of a second

The LRT design must allow for safe travel through restrictive alignments when routed through urban locations. Light rail vehicles are designed to travel at relatively high operating speeds in suburban and rural settings; maximum design speeds are desirable in these areas to provide favorable operational running times.

Where the LRT system must include at-grade portions where light rail vehicles shall operate in mixed traffic with rubber-tired vehicles, the applicable geometric design guidelines for such streets shall be met in the design of the track alignment, in addition to light rail requirements.

In this Section, the terms Desirable, Minimum, and Absolute Minimum are used to denote HRT order of preference for track alignment selections.

- Desirable shall be considered HRT's preferred design minimum or maximum limits.
- Minimum shall be considered HRT's design minimum when restrictions prohibit the use of Desirable limits. HRT shall be made aware of minimum design conditions, but no approval is required.
- Absolute Minimum represents the physical operating limits of the vehicle or other equipment and shall be incorporated only with written approval by HRT.

In the unlikely event that the LRT system includes areas where vehicles shall operate in joint usage with railroad freight traffic, the applicable minimum geometric design guidelines for each type of rail system shall be considered and the most restrictive shall govern the design of the track alignment and clearances. Requirements for any design of freight railroad alignments, including siding tracks, are specified by the operating freight railroad. At present, LRT and railroad operating or physical interfaces are not anticipated in future HRT construction.

Guidelines for the use of shared right-of-way with freight railroads shall conform to joint Federal Railroad Administration/Federal Transit Administration (FRA/FTA) policy. For purposes of these Criteria, shared railroad-transit track is not anticipated, including operations with freight and transit time separation.

Coordination of horizontal and vertical alignments shall avoid a combination of minimum radius, maximum grade, and maximum unbalanced superelevation.

3.3 VEHICLE CLEARANCES

The clearance envelope is defined as the total space occupied by the vehicle and includes the total of clearances to allow for vehicle performance characteristics, the effects of track curvature, applied superelevation, running clearances, and applicable construction and maintenance tolerances for track and wayside facilities. For design of facilities and clearances, the current HRT vehicle (Siemens S70) is utilized for development of the vehicle clearance envelope.

This Section establishes the minimum dimensions required to assure proper clearances between the light rail vehicles and adjacent structures or wayside obstructions.

For LRT design, the following generalized lateral and track center to center minimum clearances shall be followed. Where unusually restrictive conditions warrant a more detailed calculation of clearances, such as close clearances required by temporary construction, the methodology provided in Section 3.4 may be utilized, but only with specific written approval by HRT.

Clearance Condition	Desirable Minimum	Absolute Minimum (#)
Tangent ballasted track center to center spacing with center overhead contact system poles	14’-0”	14'-0"
Tangent ballasted track center to center spacing without center overhead contact system poles	14’-0”	13'-6"
Tangent direct fixation/embedded track center to center spacing with center overhead contact system poles	14’-0”	13'-6"
Tangent direct fixation/embedded track center to center spacing without center overhead contact system poles	14’-0”	13'-0"
Clearance to a retaining wall or fence with side maintenance and defined emergency evacuation path/walkway	9’-0”	8'-0"
Clearance to a retaining wall or fence with side maintenance with no defined emergency evacuation path/walkway	10’-0”	8'-6"
Distance between LRT main track and adjacent yard or siding track	17'-0"	15'-0"
Distance between LRT track and adjacent freight railroad track, assuming fencing between LRT track and railroad track (##)	25'-0"	17'-0"
Distance between LRT track and railing or wall on aerial or tunnel structure, refuge area available on other side of track	7’-6"	6'-6"
Distance between LRT track and outer face of curb for adjacent traffic lane	8’-0"	6'-6"

(#) – Desirable and Absolute Minimum values are for tangent track only. For curved track, add ½” per each degree of curvature as per Eq. 3.2.1.2-1 for clearances to fixed objects, 1” per each degree of curvature for track centers. Construction clearances to fixed objects, or differential superelevation between adjacent tracks, shall also be increased by 3” per each 1” of actual track superelevation;

(##) – Freight railroads are likely to have additional distance requirements.

The above table corresponds to the data presented in Figure 3-2. Where a conflict in data occurs between the table and Figure 3-2, the more restrictive clearance dimension applies.

The current Tide operating rules indicate that a Close Clearance sign be located at any non-point (defined as any structure having over 4.0' in obstructing width) obstruction less than 8'-6". Where it is necessary for a non-point structure to be located less than 8'-6" from centerline of track, a close clearance signage zone shall be identified in the design. Close clearance signage is located at 25.0' maximum spacing.

A provision for a physical emergency access pathway and/or a zone of refuge shall be provided for all tracks on the light rail system. Unless a specific emergency walkway is provided and identified, the refuge zone shall not be located between tracks.

3.3.2 Special Clearance Situations

In addition to the Construction Clearance Envelope requirements described above, where required, there are several special clearance situations warranting further definition. These special situations include the vehicle interface at turnouts, station platforms, retaining walls in both cut and fill sections, through girder bridges, and maintenance and emergency evacuation paths.

If the LRT is operating on tracks shared with freight or commuter railroads (unlikely), the minimum horizontal clearance for structures on tangent track (including catenary poles, signal masts, etc.) is 10'-6" from centerline of track to the face of the structure. In addition, if the track is curved the appropriate adjustments to the clearance envelope of the railroad's vehicles for track curvature and superelevation must be applied. The criteria used to adjust for curvature and superelevation must be confirmed by the railroads operating on the track. Additional horizontal clearance may be dictated by the railroad if oversize loads are anticipated to be run on the shared tracks.

Figure 3-7 shows minimum lateral clearances through turnouts. These clearances are provided for setting track and signal appurtenances that extend above the top of rail (e.g., switch machines).

3.3.2.1 Station Platforms

The relationship of the vehicle at rest and the passenger platform is one of the most fundamental interfaces in any rail transit system. Horizontal and vertical static clearances or gaps (between platform edge and vehicle step) determine the ease of boarding/deboarding for passengers, and platforms edges often must be placed within the strict confines of clearance envelopes so as to permit safe and practical passenger movement.

At all passenger stops and stations, the edge of platform shall be set a minimum distance of 4'-8" from centerline of track (static vehicle half-width plus ~2"), with a tolerance of +¼" and –½". The resulting vehicle-platform interface is in compliance with ADA requirements, based on the current HRT light rail vehicle.

3.3.2.2 Retaining Walls

3.3.2.2.1 Cut Sections and Cut & Cover Structures

In those cases where a retaining wall along the LRT System is in a cut section, the preferred minimum clearance from the centerline of track to the near face of a retaining wall shall be 9'-0". Where no maintenance and emergency evacuation path is required adjacent to the retaining wall, the minimum clearance from the centerline of track to the near face of a retaining wall shall not be less than 7'-6". Refer to Section 3.3 for specific dimensions.

3.3.2.2.2 Fill Sections

In retained fill sections, the top of retaining wall shall be set equal to or less than the nearest top of rail elevation, and the preferred minimum distance between face of wall and centerline of track shall be 9'-0" as noted in cut sections.

Where no maintenance or emergency access path is required adjacent to the wall and the wall does not require a fence or railing, the minimum clearance between face of wall and centerline of track shall not be less than 7'-6". Refer to Section 3.3 for specific dimensions.

3.3.2.3 Through Girder Bridges

The absolute minimum lateral distance from the centerline of track to the nearest point on the girder measured 4.0' above top of nearest rail elevation shall be 9'-0".

3.3.2.4 Maintenance and Emergency Access Paths

A minimum clear width of 36" (absolute minimum width of 24") and height of 6'-6" above walkway level shall be provided between the vehicle clearance envelope and any continuous obstruction alongside the track for emergency response access and passenger evacuation.

A minimum clear width of 24" and height of 6'-6" above walkway level shall be provided between the vehicle clearance envelope and any continuous obstruction alongside the track for exclusive maintenance access.

Unless otherwise approved by HRT, walkways shall be provided either on both sides of the right-of-way or in the median, and shall permit unobstructed passage to a ground-level location from which passengers can be evacuated. For walkway clearance calculations only, at-grade traction power poles shall not be considered a permanent obstruction.

This requirement is not applicable to paved track sections.

An emergency/maintenance walkway shall be provided on each aerial structure.

3.3.2.5 Undercar Clearances

Undercar clearances below top of rail are shown in Figures 3-2 for ballasted and direct fixation track. In paved track, vertical undercar clearance is defined from top of rail with the maximum suspension deflection and car body roll, minimum vertical curve radius, and fully worn wheels. The minimum vertical clearance envelope shall be 2", except in paved track areas between the rails where a drainage crown may extend not more than ¾" above top of rail, thus reducing the worst case vertical clearance to 1¼" .

3.3.3 Vertical Clearances

The LRT system is powered by an overhead contact system, consisting of catenary wires supported by poles that may be located either along the wayside of the tracks or between tracks. Designated vertical clearances between the contact and messenger wires hanging above the track and any overhead obstructions must be maintained to allow efficient functioning of the vehicle pantograph.

The established vertical clearances take into account the vehicle clearance envelope based on the worst-case condition. Vertical clearances shall be measured between the top of highest rail and an overhead obstruction over the entire width of the vehicle.

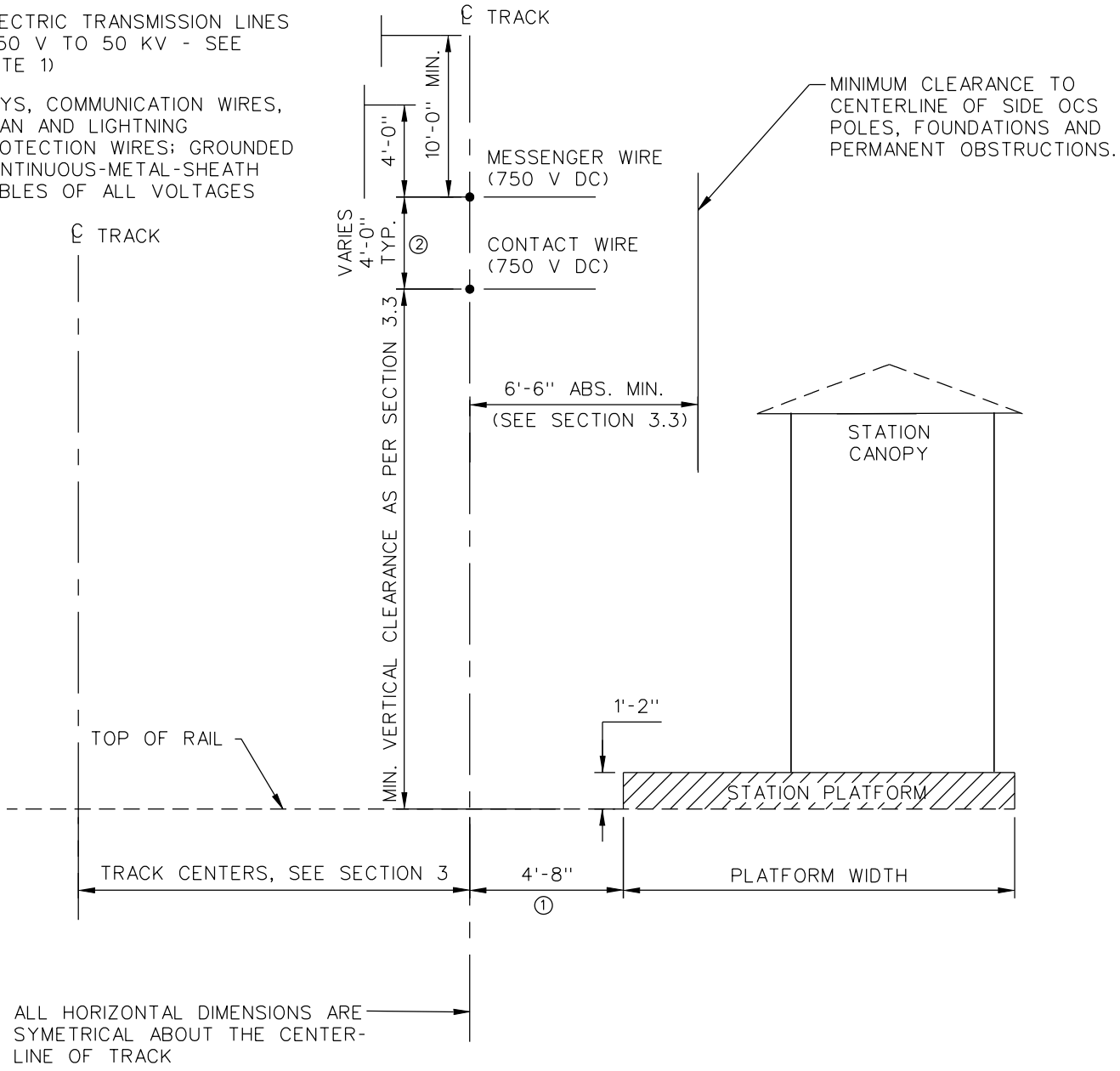
Lateral clearances between catenary poles located along the wayside of the track and adjacent obstructions must be maintained to allow unobstructed access to each pole for maintenance and repairs of the overhead contact wires. The following minimum clearances are established:

Vertical Clearances	
Desirable Clearance between Top of Highest Rail and Lowest Point of Overhead Structure:	22'-0"
Minimum Clearance above Top of Rail to Overhead Structure:	16'-0"
Absolute Minimum Clearance above Top of Rail to Overhead Structure:	14'-3"
Minimum Vertical and Lateral Clearance between Catenary Line and Adjacent Tree Line or Vegetation:	12'-0"

Figure 3-2 includes these clearances and more specific overhead electrical wire clearance requirements.

Transit structures over public highways shall be in accordance with American Association of State Highway and Transportation Officials (AASHTO) Standard Specifications for Highway Bridges, VDOT, or local jurisdiction, whichever is applicable.

Vertical clearances for transit structures over local public streets and roads shall be as required by the authority having jurisdiction over the street or roadway.



NOTES:

1. FOR ELECTRIC TRANSMISSION LINES EXCEEDING 50 KV, THE CLEARANCE SHALL BE INCREASED BY 0.5 INCHES FOR EACH 1,000 VOLTS, OR FRACTION THEREOF, IN EXCESS OF 50,000 VOLTS. REFER TO NESC AND DOMINION VIRGINIA POWER O.H. WIRE REQUIREMENTS.

① NO RUNNING CLEARANCE PROVIDED FOR CLEARANCE CALCULATIONS TO PLATFORM EDGE.

② FOR SINGLE WIRE OCS (NO MESSENGER WIRE), ABSOLUTE MINIMUM CLEARANCE TO ANY STRUCTURE IS 8", PREFERRED MINIMUM IS 12".

HAMPTON ROADS TRANSIT

CONSTRUCTION CLEARANCE ENVELOPES

FIGURE 3-2a

SECTION 14
STRUCTURES

Introduction

This Section defines the structural design criteria and standards for the LRT. Structures anticipated include bridges, retaining walls, box culverts, transit stations (at-grade and aerial) and appurtenances, buildings, and other miscellaneous structures.

14.1 GENERAL

This Section establishes the basic Design Criteria for light rail transit (LRT) structures. LRT structures include bridges, stations, retaining walls, buildings, temporary support structures, and other miscellaneous system-related facilities.

Clearance requirements measured from the centerline of the LRT tracks to all adjacent structures are set forth in Section 3 - Track Alignment & Vehicle Clearances. These requirements must be taken into consideration in the design of all structures including bridges, stations, and retaining walls.

The structural Criteria for the overhead power distribution support system are defined in Chapter 5 - Traction Power Supply & Distribution.

Criteria for Fire/Life Safety are included in Section 11 – Safety, Fire/Life Safety and Security.

The design of all structures constructed as part of the LRT system shall comply with the Criteria defined in this section to the maximum extent possible.

Where special design cases not specifically covered in these Criteria are encountered, supplemental Design Criteria based on documented technical sources must be submitted for approval.

In addition to these Criteria, the design shall comply with applicable municipal, county, state, and Federal regulations and codes.

The vast majority of light rail aerial structures at Hampton Roads Transit (HRT) were constructed with friction pile bents, precast concrete girders, and open deck trackwork. In limited locations with sharp curvature and station platforms, a concrete deck/direct fixation track structure was used. This design was selected primarily due to limitations in available cost and design effort with no consideration of either visual impacts or maintenance.

As noted in Section 4, HRT does not intend to repeat the existing open deck trackwork design in any location other than short water crossings. Concurrently, HRT also intends to reduce or eliminate its driven pile substructure design to the greatest extent possible, and definitely on sites within public view.

To this end, typical sections for structures shown in Figures 14-2 to 14-3 show single stem piers and concrete box girder sections. It is recognized that other structure configurations are available to the design, particularly ballasted deck bridge sections (See Section 4, Figure 4-7), that when feasible and economical, shall be utilized in lieu of open deck bridges and direct fixation structures. It is also recognized that special long span aerial stations (e.g., NSU Station over Brambleton Ave., Norfolk) over major roadways may restrict available design options.

For guidance, the design should consider available foundation, pier, and abutment designs utilized by the Virginia Department of Transportation (VDOT) in its selection of aerial structure type.

Figure 14-4 shows a tunnel section as reference. Given the general topography and soil conditions of the Hampton Roads area. HRT does not anticipate tunnel construction in any light rail project except for potential special enclosed segments of track to protect adjacent structures.

14.2 DESIGN CODES

14.2.1 General

The design and construction of structures associated with the LRT system shall be in accordance with these criteria and the current edition of the codes, manuals, and specifications listed herein. These codes are to be used in accordance with the requirements that are specified by the individual owner, or operating agency that has possession of the structure which is being designed, modified, or rehabilitated as a part of the LRT system.

14.2.2 Codes, Manuals, and Specifications

The following shall apply. Unless noted otherwise, the most stringent Criteria, manual, code, or specification shall govern.

- National Fire Protection Association (NFPA) Standard 130, Standard for Fixed Guideway Transit and Passenger Rail Systems
- For bridges, aerial structures, walls and other structures, that support LRT loading, the design requirements of applicable vehicle loading specified in this section, the "LRFD Bridge Design Specifications", with interim specifications of the American Association of State Highway and Transportation Officials, (AASHTO) shouldbe used, except as otherwise noted herein. When AASHTO is not applicable, the current edition of the "Manual for Railway Engineering" of the American Railway Engineering and Maintenance-of-Way Association (AREMA) should be used.
- For bridges that support railroad loading, the design requirements of the applicable railroad shall apply. In the absence of such requirements the current edition of AREMA Manual for Railway Engineering should be used.

- For bridges, walls, and other structures that support highway loading, the design requirements of the applicable jurisdiction should be used, generally the requirements of the Virginia Department of Transportation. In the absence of such requirements, the current edition of AASHTO LRFD Bridge Design Specifications should be used.
- For concrete, reinforced concrete, precast concrete and prestressed concrete structures, other than bridges, subjected to LRT, railroad or highway loading, the "Building Code Requirements for Reinforced Concrete" of the American Concrete Institute, hereinafter referred as the ACI-318, should be used.
- For structural steel structures, other than bridges, subjected to LRT, railroad, or highway loading, the "Manual of Steel Construction – Load and Resistance Factor Design" of the American Institute of Steel Construction (AISC) shall be used.
- American Welding Society (AWS) Structural Welding Code – Steel, Structural Welding Code – Reinforced Steel and the Bridge Welding Code should be used where appropriate.
- Precast/Prestressed Concrete Institute (PCI), PCI Design Handbook – Precast and Prestressed Concrete should be used where appropriate.
- For building structures, the American Society of Civil Engineers (ASCE), "Minimum Design Loads for Buildings and Other Structures", Standard ASCE/SEI 7-10, shall be used.

The following codes, manuals and specifications shall be applicable to the design of all other structures (all publications listed shall be the latest edition unless noted otherwise):

- Virginia Department of Transportation, Manual of the Structure and Bridge Division.
- Virginia Department of Transportation Modifications to the AASHTO LRFD Bridge Design Specifications.
- Virginia Department of Transportation Road and Bridge Specifications.
- Virginia Department of Transportation Road and Bridge Standards.
- American Association of State Highway and Transportation Officials (AASHTO) LRFD Bridge Design Specifications with interim specifications, hereinafter referred to the AASHTO LRFD Specifications.
- AREMA Manual for Railway Engineering, hereinafter referred to as the AREMA Manual.
- Virginia Uniform Statewide Building Code (USBC)
- International Building Code (IBC)
- American Concrete Institute (ACI) ACI 318 Building Code Requirements for Reinforced Concrete, Alternate Design Method, hereinafter referred to as ACI 318.

- American Institute of Steel Construction (AISC) Specification for Structural Steel Buildings - Allowable Stress Design, hereinafter referred to as the AISC Specifications.
- Aluminum Association, Inc. the current edition of The Specification for Aluminum Structures.

14.2.3 Private Facilities

Privately owned structures shall be designed using codes specifically prescribed by the individual owners. In all cases, privately owned structures shall conform to the Virginia Uniform Statewide Building Code and all local jurisdictional amendments to the Code.

14.3 MATERIALS

14.3.1 General

All materials shall conform to the applicable specifications and codes listed above. If significant economies can be achieved using different materials than those specified in this section, while providing at least the same level of performance and durability, the design may substitute alternate material standards after receiving written approval from HRT. Except for temporary structures during construction, timber shall not be used for LRT structures.

14.3.2 Minimum Material Properties

Materials used for structural applications on the LRT shall conform to the minimum material properties specified in this Section.

14.3.2.1 Specifications

Structural design shall conform to the general requirements of Table 14-1.

TABLE 14-1: GENERAL STRUCTURAL SPECIFICATIONS

Structural Steel:	ASTM A36	
Steel Reinforcement:		
Primary reinforcement:	ASTM A615	Grade 60
Secondary reinforcement:	ASTM A615	Grade 40 or 60
Prestressing Steel:		
Stress relieved steel wire:	ASTM A421	
Stress relieved steel strand:	ASTM A416	
High strength steel bar:	ASTM A722	
Fill concrete:	f_c = 2000 PSI	
Cast-in-Place Concrete:	f_c = 4000 PSI	Minimum
Precast Concrete:	f_c = 5000 PSI	Minimum

Fasteners:		
Anchor bolts:	ASTM A307 or ASTM F1554	Grade C Grade 36 minimum
Anchor bolt nuts:	ASTM A563	
Anchor bolt washers:	ASTM F436	
High strength bolts:	ASTM A325	
High strength nuts:	ASTM A563	
High strength washers:	ASTM F436	
Welding:	E70XX	
Elastomeric Bearings:		
Neoprene or natural rubber:	Nominal durometer hardness of 70 or less	

14.3.3 Modulus of Elasticity

In the event that more accurate data cannot be obtained from manufacturers or from tests, the following design values may be used for the modulus of elasticity of the following materials:

- Structural Steel: 29,000,000 psi
- Steel Reinforcement: 29,000,000 psi
- Prestressing Steel:
  - Cold drawn wire 29,000,000 psi
  - Seven wire strand 28,500,000 psi
  - Strand (greater than seven wires) 28,500,000 psi
  - High strength bars 28,500,000 psi
- Concrete 3,600,000 psi for 4,000 psi concrete

14.3.4 Poisson's Ratio

For concrete design, Poisson's Ratio shall be taken as 0.2.

14.3.5 Thermal Properties

The following coefficients of thermal expansion shall be used for design of structures:

- Concrete 0.0000060/degree Fahrenheit
- Steel 0.0000065/degree Fahrenheit
- Rail 0.0000065/degree Fahrenheit

14.4 LOADS

14.4.1 General

All structures designed for the LRT shall be proportioned to safely withstand the combination of loads specified by the respective design codes and defined in these Criteria.

14.4.2 Dead Load (DL)

The dead loads consist of the actual weight of the structure including permanently installed trackwork, walls, floors, partitions, roofs, electrification, safety walks, pipes, conduits, cables, utilities, services, and all other permanent construction and fixtures. Since dead load stresses are always present, each structure shall be designed to sustain them at all times.

Trackwork, appurtenances and secondary elements supported by the structure and added after construction of the basic structure shall be considered as superimposed dead load. In areas of tie and ballast construction, the weight of the ties and ballast shall also be considered as superimposed dead load.

The dead load shall be computed from the weights of the material composing the structure and its permanent fixtures. The design weights of materials shall be as listed in ASCE-7.

In cases where Codes are silent the following information may be used as the basis of:

- Aluminum alloys: 175 pcf
- Asphalt mastic, bituminous macadam: 150 pcf
- Ballast, crushed stone: 120 pcf
- Ceilings, plasterboard, unplastered: 3 psf
- Gypsum ceiling tile, 2" unplastered: 9 psf
- Pressed steel: 2 psf
- Ceramic glazed structural facing, 4": 33 psf
- Concrete crosstie: 620 lbs
- Electrical overhead pickup equipment @ 20' cc in subsurface: 60 lbs
- Floors, gypsum floor slab, per inch: 5 psf
- Asphalt mastic: 5 psf
- Ceramic tie, on 1" mortar bed: 23 psf
- Linoleum, 1/4": 2 psf
- Maple, 7/8" on sheathing, 2" cylinder fill, no ceiling: 18 psf

- Oak, 7/8" on sheathing, wood joists at 16" centers, no ceiling: 11 psf
- Glass: 160 pcf
- Gravel, sand: 120 pcf
- Iron, cast: 450 pcf
- Partitions, plaster, 2" channel stud metal lath: 20 psf
- Plaster; 4" channel stud, metal lath: 32 psf
- Hollow plaster; 4" metal lath: 22 psf
- Gypsum block, solid; 3", both side plastered: 19 psf
- Gypsum block, hollow; 5', both side plastered: 22 psf
- Steel partitions: 4 psf
- Ceramic glazed structure tile, 4": 33 psf
- Rail and fastenings, per track (2 rails): 200 plf
- Roofs, roofing felt, 3 ply, and gravel: 5 ½ psf
- Roofs, 5 ply: 6 ½ psf
- Sheathing, 3/4" thick: 3 ½ psf
- Steel: 490 pcf
- Timber, untreated: 48 pcf
- Timber, treated: 60 pcf
- Walls, brick solid, per in.: 10 psf
- Glass, structural, per in.: 15 psf
- Windows, frame, glass, sash: 8 psf
- Stone, 4": 55 psf
- Steel sheet, 14 gauge: 3 psf
- Concrete, reinforced or prestressed: 150 pcf
- Concrete median barrier: 500 plf
- Permanent wearing course, 2" thick: 25 psf
- Future surfacing allowance (additional ballast): 60 psf
- Sign structures: As required
- Utilities, including scuppers drain pipes & light poles: 100 plf of track
- Single Track Dead Load: 115RE rail, concrete ties @ 30” centers, 10" ballast under ties, approximate track structure weight (rails, ties, OTM, and ballast) with allowance for future raises and not including electrification or signal: 4800 plf per track

- Double Track Dead Load: 115RE rail, concrete ties @ 30” centers , 10" ballast under ties, approximate track structure weight (rails, ties, OTM, and ballast) with allowance for future raises and not including electrification or signal: 9700 plf per double track

For items not listed, the best available technical information shall be used and its source or reference shown or provided in calculations.

A specific check should be made as to the actual weight where a variation might affect the design adequacy, or in cases where the construction may vary from normal practice.

14.4.3 Live Load (LL)

Live load shall consist of any non-permanent loads including the weight of machinery, equipment, stored materials, persons, motor vehicles, transit vehicles, freight trains or other moving objects, construction loads, and loads due to maintenance of operations.

14.4.3.1 Light Rail Vehicle Design Load

A schematic diagram that depicts the position and load of each LRT vehicle axle is shown in Figure 14-1a. In all cases, the combination of train lengths used for structural design shall be the one that produces the most severe conditions on the element being designed. The LRT train may consist of one, two, or three vehicles.

14.4.3.2 Maintenance Vehicle Design Load

A schematic diagram that depicts the position and load for worst-case ballast train axles is shown in Figure 14-1. This represents the heaviest maintenance vehicle anticipated on the LRT system.

14.4.3.3 Freight Train Loading

Structures that support freight trains shall be designed in accordance with the AREMA requirements for the Cooper E-80 load, or the AREMA “Alternate Live Load” from Figure 15-13 of the AREMA Manual, whichever produces the more critical condition.

14.4.3.4 Pedestrian Live Loads

Pedestrian Areas

LRT station or stop platforms, stairways, pedestrian ramps, mezzanines, and other pedestrian areas shall be designed for a uniform load of at least 150 pounds per square foot (psf) with no access for cars and trucks, and for a minimum uniform load of 250 pounds per square foot (psf) with access for cars and trucks.

Service Walkways

Service walkways and emergency walkways shall be designed for a uniform load of at least 85 psf.

14.4.3.5 Railings and Posts

Railings along passenger platforms shall be designed for a horizontal force of at least 150 pounds per linear foot (plf), and a vertical force of at least 100 plf applied to the top rail. Railings in other places of public assembly shall be designed in accordance with the IBC. Railings in equipment rooms and working areas shall be designed for a force of 200 pounds applied in any direction at any point. LRT bridge railings shall be designed in accordance with AASHTO LRFD Specifications. shall.

Post along passenger platforms shall be designed for a horizontal force, F= PL, where P is the maximum horizontal force (uniform or concentrated force) on each railing and L is the post spacing. LRT bridge posts shall be designed in accordance with AASHTO LRFD Specifications.

14.4.3.6 Miscellaneous Live Loads

Refer to ASCE "Minimum Design Loads for Buildings and Other Structures", Standard ASCE/SEI 7-10, Chapter 4.

14.4.3.6.1 STAIRS

Stair treads shall be designed for a uniform load of at least 100 pounds per square foot, plus a concentrated load of at least 300 pounds per stair tread acting in an area of 4 inches square located to produce a maximum stress condition.

14.4.3.6.2 FLOORS, AND ALL OTHER AREAS NOT SPECIFIED HEREIN

In office areas only, 150 pounds per square foot, or a concentrated point load of 2,000 pounds acting in an area 3 inches square, located to produce a maximum stress condition, whichever gives the higher stress.

Mezzanine storage and other areas of material or equipment storage or access shall be designed to ASCE Heavy Manufacturing Standards; i.e., 250 pounds per square foot, or a concentrated point load of 3,000 pounds acting in an area 3 inches square, located to produce a maximum stress condition, whichever gives the higher stress.

14.4.3.6.3 EQUIPMENT ROOMS

Equipment load, or 250 pounds per square foot, whichever produces the greater stress.

14.4.3.6.4 STORAGE SPACES AND ROOMS

Design for the loading to which they may be subjected, but not less than 250 pounds per square foot.

14.4.3.6.5 AERIAL STRUCTURES

Provisions shall be made for all loads resulting from the method and route to be used for the installation and subsequent removal and replacement of the various items of plant and equipment.

14.4.3.6.5 HIGHWAY LIVE LOADS

Highway live loads shall be as specified in VDOT Modifications to AASHTO LRFD Bridge Design Specifications for HS-93 loads.

14.4.3.6.5 SYSTEMS EQUIPMENT LOADS

Design shall include loads and forces produced by the systemwide elements such as electrification, signalization and communication equipment.

14.4.4 Impact (I)

The vertical impact force shall be a fraction of the LRV load, as determined by the following formula:

(Eq. 14.4.4-1) $$I = \frac{50}{L + 125}$$

I = Impact fraction (maximum 30 percent)

L = Length in feet of the portion of the span that is loaded to produce the maximum stress in the member (ft)

Impact loads shall be applied to the superstructure and generally to those members of the substructure that extend down to the top of footings. The portion above the ground line of concrete or steel piles rigidly connected to the superstructure, as in rigid frame or continuous design, should also be designed to include impact.

Impact shall not be considered for service walkways, abutments, retaining walls, piles and footings, except for the portion of piles rigidly connected to the superstructure.

In the above-defined formula, the loaded length shall be determined as follows in Articles 14.4.4.1 through 14.4.4.5 and the AASHTO LRFD Specifications. Where a conflict occurs between the articles below and the AASHTO Specification, the AASHTO Specification shall be used.

14.4.4.1 Decks

The design span length shall be used.

14.4.4.2 Transverse Members

The span length of floor beams or other transverse members measured member center to center of supports.

14.4.4.3 LRT Moments

The span length, or for cantilever arms, the length from the moment center to the further most axle shall be used.

14.4.4.4 Shear Due to the LRT Vehicle

The length of the loaded portion of span from the point under consideration to the far reaction shall be used. For shear in cantilever arms, use a 30 percent impact factor.

14.4.4.5 Continuous Spans

The length of span under consideration for positive moment and the average of two adjacent loaded spans for negative moment shall be considered.

14.4.5 Centrifugal Force (CF)

Structures supporting a LRT vehicle on curves shall be designed for a horizontal radial force equal to the following percentage of the live load without impact, on all tracks:

(Eq. 14.4.5-1) $CF = 0.0012 \quad V^2 \quad D$

CF = Centrifugal force, in percent of the live load, without impact
V = Design speed, mph
D = Degree of curve

Determination of centrifugal force due to rail transit vehicles on curved track shall be as provided in AASHTO LRFD specifications, except the resulting force shall be applied four feet above the top of the lower rail of the track.

14.4.6 Rolling Force (RF)

A rolling force equal to 10 percent of the LRT vehicle loading per track shall be applied downward on one rail and upward on the other rail, on all tracks.

14.4.7 Hunting Force (HF)

A transverse horizontal hunting force equal to 25 percent of the LRT vehicle load, without impact, shall be applied as concentrated loads at the axle locations, acting in either direction transverse to the track through a point at the top of the low rail. The hunting force is caused by the lateral interaction of the vehicle and the guideway. Use the AREMA Manual to determination which members this force should be applied to. If centrifugal and hunting forces can act simultaneously, only the larger of the two lateral forces shall be considered.

14.4.8 Earth Pressure (E)

All substructure elements shall be proportioned to withstand earth pressure in accordance with the provisions of the Geotechnical Information article in this section and as stipulated by a Geotechnical Engineer.

In general, the following Criteria shall be adhered to:

14.4.8.1 Retained Earth Structures

Structures that retain earth shall be designed for active pressure due to earth abutting against the structure and load surcharges imposed on abutting earth. Consideration shall be given to multi-layered effects where substantial differences in soil properties occur over the depth of the structures.

Light rail transit loading may be assumed as a uniform surcharge load equal to three additional feet of earth. Live and dead loads from adjacent foundations of structures shall be considered in computing horizontal pressures.

14.4.8.2 Buildings

Live loads and dead loads from adjacent building foundations shall be considered in computing horizontal pressures.

Where LRT vehicle and railroad loading occurs, the surcharge shall be calculated using AREMA Criteria.

Passive earth pressure acting against the front face of a wall shall be neglected when computing the factors of safety for sliding or overturning.

14.4.9 Buoyancy (B)

The effects of hydrostatic pressure and buoyancy shall be included in the design of any structure where the presence of groundwater is indicated. The possibility of future major changes in groundwater elevation shall also be taken into account. Each design must include an evaluation of groundwater effects for the construction stage as well as for the permanent condition.

During construction and backfill operations, the elevation of groundwater shall be observed and controlled so that the calculated total weight of structure and backfill shall always have a minimum factor of safety against uplift due to buoyancy of 105 percent. The design shall take into account the effect of hydrostatic pressures pertaining to construction sequence.

The permanent structure shall have a minimum factor of safety against uplift due to buoyancy of 110 percent.

Backfill considered as resisting uplift shall be restricted to the volume contained within vertical planes defined by the outside limits of structure. Resistance due to soil friction shall be neglected.

14.4.10 Wind Load on Structure (W)

Aerial structures that support LRT vehicles shall be designed for a wind load of 50 pounds per square foot on the vertical projection of the structures, applied at the center of gravity of the vertical projection. The wind load shall be assumed to act horizontally, in a direction perpendicular to the centerline of the track. The structure shall also be designed in accordance with AASHTO LRFD Specifications, which require analysis of the structure under both transverse and longitudinal wind loads.

Where a conflict occurs between this Article and the AASHTO Specification, the AASHTO Specification shall be used.

The effect of forces tending to overturn structures shall be calculated assuming a wind direction at right angles to the longitudinal axis of the structure. In addition, an upward force shall be applied at the windward quarter point of the transverse superstructure width. This force shall be 20 pounds per square foot of deck plan area.

Provisions shall be made for adequate attachment of the superstructure to the substructure by ensuring that the calculated uplift at any support is resisted by tension members engaging a mass equal to the largest force obtained under one of the following conditions:

- 100 percent of the calculated uplift caused by any loading or combination of loading in which the live plus impact loading is increased by 100 percent.
- 150 percent of the calculated uplift at working load level.

Anchor bolts subject to tension or other elements of the structure stressed under the above conditions shall be designed at 150 percent of the allowable basic stress.

14.4.11 Wind Load on Live Load (WL)

Wind Loads on structures and live load shall be calculated per AASHTO LRFD Specifications, VDOT standards, AREMA standards or local Building Code requirements as appropriate to the structure being designed.

Wind loading on catenary shall be considered in the design of both superstructure and substructure elements. Loads (magnitude and location) shall be determined by Catenary Design Engineer.

14.4.12 Longitudinal Force from Live Load (LF)

Structures that support LRT vehicles shall be designed for a live load induced longitudinal force in accordance with provisions stipulated by AREMA manual, as modified herein.

A force equal to 15% of the LRV, without impact, per track, shall be applied 5 feet above the top of rail on all tracks. Consideration shall be given to combinations of acceleration and deceleration forces where more than one track occurs. 50% of this force may be assumed to be transferred outside of the structure when ballasted tracks with continuously welded or bolted rails spanning the entire structure are used.

14.4.13 Longitudinal Force Due to Friction or Shear Resistance at Expansion Bearings (FF)

LRT bridge structures shall be designed to accommodate forces due to friction or shear resistance generated at expansion bearings.

14.4.14 Earthquake (EQ)

Seismic design for all structures designed as part of the LRT shall be in accordance with the VDOT Modifications to AASHTO LRFD Specifications for Seismic Design.

14.4.15 Stream Flow Pressure (SF)

Local flooding may add load to structures in the flood plain. Design of the structures should make allowance for this loading as required by the particular type of structure and the conditions affecting each location. Anticipated flood elevations shall be determined by a study of official flood records.

The piers and other portions of aerial structures subject to the force of flowing water or drift shall be designed to resist the resultant maximum stress. In place of a more rigorous analysis, the stream flow pressure may be calculated using the provisions of AASHTO LRFD Specifications and VDOT.

14.4.16 Ice Pressure (ICE)

The effects of both static and dynamic ice pressure shall be considered in the design of structures where conditions warrant. In place of a more rigorous analysis, the effects of ice pressure may be calculated using the provisions of AASHTO LRFD Specifications.

14.4.17 Other Forces (OF)

LRT structures shall be designed to accommodate forces that are special or unique to the operation of a LRT transit system. The design shall identify and determine the magnitude and frequency of these forces.

14.4.17.1 Rib Shortening

In the case of concrete arch structures where transverse expansion joints are not provided in the deck slab, the combined action of the arch rib, columns and deck slab shall be considered for shrinkage and temperature effects.

14.4.17.2 Shrinkage(S)

Shrinkage is defined as the time dependent deformation of concrete caused by drying and chemical changes. The design of all concrete structures shall consider the stresses or deformations induced by shrinkage. Unless more accurate data is available, the coefficient of shrinkage for normal weight concrete may be taken as 0.0002.

14.4.17.3 Creep(S)

Creep is defined as a time-dependent deformation of concrete under a sustained load. The design of concrete structures shall consider the stresses or deformations induced by creep, where applicable, and included in the load combinations.

14.4.17.4 Temperature (T)

Provisions shall be made for stresses and deformations resulting from temperature changes including stresses induced in the structure due to temperature variations and breaks in the rails of direct fixation trackwork.

The total movement of an aerial structure at its movement joints shall be determined based on the anticipated temperature changes measured from an assumed neutral temperature.

Concrete

- Temperature Rise 50° F
- Temperature Fall 50° F

Steel

- Temperature Rise 60° F
- Temperature Fall 60° F

Rail

- Temperature Rise 50° F
- Temperature Fall 90° F
- Assumed Neutral Temperature 90° F

14.4.17.5 Settlement of Supports (FS)

Loads induced on structures by a tolerable differential settlement shall be considered in this group of load combinations. The differential settlement between two adjacent aerial structure piers shall not exceed 1/1500 times the sum of the length of any two adjacent spans.

14.4.17.6 Vehicle Derailment (DR)

LRT aerial structures shall be designed to accommodate a vertical load caused by a derailed light rail vehicle. The derailed vehicle shall be assumed to be positioned with its longitudinal axis parallel to the track at a minimum distance of 1'-6" to a maximum distance of 3'-0" from the centerline of the track.

In determining the loads on any component of superstructure or substructure that supports two or more tracks, only one train on one track shall be considered to have derailed, with the other track being unloaded or loaded with a stationary train.

Derailment loads shall be calculated based on the percentage of basic unit stress increased to 150 percent. For prestressed concrete members, the steel stress shall not exceed 85 percent of the ultimate tensile strength (0.85 f_S), and the concrete stress shall not exceed 60 percent of the 28-day compressive strength (0.60 f'_C). For load factor design, the group load factor may be reduced to 1.1.

Impact on structures subject to railroad loading shall be in accordance with the requirements in the AREMA Manual. This generally includes crash wall designs.

14.4.17.6.1 VERTICAL DERAILMENT LOADS

Vertical Derailment Load shall be produced by two to three vehicles placed with their longitudinal axis parallel to the track.

Guardrails shall be used on all bridges to restrict the travel of a derailed vehicle. The maximum excursion shall be limited to that allowed by the placement of the guardrails.

A vertical impact factor of 100% of vehicle weight shall be applied in computing the equivalent static derailment load. The derailment impact shall be applied to any two adjacent axles at a time, and the normal AASHTO LRFD vertical impact factor shall be used for all other axles, which produces the critical loading condition for the structure.

When checking any component of superstructure or substructure, which supports two or more tracks, only one train on one track shall be considered to have derailed, with one other track being loaded with a stationary train.

A rolling force equal to 10% of the light rail transit loading per track shall be applied downwards on one rail and upwards on the other, on all tracks.

All elements of the structure shall be checked assuming simultaneous application of all derailed wheel loads. On closed deck bridges utilizing direct fixation trackwork, the deck shall be checked at 100% impact and the rest of the structure checked using the calculated normal impact factor.

On open deck bridges, the girders should be designed for 100% and the rest of the structure checked using the calculated normal impact factor. In all cases, the substructure should be designed only for the calculated impact with the load displaced the distance required by the guardrail limitation. However, the reduction of positive

moment in continuous slabs due to derailed wheel loads in adjacent spans shall not be allowed. The above requirements are based on AREMA Manual requirements; the design shall conform to any revisions in the Manual at the time of design.

14.4.17.6.2 HORIZONTAL DERAILMENT LOADS

For cross-sections having clearance between vehicle and barrier wall of 6" to 3'-0", with maximum vehicle speeds of 60 MPH, the force due to horizontal derailment loads shall be taken as 40% of a single vehicle weight acting two feet above top of rail and normal to the barrier wall for a distance of 10 feet along the wall. Barriers farther than 3'-0" clear from vehicles are not contemplated. For tracks supported by guardrails, the guardrails shall resist this force impact.

Impact on structures subject to LRT and/or highway loading shall be in accordance with the requirements in the AASHTO LFRD Specifications or Structural Design Criteria. In addition to the vertical impact provided in AASHTO LRFD specifications, a Horizontal Impact (or Nosing) Force, equal to 10% of rail transit design vehicle load shall be applied. This force shall be equally distributed to the individual axles of the vehicle, and shall be applied horizontally in the vertical plane containing each axle. The force shall be assumed to act in either direction transverse to the track through a point 3'-6" above the top of the lower rail.

The above requirements are based on AREMA Manual requirements; the design shall conform to any revisions in the Manual at the time of design.

14.4.17.7 Collision

Piers or other guideway support elements situated less than 10 feet from the edge of an adjacent street or highway shall be designed to withstand a horizontal static force of 225 kips, unless protected with suitable barriers. This force is to be applied on the support element at an angle of 10 degrees from the direction of the road traffic and at a height of 4 feet above ground level. This condition occurs with the dead load of the structure but need not be applied concurrently with other loading.

The above requirements are based on AREMA Manual requirements; the design shall conform to any revisions in the Manual at the time of design.

14.4.17.8 Broken Rail (BR)

Continuous welded rail on an aerial structure is restrained from temperature related movement except at the ends of the rail string, normally located outside of the structure limits. Except at ballasted track, continuous welded rail forces can be transferred to the supporting structure by the rail fasteners if a rail break occurs. The resulting pull-apart force shall be assumed to be resisted by the structure only and not by the adjoining rails. The distribution of theses broken rail forces to the structure shall be determined based on the site and structure specific conditions. For track on or near a structure, only one broken rail shall be assumed.

The restraining force in the rail due to temperature change can be calculated by the following formula:

(Eq. 14.4.17.8-1) $N_T = 0.0000065 \quad E \quad A \quad \Delta T$

N_T = Restraining force in rail, pounds
E = Modulus of elasticity of rail (30×10^6 psi)
A = Cross sectional area of 115 RE rail (11.25 in^2)
ΔT = Maximum temperature change (See Sec. 14.4.17.4).

Restraining force (N_T) is typically 219,000 lbs for 115 RE rail for typical climatological conditions in the Mid-Atlantic Region.

If a rail break occurs, the rails adjacent to each side of the break should move apart until the cumulative restraints developed by all of the rail fasteners are equal to the calculated restraining force. Direct fixation fasteners may be designed with different amounts of longitudinal restraint and some of the fasteners may have zero longitudinal restraint as described in Section 4 – Trackwork. The longitudinal restraining force resists sliding of a broken rail through the direct fixation fastener. This resisting force is transferred into the structure deck through the fastener anchors and shall be considered in the design of bearings used at the structure abutments and piers.

Special trackwork shall not be located on aerial structures without specific approval from HRT. The layout of the track and aerial structure shall be such that there will be a minimum relative movement due to thermal conditions between the rails and the superstructure at track switch locations. The longitudinal restraint properties of special trackwork fasteners shall vary from those of standard direct fixation fasteners, particularly at frogs. Therefore, broken rail forces at special trackwork must be analyzed separately.

14.4.18 Transit Vehicle Load Distribution

For structures carrying rail transit loads, one train per track shall be considered on the structure, for both strength and serviceability considerations in all materials. When intended to occupy the same deck space as highway loads, either concurrently or at separate periods of structure life, the rail transit loads shall be treated as alternatives, interchangeable with the highway loads. When all or a portion of deck width is dedicated exclusively to rail transit, the rail transit loads shall apply only to that width.

For structures carrying rail transit loads, a track shall be as a traffic lane in applying the provisions of AASHTO LFRD Bridge Design Specifications and the AREMA Manual, as appropriate.

14.4.18.1 General

In the absence of an elastic analysis, the following empirical methods of load distribution may be employed. These methods are limited to monolithic concrete deck slabs on skews of less than 20 degrees. The skew angle is defined as the angle intersected by a

horizontal line parallel to the pier or abutment and a horizontal line perpendicular to the girder centerline. These methods are applicable for unballasted track only.

The AREMA Special Provisions for Slabs and Footings should be used to evaluate the capacity of deck slabs to resist derailment loads.

For ballasted deck bridges, the effects of the ballast in distributing the wheel loads shall be considered based on AREMA Manual procedures for the distribution of transit vehicle live loads through ballasted deck bridge structures.

14.4.18.2 Contact Areas

Under normal service conditions, each wheel load shall be distributed through the running rail to produce an effective contact area of six inches (measured parallel to rail) by 12 inches measured at the bottom of the bearing pad under the rail fastener.

Under derailment conditions, each derailed wheel in direct contact with the deck slab shall be assumed to create a groove between 0.25 inches to 0.50 inches deep based on a wheel-to-concrete contact area of 2 inches wide by 8 inches long.

14.4.18.3 One-Way Slabs (Excluding Cantilevers)

Dispersion of Loads Along the Span:

The effective length of the slab on which a wheel acts shall be taken as equal to the dimensions of the contact area in the direction of the span plus twice the depth of the slab measured to the centerline of the bottom reinforcement of the slab.

Effective Width of Slab Resisting Bending Moment and Shear:

A solid one-way slab supported on two opposite edges shall be designed to resist the maximum bending moment and shear force caused by the applied loads. Such bending moment and shear forces shall be assumed to be resisted by an effective width of slab E (measured parallel to the supported edges, in feet) according to the following empirical formula:

- Main reinforcement perpendicular to the track (spans 2 to 24 feet inclusive):

(Eq. 4.18.3-1) $$E = KX\ (1 - X/L) + W$$

E = Effective slab width, not to exceed 7 feet, or actual distance between vehicle axles (ft)
X = Distance in feet from the center of gravity of the wheel load to the near face of support.
L = Effective span in the case of simply supported slabs and the clear span in the case of continuous slabs.
K = 2.5 for simply supported slabs.
K = 2.2 for continuous slabs over three or more supports
W = Spacing of the rail fasteners

W = 2 feet for a derailed wheel load in direct contact with the slab.

In the case of a load near the unsupported edge of a slab, E should not exceed the above value nor half the above value plus the distance from the load to the unsupported edge.

- Main reinforcement parallel to the track, effective width (in feet) of the slab resisting a wheel load should be taken as:

(Eq.4.18.3-2) $E = 4 + 0.06\ L$ (not to exceed 5.0 feet).

Full edge beams shall be provided for all slabs having main reinforcement parallel to the track. The beam may consist of a slab section with additional reinforcement, a beam integral with and deeper than the slab, or an integral reinforced section of slab and curb.

For simple spans, the edge beam shall be designed to resist a live load moment of M = 0.10 (PL) where P is the wheel load and L is the span length. For continuous spans, 80 percent of the above-calculated value shall be used for both positive and negative moments, unless a greater reduction can be justified based on a rigorous analysis.

14.4.18.4 Two-Way Slabs

Two-way slabs are those supported on all four sides and reinforced in both directions. For rectangular slabs simply supported on all four sides, the proportion of the load carried by the short span of the slab may be estimated by the following equations:

For load uniformly distributed:

(Eq. 14.4.18.4-1) $$P = \frac{L_2^4}{L_1^4 + L_2^4}$$

For load concentrated at center:

(Eq.14.4.18.4-2) $$P = \frac{L_2^3}{L_1^3 + L_2^3}$$

P = Proportion of load carried by short span
L_1= Length of short span of slab
L_2 = Length of long span of slab

In cases where L_2 exceeds 1.50 (L_1), the slab shall be designed as a one-way slab spanning in the short direction (span L_1).

For a concentrated load, the effective slab width, E, for the load carried in either direction shall be determined as specified above for one-way slabs.

The moments obtained shall be used in designing the center half of the short and long spans. The reinforcement steel in the outer quarters of both short and long spans may be reduced 50 percent.

14.4.18.5 Cantilever Slabs

Wheel Load:

For the design of a cantilever deck slab in which the main reinforcement is perpendicular to the track, a concentrated wheel load shall be assumed to be uniformly distributed over an effective width E of the slab, not exceeding 7 feet:

(Eq. 14.4.18.5-1) $E = 0.8X + 3.75$ (non-derailed condition)

(Eq. 14.4.18.5-2) $E = 0.8X + 3.00$ (derailed condition)

X = Distance in feet from the load to the face of cantilever support.

Railing or Parapet Load:

Loads transmitted from railing, barrier or parapet attachments to a cantilever deck slab shall be distributed over the effective width E as specified above for wheel loading, except that X is the distance in feet from the railing of parapet support to the point along the cantilever that is under investigation, and E shall be limited to the longitudinal spacing of the railing or parapet supports.

14.4.18.6 Unsupported Edges (Transverse)

The design assumptions of the sections on one-way and two-way slabs above do not provide for the effect of loads near unsupported edges. Therefore, at points where the continuity of the slab is broken, the edges shall be strengthened by diaphragms, strengthening of the slab, or other suitable means, and shall be designed to resist the full moment and shear produced by the applied wheel loads.

14.4.18.7 Longitudinal Beams

In calculating bending moments in longitudinal beams no longitudinal distribution of the light rail vehicle axle loads shall be assumed. The axle loads shall be taken as concentrated loads and shall be placed to cause the maximum bending moment in the longitudinal beams.

14.4.18.8 Distribution of Wheel Loads on Girders Due to Derailment

For the derailment condition, the wheel load shall be distributed to the girders assuming:

- A simply supported deck slab when the wheel load falls between girders.

- A deck slab that is continuous over multiple girders when the wheel load falls on the cantilevered portion of the slab.

14.5 LOADING COMBINATIONS

14.5.1 Service Load Design

For general structure members, design loads to the structure shall be based on the most critical of the following combinations:

AASHTO LRFD Specifications

AASHTO LRFD load combinations are provided in Figure 14-5 as reference.

Group Loading	Allowable Pct. of Basic Unit Stress
Group I = DL +LL + I + RF + CF + E + SF + B + OF	100%
Group II = DL + W + SF + B + S + T + E + OF	140%
Group III = DL + LL + I + RF + CF + E + SF + B +0.3W + WL +LF + OF	125%
Group IV = DL + LL + I + RF +CF + E +SF + B + 0.3 W + WL + LF + T + OF	133%
Group V = DL + E + B +SF + LF + 0.85DR + OF	125%
Group IV = DL+0.85BR + OF	125%

Where,

DL	=	Dead Load
LL	=	Live Load
I	=	Impact
CF	=	Centrifugal Force
RF	=	Rolling Force
LF	=	Longitudinal Breaking and Tractive Forces
E	=	Horizontal Earth Pressure
B	=	Hydrostatic Pressure and Buoyancy
T	=	Thermal Force
W	=	Wind Load on Structure
WL	=	Wind Load on Live Load
SF	=	Stream Flow Pressure
ICE	=	Ice Pressure
DR	=	Derailment
OF	=	Other Forces
BR	=	Rail Break/Broken Rail

Where ice may be anticipated, the thickness of ice and height at which it applies shall be determined by investigation at the site of the structure, and its effects on the structure

shall be determined following the suitable group loading combinations outlined in AASHTO.

The design of prestressed concrete members, stability, crack control, fatigue, and deflection calculations, and soil bearing pressures shall be based on the most critical of the following combinations.

			Allowable Percentage of Basic Unit Stress
(Eq.14.5.1-1)	Group I	= DL+LL+I+HF+CF+RF+E+B+SF+ICE+PS	@100%
(Eq.14.5.1-2)	Group II	= DL+LL+CF+ICE+LF+T+S+B+SF+PS	@100%
(Eq.14.5.1-3)	Group IIa	= DL+LL+I+HF+RF+CF+T+RS+PS	@100%
(Eq.14.5.1-4)	Group III	= DL+E+B+W+SF+ICE+PS	@125%
(Eq.14.5.1-5)	Group IIIa	= DL+PS+E+B+SF+ICE	@100%
(Eq.14.5.1-6)	Group IV	= Group I+30% W+WL+FS	@125%
(Eq.14.5.1-7)	Group V	= Group II+30% W+WL+RS+FS	@125%
(Eq.14.5.1-8)	Group VI	= Group III+EQ – W	@133%

Where,

DL	=	Dead load
LL	=	Live load
I	=	Impact
CF	=	Centrifugal force
RF	=	Rolling force
HF	=	Hunting force
LF	=	Longitudinal braking and traction force
E	=	Horizontal earth pressure
B	=	Buoyancy
SF	=	Stream flow pressure
S	=	Shrinkage and creep force
T	=	Thermal force, total
DT	=	Forces due to thermal gradient
W	=	Wind load on structure
WL	=	Wind load on live load
RS	=	Rail/structure interaction force
PS	=	Prestressing forces
FS	=	Foundation settlement forces
EQ	=	Seismic force

14.5.2 Strength Design

Reinforced concrete members and structural steel members shall be designed by the strength method. Prestressed concrete members shall be checked using strength method. Reinforced concrete, structural steel, and prestressed concrete members shall comply with AASHTO LRFD Specifications, and have the capacity of resisting any of the load groups listed below:

(Eq.14.5.2-1) Group A = 1.3 (DL+1.67 (LL+I+HF+RF)+CF+1.33E+SF+ICE+B)

(Eq.14.5.2-2) Group B = 1.3 (DL+W+SF+ICE+B+S+T+E)

(Eq.14.5.2-3) Group C = 1.25 (DL+LL+I+HF+RF+CF+E+SF+ICE+B+ 0.3W+WL+LF)

(Eq.14.5.2-4) Group D = 1.25 (DL+LL+I+HF+RF+CF+E+SF+B+0.3W+WL+LF+T)

(Eq.14.5.2-5) Group E = 1.3 (DL+0.85 BR)

14.6 LRT STRUCTURE DESIGN

14.6.1 General

The criteria defined in this Section pertain specifically to the design of structures supporting LRT operations. These criteria shall be used to supplement the provisions stipulated by applicable design codes.

14.6.2 Foundations

The foundations for all bridges and viaduct structures supporting LRT vehicle loads shall be designed such that the maximum settlement at any pier foundation shall not cause a combined change of gradient for any two adjacent spans to exceed 0.1 percent. Any proposed deviation shall be submitted to HRT for consideration and approval.

14.6.2.1 Spread Footings

Spread footings shall be designed such that the maximum bearing pressure for the various loading combinations is below the allowable bearing value as determined by geotechnical analysis, with soil pressures kept as nearly uniform as practical. Uplift at edges or corners of spread footings shall not be permitted.

14.6.2.2 Piles

Uplift force on any friction pile shall not exceed 5 percent of the design capacity, unless determined otherwise from geotechnical analysis based on actual subsurface conditions. Where there is to be an uplift force on a friction pile, sufficient anchorage shall be provided between the pile and the supported structure.

Uplift shall not be permitted for bearing piles.

14.6.2.3 Drilled Shafts

The design of drilled shafts, piers, and caissons shall allow for an accidental misplacement of the center of gravity of a shaft, by six inches in any direction.

14.6.2.4 Lateral Resistance

Each design shall account for the ability of piles or drilled caissons to resist lateral loads. Battered piles shall be used in a pile foundation either where the lateral resistance of the soil surrounding the piles is inadequate to counteract the horizontal forces transmitted to the foundation, or where increased rigidity of the entire structure is required. Battered piles shall have a batter not greater than three horizontal to twelve vertical. Where battered piles are to be used, precautions shall be taken to prevent the pile tips from encroaching onto property outside of the right-of-way.

14.6.2.5 Axial Resistance

The axial loads on piles and caissons will be determined by static analysis of the moment resistant group, by the method of elastic center, or by any other generally accepted engineering method. Each member, vertical or battered, in a pile or drilled caisson group may be assumed to have a horizontal resistance capacity in addition to the horizontal component of the axial load on the battered members, equal to the least of the following values:

- Capacity as determined from geotechnical analysis.
- Capacity of the pile or caisson as a structural member.

Unless a pile or caisson is installed to a sufficient depth in competent material to develop fixity, it shall be assumed to have no capacity to resist lateral loads in bending. Conversely, those piles that do develop fixity shall be designed considering their capacity to resist lateral loads.

14.6.3 Retaining Walls and Abutments

14.6.3.1 General

Retaining walls and abutments are defined to include bridge abutments, wing walls, retaining walls, crib walls, and other miscellaneous structures that are subject to lateral earth pressures.

14.6.3.2 Types of Retaining Walls, Abutments, and Wingwalls

Retaining walls and wing walls shall be designed as reinforced concrete cantilever type structures. Other types of retaining walls and wing walls may be used, if cost effective and feasible based on site constraints.

Abutments for railroad bridges may be of the reinforced concrete cantilever type or the reinforced concrete semi-gravity type, depending on the requirements of the railroad. Other abutments shall generally be of the reinforced concrete cantilever type.

Precast structures such as crib walls may be used for certain retaining walls or wing walls, but shall not be used for abutments. When used, crib walls shall conform to the requirements of AREMA Manual for Railway Engineering.

14.6.3.3 Reinforced Concrete Retaining Walls

For retaining walls up to 20 feet in height, the design earth pressure shall be computed by the AREMA empirical method in AREMA Manual, Chapter 8. Retaining walls above 20 feet in height shall be designed on the basis of specific soils information related to the actual backfill material in accordance with the procedures outlined in AREMA.

14.6.3.4 Proprietary Walls

Proprietary walls shall not be used for the LRT construction unless otherwise approved by HRT. Proprietary walls, when permitted, shall be designed in accordance with the provisions of AASHTO Section 5.

14.6.4 Substructures

Where an LRT bridge structure crosses streets, highways, or railways, the spacing and location of piers shall be controlled by clearance requirements of the roadways or railways as well as the necessity of avoiding existing improvements such as underground utilities whose relocation is not feasible. The minimum horizontal and vertical clearances between the structure and privately or publicly owned streets, highways, utility lines, and other structures or property shall be established considering the design standards of the respective owners. The minimum horizontal clearance for streets and highways shall preferably include a minimum of three feet of lateral clearance between the face of pier and the street ROW line.

In addition, pier protection (i.e., traffic barriers, posts, or guardrails) shall be provided to mitigate damage to piers adjacent to a street right-of-way due to accidental vehicle collisions.

14.6.4.1 Lateral Displacement of Pier

The following considerations shall be made in establishing the maximum lateral displacement of piers:

- The deformation of the soil shall not exceed the elastic limits.
- The absolute displacement at top of pier, including rotation of foundation and deflection of piles shall not exceed h/300, where h is the distance from the top of foundation to the top of pier.
- Continuous welded rail forces from vehicle braking and broken rail forces.

14.6.6 At-Grade Structures

14.6.6.1 At-Grade LRT Stations

At-grade LRT stations shall be designed for the applicable transit loads and forces that are specified in these Criteria, and in accordance with requirements specified by the local jurisdictional codes and the Virginia Uniform Statewide Building Code, together with the amendments of the local jurisdiction.

Where other standards are silent with regard to loading for LRT stations, the following values may be used of design:

- Public spaces including passenger platforms, stairways, escalators, mezzanines, corridors, and public restrooms: 150 psf

- Stairways: 100 psf or 300 pounds acting in an area of 4 inches square on the center of stair treads, whichever produces the critical load.
- Railings on Station Platforms: 150 plf horizontal and 100 plf vertical at the top.
- Equipment Rooms and Working Areas: 200 pounds applied in any direction at any point. Other areas: in accordance with local building codes.
- Office Areas: 50 psf
- Storage Areas: Light Storage - 125 psf, Heavy Storage - 250 psf

Equipment spaces (rooms in transit stations or in separate buildings) shall be designed for 125 psf or the actual weight of equipment, whichever is greater.
Other structures not subjected to LRT train, railroad, or highway loading shall be designed for live loads prescribed in the Virginia Uniform Statewide Building Code (USBC), or where not applicable, the International Building Code (IBC).

14.6.6.2 Buildings

Buildings and related facilities for the LRT system shall be designed in accordance with the Virginia Uniform Statewide Building Code or as required by the local jurisdiction. All buildings shall be designed to withstand the applicable loads and forces defined in these Criteria.

Seismic design of buildings and other structures for forces and displacements produced by ground shaking shall be in accordance with the Virginia Uniform Statewide Building Code, unless precluded by local codes.

Soil conditions in the HRT service area vary widely. Site specific soil and geologic data shall be used for the design of structures, particularly field investigations and soil borings.

Wind load design in the Hampton Roads region is generally based on a basic wind speed of 100 mph as defined by BOCA; however, local codes in coastal areas (e.g., Virginia Beach Oceanfront) typically require design for 120 mph basic wind speed.

14.6.6.3 Fire Protection of Structures

Except for piles and temporary material used during construction only, all structures shall be not less than Type I or Type II as defined in NFPA220.

All material other than concrete, masonry, tile, steel, and similar materials shall be certified as passing ASTM E136, modified by the further requirement that no flaming shall be permitted during any portion of the test period. Flame-proofing of material is not acceptable.

In cases where no suitable material conforms to these requirements, very minor quantities of an accessory material may be permitted if prior approval in writing is obtained from HRT.

14.6.6.4 Concrete Track Slab

Concrete track slabs shall be designed to carry loads and forces specified in these Criteria. The sub-base foundation or sub-grade shall be constructed utilizing materials to provide frost protection. These materials shall extend a minimum of 2'-0" beyond the sides of the concrete slab.

The track slab thickness and reinforcement shall be based on providing longitudinal bending stiffness adequate to carry the following:

- Dynamic wheel loads (vehicle live loads times impact factor of 1.30).
- Where freight traffic is anticipated the design shall be based on maximum live loads authorized.
- Warping stresses caused by the temperature differentials between the top and bottom of the slab (assuming a temperature gradient of 2.25 degrees Fahrenheit per inch).
- Thermal stresses caused by the fastening of continuous welded rail to the concrete slab and other horizontal stresses due to braking/acceleration forces.

The modulus of subgrade reaction shall be based on specific soil information for the site and shall be adjusted to account for the size of the track slab.

14.6.6.5 Light Standards

Light standards included as a part of the LRT shall be designed in accordance with AASHTO LRFD Specifications for Structural Supports for Highway Signs, Luminaries and Traffic Signals, and the provisions of Section 19 in these Criteria.

14.6.7 Structural Rehabilitation

Existing structures selected for use as a part of the LRT system shall be inspected, analyzed, and rehabilitated or modified in accordance with the provisions stipulated by these Criteria and all applicable codes, including the Fire and Life Safety requirements in Section 11. Except for piles, all structural materials shall be non-combustible.

Existing buildings, bridges, and other miscellaneous structures shall be surveyed to verify that the existing facility has the geometric adequacy to support the intended function. An in-depth inspection of each existing structure shall be performed before final design is initiated for that structure.

In general, the inspection should follow the Criteria presented in the AASHTO Manual for Condition Evaluation of Bridges. Inspections shall determine the following:

- Material properties of the primary structural elements using laboratory testing techniques as necessary.

- Condition assessment of the load carrying members and identification of any structural deficiencies.
- Identification of the structure's foundation system using as-built drawings, exploratory test pits, or any other generally recognized methods of making a reliable determination.
- Evaluation of the hydraulic requirements of any waterway crossings and inspection of the existing foundations for scour.
- Hazardous material survey and documentation of findings.

The load carrying capacity of existing structures shall be calculated based on the actual condition of the structural elements as determined from in-depth inspection. The results of this structural analysis shall be used in coordination with information collected during the in-depth inspection to determine the viability of using the existing structure for LRT operations.

Structures that are viable candidates for rehabilitation shall be treated in accordance with these Criteria using the same standards that would apply to a new facility.

14.6.8 Excavation Support Structures

Support and underpinning of existing structures shall be determined on a site-specific basis considering the following:

- Type of structure to be underpinned
- Proximity and type of adjacent construction
- Soil properties and tolerable structural deformations

Underpinning methods include jacked-down piles, slant-drilled piles, mini-piles, augured shafts, and hand-mined shafts.

Rigid protection wall support systems include diaphragm (slurry) walls, contiguous pile (tangent or secant) walls and closely spaced soldier pile walls.

Other methods of controlling ground movement and minimizing settlements include compaction grouting, chemical grouting and ground freezing.

Support of excavation structures shall generally be designed by the contractor based on owner supplied criteria. When planning for structures requiring excavation support, spatial and physical constraints (adjacent structures, utilities, etc.) shall be considered.

Contract drawings and specifications shall cover traffic diversions, mandatory restrictions, and necessary construction staging approved by public authorities and utility companies as applicable. Acceptable locations for construction access ramps, or any other construction facility that affects the work shall be indicated.

Temporary decking, sheeting, and bracing shall be designed by the contractor and reviewed by HRT and appropriate local jurisdictions. The design of temporary structures shall be in accordance with the design criteria and standards specified in the contract drawings and specifications.

Provisions shall be provided in the Specifications or Contract to indicate that the Contractor shall be responsible for the all repairs or replacements of structures damaged or altered as a result of construction operation during the final design. The restoration shall be to a condition equal to or better than they were prior to start the work.

It shall be a requirement in the contract documents that the design of excavation support structures be prepared, checked, and sealed by a Professional Engineer registered in Virginia.

14.7 GEOTECHNICAL INFORMATION

Geotechnical testing and analysis input to the design of structures shall be based upon subsurface investigation programs commensurate with the corresponding level of design. Subsurface investigations for conceptual/preliminary design and final design shall generally include the following where appropriate for structure type and site conditions:

- Groundwater levels
- Soil and rock unit weights
- Soil bearing capacity
- Angle of internal friction
- Coefficients of active and passive resistance
- At-rest pressures
- Swelling potential
- Modulus of elasticity
- Soil modulus of subgrade reaction
- Poisson's ratio
- Compressive and tensile strengths
- Shear strength
- Consolidation
- PH
- Electrical resistivity
- Chemical properties
- Particle grain size

- Atterberg Limits
- Moisture content
- Retaining wall design requirements, improvements, and recommendations
- Structure foundation design requirements, improvements, and recommendations
- Seismic site class and design parameters
- Other items as determined for specific site conditions

The basic difference between the levels of investigation is that the investigation in support of conceptual/preliminary design may be based upon limited testing, whereas the investigation in support of final design provides more detailed site-specific information.

The soils in the Hampton Roads region vary widely. Site specific soil and geologic data shall be used for the design of structures.

14.8 REFERENCES

1. Hampton Roads Transit, “Manual of Design Criteria”, Norfolk LRT Project, Draft, HRT, Dec. 2004.
2. See Section 14.2.2, Codes, Manuals, and Specifications

Figures

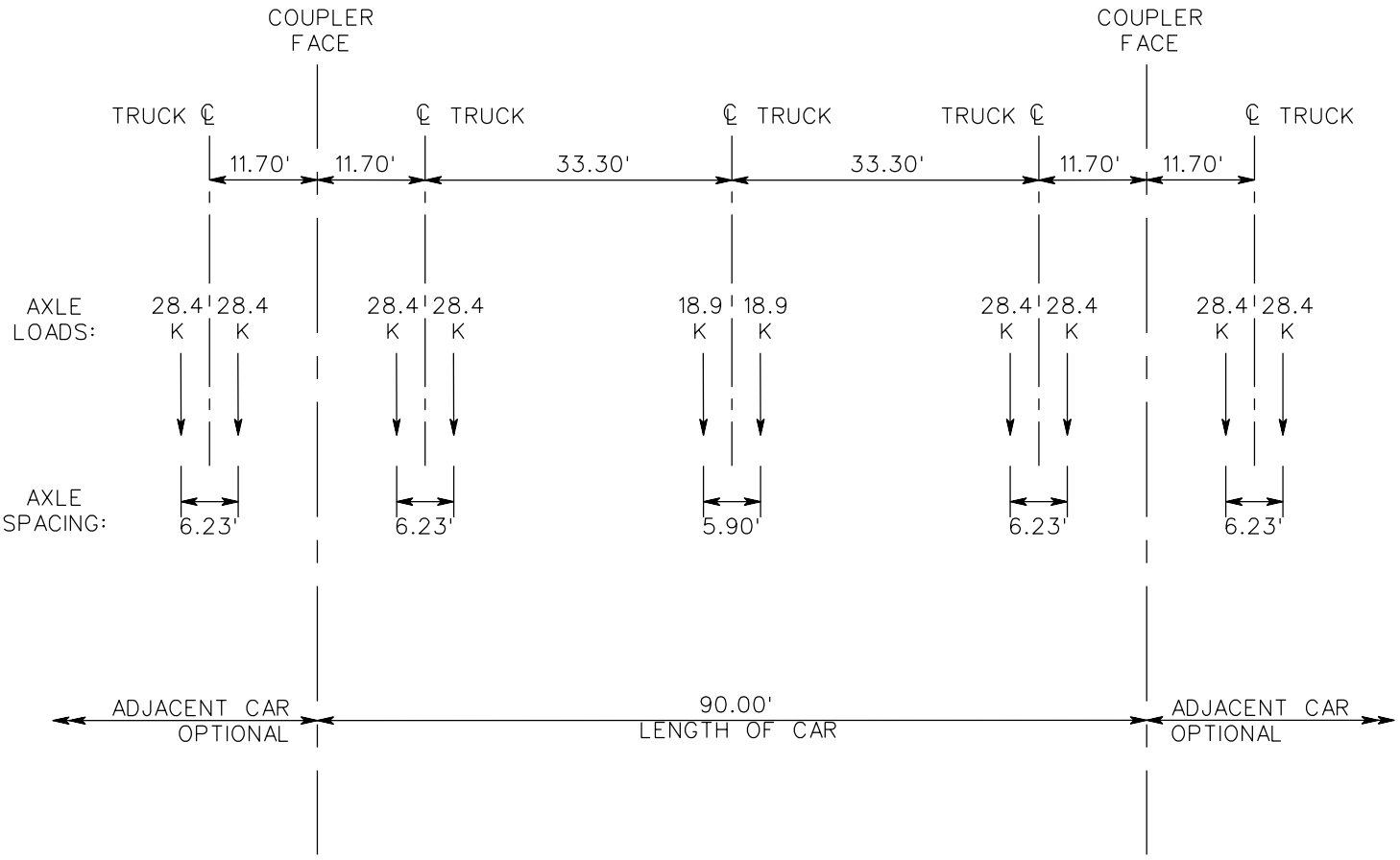
Figure 14-1a: Transit Rail, Vehicle Design Loading

Figure 14-1b: Maintenance of Way Vehicle Design Loading

Figure 14-2h: Aerial Structure, Driven Concrete Pile Structure Installation

Figure 14-2i: Aerial Structure, Typical Direct Fixation Track Concrete Deck

Figure 14-5: AASHTO LRFD Bridge Design Specification Load Factors



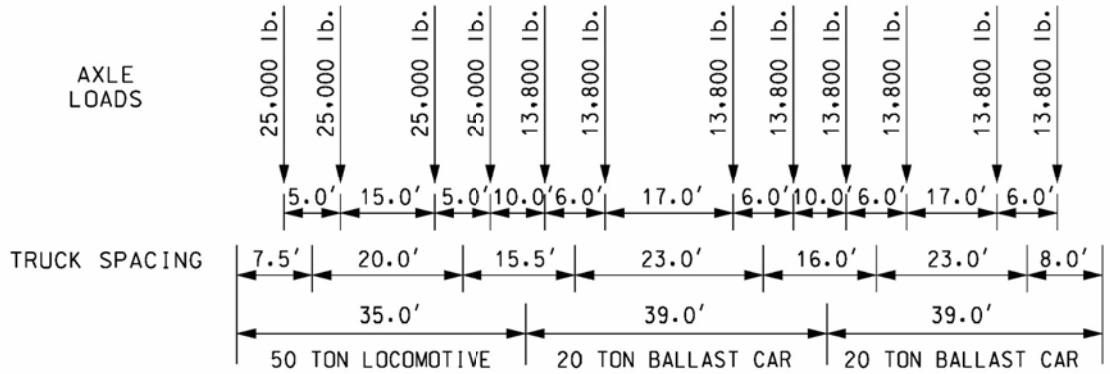
TRANSIT RAIL VEHICLE STATIC LOADING

1. AXLE LOAD ARE SHOWN IN KIPS.
2. TOTAL LOAD 151,400 LB/CAR (AW4, EMPTY VEHICLE WEIGHT = 105,000 LB).
3. THE LRT TRAIN SHALL CONSIST OF EITHER ONE, TWO, OR THREE CARS, WHICHEVER PRODUCES THE MOST CRITICAL CONDITION FOR THE ELEMENT UNDER CONSIDERATION. THIS APPLIES TO BOTH DIRECTIONS.
4. THE LOADS AND DISTANCE DEPICTED ARE WORST CASE SCENARIO.
5. THE VEHICLE IS ASSUMED TO HAVE AN AXLE LOAD/CONFIGURATION THAT DOES NOT EXCEED THIS STANDARD LOAD.
6. THIS FIGURE SHOWS THE HEAVIEST TYPE OF LRT VEHICLE THAT MAY BE USED. THE LOADING FOR THE VEHICLE TYPE USED IN A PROJECT SHALL USED FOR DESIGN CALCULATIONS.

HAMPTON ROADS TRANSIT

TRANSIT RAIL VEHICLE DESIGN LOADING

FIGURE 14-1a



MAINTENANCE VEHICLE LOADING DIAGRAM

1. THE MAINTENANCE VEHICLE SHALL CONSIST OF ONE LOCOMOTIVE AND ONE, TWO, THREE OR FOUR BALLAST CARS; WHICHEVER PRODUCES THE MAXIMUM LOAD FOR THE ELEMENT UNDER CONSIDERATION.
2. AXLE LOAD IN POUNDS.
3. WEIGHT OF EMPTY BALLAST CAR IS 15,000 POUNDS.

REF: HRT LRT-46403, DWG. NST-004 (.DGN FILE)

HAMPTON ROADS TRANSIT DESIGN CRITERIA

HAMPTON ROADS TRANSIT

AERIAL STRUCTURE DRIVEN CONCRETE PILE STRUCTURE INSTALLATION

FIGURE 14-2h

HAMPTON ROADS TRANSIT DESIGN CRITERIA

HAMPTON ROADS TRANSIT

AERIAL STRUCTURE
TYPICAL DIRECT FIXATION
TRACK CONCRETE DECK

FIGURE 14-2i

LOAD COMBINATIONS AND LOAD FACTORS FOR LRT STRUCTURES

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM(1) CE BR PL LS	WA	WS	WL	FR	TU(2)	TG	SE	EQ	Use one of these at a time			RB
											IC	CT	DR(1)	
STRENGTH I	γ_p	1.75	1.00	-	-	1.00	0.5/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
STRENGTH II	γ_p	1.35	1.00	-	-	1.00	0.5/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
STRENGTH III	γ_p	-	1.00	1.40	-	1.00	0.5/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
STRENGTH IV	γ_p	-	1.00	-	-	1.00	0.5/1.2	-	-	-	-	-	-	-
STRENGTH V	γ_p	1.35	1.00	0.40	1.00	1.00	0.5/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
EXTREME EVENT I	γ_p	γ_{EQ}	1.00	-	-	1.00	-	-	-	1.00	-	-	-	-
EXTREME EVENT II	γ_p	1.00	1.00	-	-	1.00	-	-	-	-	1.00	1.00	1.00	-
EXTREME EVENT III	γ_p	1.00	1.00	-	-	1.00	0.5/1.2	-	-	-	-	-	-	1.00
SERVICE I	1.00	1.00	1.00	0.30	1.00	1.00	1.0/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
SERVICE II	1.00	1.30	1.00	-	-	1.00	1.0/1.2	-	-	-	-	-	-	-
SERVICE III	1.00	1.00	1.00	-	-	1.00	1.0/1.2	γ_{TG}	γ_{SE}	-	-	-	-	-
SERVICE IV	1.00	-	1.00	0.70	-	1.00	1.0/1.2	-	1.00	-	-	-	-	-
FATIGUE	-	1.00	-	-	-	-	-	-	-	-	-	-	-	-

Permanent Loads
CR = Creep forces
DC = Dead load of structure
DD = Downdrag
DW = Dead load of overlay, utilities
EH = Horizontal earth pressure
EV = Earth fill dead load
ES = Earth surcharge load
EL = Locked in forces
PS = Secondary forces from P/T
SH = Shrinkage forces

Transient Loads
BR = Vehicular braking force
CE = Vehicular centrifugal force
CT = Vehicular collision force
DR = Derailment loading
EQ = Earthquake load
FR = Friction load
IC = Ice load
IM = Vehicular dynamic load
LL = LRV live load
LS = Live load surcharge
PL = Pedestrian live load

RB = Rail break loading
SE = Force effect due to settlement
TG = Force effect due to temperature gradient
TU = Force effect due to uniform temperature
WA = Water load, stream pressure
WS = Wind load on structure
WL = Wind on live load

Load Combination Notes
STRENGTH I - Normal vehicular use, without wind
STRENGTH II - Load combination not used at this time
STRENGTH III - Wind velocity exceeding 55 mph
STRENGTH IV - High dead load to live load ratio
STRENGTH V - Normal vehicular use with 55 mph wind
EXTREME EVENT I - Earthquake loading
EXTREME EVENT II - Ice loading, or vehicular collision loading, or derailment loading
EXTREME EVENT III - Rail break
SERVICE I - Normal operation, 55 mph wind, all other loads at nominal value
SERVICE II - Loading for yielding of steel structures and slip of slip-critical connections
SERVICE III - Loading for longitudinal tension in prestressed concrete superstructures
SERVICE IV - Loading only for tension in prestressed concrete columns
FATIGUE - Fatigue and fracture loading

Load Factor Notes
γ_p - Reference AASHTO Table 3.4.1-2 for load factors for permanent loads and Table 3.4.1-3 for load factors for permanent loads due to deformations.
γ_{EQ} - Use 0.85
γ_{TG} - 1.0 when live load is not considered and 0.50 when live load is considered, for service limit states only unless otherwise required as project specific.
γ_{SE} - Use both 1.0 and 0.0 for envelope load effects.
Load factor of TU shall be applied in accordance with AASHTO Section 3.4.1

Loading Application Notes
(1) For the Extreme Event II Load Combination, vertical impact shall be applied per Light Rail Design Criteria Section 6.4.4. Normal live load impact as described in Section 6.4.3 shall not be applied simultaneously with this loading.
(2) Rail structure interaction loading for direct fixation track shall be included in the uniform temperature loading, TU.

SECTION 15
CIVIL WORKS

Introduction

This Section incorporates basic requirements, including reference standards, for grading, road and pavement work, drainage, surveying, right-of-way, real estate acquisition and description, and fencing. It is intended to apply to the variety of operating and construction environments that would be part of a HRT light rail line, focusing on street-running portions and parking areas.

15.1 GENERAL

This Section establishes the basic civil engineering guidelines to be used in design of the LRT system. It includes criteria for the design of grading, roads/paving, grade crossings, fencing, drainage, surveying/mapping, and for determining the required right-of-way.

Storm water drainage shall meet the requirements of specifications and design guidelines of Federal, Virginia, or local agency having jurisdiction for the drainage area under consideration. This may include provisions required by the Army Corps of Engineers for navigable waterways.

15.2 GRADING

All unpaved areas of proposed construction shall be cleared and grubbed, including the removal of unsuitable backfill material and root mat. Areas disturbed by construction shall be protected by an approved erosion and sediment control system. Methods of erosion control to be considered include seeding and mulching, sodding, application of geotextile fabrics to stabilize areas, and the application of a coarse rock blanket. Local jurisdictional codes generally provide guidance for acceptable methods of erosion and sediment control.

Cut and fill slopes along the LRT shall be two horizontal to one vertical (2:1), or as otherwise determined by geotechnical analysis. Along roadway areas, cut slopes shall generally be 2:1 maximum or flatter as required for sight distance around curved alignments. Roadway fill slopes shall be 2:1 maximum, but shall be flattened to 4:1 where possible to minimize the need for guide rail. Typical grading sections for the LRT are shown in Section 4, including transition sections from direct fixation and embedded track structures.

Refer to the standards in the section below for further direction in grading design. To the greatest extent possible, local standards shall be utilized in sitework design and specifications.

15.3 ROADS AND PAVING

15.3.1 General

Roadway design in public right-of-way shall be in conformance with the specifications and design guidelines of the state, municipal, county, or local agency having jurisdiction. Pavement structural cross section shall be designed for a 20-year service life to support the anticipated traffic use.

Road and parking surfaces shall be either Portland cement concrete or bituminous concrete, as required by the Owner. The guidelines in this section are applicable to the design of alterations of existing streets, new streets and park-and-ride lots and access roads.

15.3.2 Applicable Standards

Roadway design in public rights-of-way shall be in conformance with the specifications and design guidelines of the local agency having jurisdiction. For those cases where the local jurisdictions have no design guidelines, the Virginia Department of Transportation (VDOT) *Road Design Manual* and/or the *Policy on Geometric Design of Highways and Streets* by the American Association of State Highway and Transportation Officials (AASHTO) shall be used.

All roadway sections of public streets shall conform to the current specifications and standards of the involved local jurisdictions. In a case where the local jurisdictions have no codes or standards, the VDOT *Road Design Manual* and/or the AASHTO *Policy on Geometric Design* shall be followed.

A complete listing of civil design reference materials is not included in this document. However, for example, the current versions of the following VDOT and regional documents shall be incorporated into the project design wherever possible, unless superseded by local jurisdictional requirements:

- VDOT Road Design Manual
- VDOT Road & Bridge Standards
- VDOT Traffic Engineering Manual
- VDOT Road and Bridge Specifications
- VDOT Pavement Design Guide
- VDOT Virginia Supplement to the Manual on Uniform Traffic Control Devices
- VDOT BMP Design Manual of Practice
- VDOT Drainage Manual
- Virginia Work Area Protection Manual (WAPM)
- Hampton Roads Planning District Commission (HRPDC) Regional Construction Standards (with local modifications)

Local jurisdictional standards always preclude state (VDOT) or regional (HRPDC) standards on local roadways. For example, the City of Norfolk standard curb and gutter requires an aggregate subbase below the curb; VDOT standards do not. Using a state standard in this case for design would require a change order during construction.

15.3.3 Roadway Geometrics

Design of roadways and parking lots shall be in accordance with guidelines defined in the VDOT *Road Design Manual* and *A Policy on Geometric Design of Highways and Streets*, the current version of the American Association of State Highway and Transportation Officials (AASHTO).

AASHTO design documents provide minimal guidance for the design of parking lots. Local jurisdictional code and documents such as the City of Norfolk Roadway Access Manual or HRPDC standard details shall be used in lieu of general guidelines such as the *Architectural Graphics Standards*.

New facilities and replacement of streets and facilities to be owned and/or maintained by agencies other than HRT shall be designed or replaced in accordance with the current standards of the agency having jurisdiction.

15.3.3.1 Traffic Lane Widths

The following criteria indicate the desirable traffic lane widths. In cases of a lateral constraint, a width reduction may be necessary:

- Through Traffic Lanes 12’-0”
- One Lane with Curbs 13’-0”
- Right and Left Turn Lanes 12’-0”
- Curb Lane with Parking 20’-0”
- Parking Lane 8’-0” minimum
- Right Shoulder 10’-0”

Absolute minimum through traffic lane width is 10’-6”. The intent of the criteria above is not to supersede local requirements, but to provide some clearance leeway for conditions such as vehicle operation immediately adjacent to an LRT track, where additional lane width is beneficial to both traffic and LRT operations. If local jurisdictional requirements exceed the desired traffic lane widths stated above, jurisdictional requirements shall supersede.

15.3.3.2 Number of Traffic Lanes

The number of traffic lanes and type of lanes (through or turning lanes) shall be determined in consultation with the affected jurisdictions, generally based on a traffic analysis which considers projected traffic volumes, transit rail vehicle intersection crossings, critical traffic movements, and geometric configurations. Figures 15-1 to 15-4

show schematic typical sections of various in-street transit lane configurations. Section 4 includes details of embedded track.

15.3.3.3 Parking Lanes

Parking locations shall be determined in consultation with the affected jurisdictions based on traffic analysis, safety considerations and demand for on-street parking. Twenty-four hour parking prohibition shall be considered at those locations near intersections and at LRT stations, where the roadway width is not adequate to provide the necessary number of through lanes. Peak hour parking prohibition shall be considered at those locations where traffic analysis shows that the capacity of the traveled way without the parking lane provides at least a Level of Service D.

15.3.3.4 Normal Cross Slopes

The following criteria indicate the desirable cross slopes to be provided in non-superelevated pavement areas. New roadways shall be superelevated in accordance with jurisdictional agency requirements wherever practical.

- Portland Cement Concrete Pavement Roads 2.0%
- Bituminous Concrete Paved Roads 2.0%
- Stone Aggregate or Gravel Surface 2.0%
- Paved Parking Areas 0.5% min., 4.0% max.
- Shoulders 4.0%

15.3.3.5 Clearances

Where possible, the design of public streets adjacent to LRT facilities shall not preclude the construction of LRT stations. Section 3 covers general clearance requirements for facility design.

The minimum vertical clearance above the traffic lanes and shoulders on all roadways shall be 14’-6”, except where a greater clearance is required by the agency having jurisdiction. The clearance shall apply over the entire vehicle roadway width including any contiguous auxiliary (turning) lanes and shoulders.

15.3.4 Curbs, Wheelchair Ramps, and Curb Cuts

15.3.4.1 Curbs

Concrete curbs shall be installed along all new, widened or reconstructed streets or access roads to be owned or maintained by the LRT or the applicable jurisdictions. Curbs shall be installed along reconstructed or widened roadways owned by other state agencies in accordance with their respective design standards. Concrete curb shall also

be installed around the perimeter and islands of new park-and-ride lots constructed at LRT stations.

Curbs, other than those used for station platforms, shall meet the clearance conditions specified in Section 3 and shall be no less than 6'-6" from the track centerline as measured to the curb face. Clearances of less than 6'-6" are prohibited without specific written approval from HRT.

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Note that use of curbs and curb/gutter installations generally require closed drainage systems as per local design codes. Concentrated stormwater runoff at the end of a curb run without drainage inlets are prohibited in almost all cases.

15.3.4.2 Wheelchair Ramps

Wheelchair ramps with corresponding curb cut ramps shall be provided in accordance with the following:

- All existing ramps shall be replaced or restored.
- New ramps shall be installed at intersections where sidewalk exists and the curb returns need to be modified as part of this project. It is not necessary to provide ramps and curb cuts where no sidewalk exists.
- Ramps and curb cuts shall be installed at intersections or mid-block locations, where new curb and sidewalk will be constructed, particularly in public spaces.

The Design Engineer shall obtain from the local jurisdiction or proper authority the locations of curb cuts.

The design of curb cuts and ramps shall be in strict accordance with the applicable provisions of the *U.S. Department of Transportation's Transportation (USDOT) for Individuals with Disabilities: Final Rule*. This shall include the provisions for tactile warning strip installation.

15.3.4.3 Curb Cuts

The design and location of curb cuts and ramps shall be in accordance with the applicable provisions of the USDOT's *Standards for Accessible Transportation Facilities* to comply with the Americans with Disabilities Act (ADA), and the local governing jurisdiction.

15.3.5 Sidewalks

Sidewalks shall comply with the standards of the applicable jurisdiction. At an absolute minimum, all sidewalks must have at least 4.0' clear width, but most jurisdictions require at least a 6.0' width. Cross slopes on sidewalks shall be adequate for drainage and shall not exceed two percent. Existing sidewalks impacted by the project will be repaired or replaced in kind where practical. New sidewalks shall only be provided upon request of the agency having jurisdictional responsibility. The paid limits of new sidewalk

construction in Federally funded projects are subject to the applicable funding agreements for the particular project. Sidewalks shall meet all ADA requirements.

15.3.6 Driveways

Driveway pavement types and minimum widths shall be as per standards of the applicable jurisdiction. In general, all existing driveways impacted by the project shall be replaced in kind, where practical.

Driveway closings required to facilitate the LRT operations or construction must be approved by the local agency having jurisdiction.

15.3.7 Bus Loading Zones

Bus loading zone designs in order of preference are parallel, saw tooth, and recessed in relation to the curb. The locations for bus loading zones shall be determined in coordination with HRT requirements and any local jurisdictional requirements. Bus stops are covered in Section 27. In general, AASHTO requirements govern, as modified in Section 27.

15.3.8 Paving

All pavements in public streets shall be in conformance with the current specifications and practices of the involved local jurisdictions. In a case where the local jurisdictions have no codes or standards, the VDOT *Road Design Manual* and VDOT *Pavement Design Guide* shall be followed.

No street, sidewalk, or alley widening shall be included, unless required by new construction, or by agreement with the jurisdiction involved.

Restored or widened pavements shall be of similar materials existing prior to transit construction, except that if an existing street is found to be based on obsolete paving materials, such as stone pavers, replacements shall not be in kind, but current specifications and practices shall control.

New pavements shall be of materials conforming to the latest standards of the agency having jurisdiction and maintenance responsibility. For coordination with track construction, typical embedded (paved) track sections are shown in Section 4.

15.3.9 Traffic Maintenance and Protection During Construction

The design drawings shall be in accordance with the *Manual on Uniform Traffic Control Devices* (MUTCD), the *Virginia Work Area Protection Manual*, and any supplements or other requirements of the applicable jurisdiction and shall include traffic staging and detour plans submitted to and approved by local agencies.

Traffic maintenance protection is generally covered by the provisions of the Work Area Protection Manual (WAPM).

The maintenance and protection of both vehicular and pedestrian traffic must be addressed on the plans. Traffic control requirements for permanent installations are in Section 26.

15.4 DRAINAGE

15.4.1 General

The design of drainage systems using the criteria contained herein is intended to protect the LRT system and facilities from storm-runoff damage, and to protect the LRT owner/operator from any liability for damage to property.

The design of LRT drainage facilities shall be in accordance with the manuals, standards, and guidelines of the appropriate state or local jurisdiction.

Drainage facilities belonging to other jurisdictions, which need to be relocated or modified because of LRT construction, and which do not either cross or run parallel to the LRT system facilities or track bed, shall conform to the design criteria and standards of that jurisdiction. All required relocations of existing drainage facilities shall be "replacement-in-kind" or of an "equal construction". Costs associated with any betterments of this type shall be negotiated within project cost agreements.

The goal in the design of transit system drainage is to protect the rail system track/guideway and facilities from stormwater runoff damage, and to protect HRT from liability for damage to property from resulting stormwater runoff, either passing through or caused by HRT construction, while maintaining consistency with the requirements of the Clean Water Act.

The objective of the proposed stormwater management facilities is to prevent adverse impacts to existing hydraulic conditions due to the construction of the LRT facilities. The proposed stormwater management (SWM) facilities are not designed to correct existing substandard conditions, including inadequate downstream facilities. The SWM plan shall maintain pre-developed flows or discharge to an adequate receiving facility.

Any casing pipes must meet AREMA Class 1 railroad requirements for loading. All other drainage facilities shall be in accordance with local jurisdictional codes/standards and the requirements of the Virginia Department of Transportation (VDOT). The LRT vehicle loading conditions do not exceed previous freight train traffic on the existing track.

Designs of drainage facilities belonging to other agencies which are relocated or modified because of HRT construction and which do not cross or parallel rail system trackbeds or facilities, shall conform to the design criteria and standards of the agency or jurisdiction involved, or as approved by HRT if no standard or code is applicable.

15.4.2 Submittals

Drainage designs of facilities requiring review and approval of jurisdictional agencies shall be submitted in accordance with the procedures established by the respective agency. Agencies having jurisdiction may include state agencies, municipalities and counties. All construction, relocation and restoration of storm sewers and drainage facilities and maintenance of existing facilities during construction shall conform to the design standards of those agencies.

In general, HRT and local jurisdictions require a Drainage Manual submittal in all areas to document drainage impacted by the project for both current liability and future construction impact purposes.

15.4.3 LRT Drainage

LRT drainage criteria apply only to design of drainage facilities under the jurisdiction of the LRT. Drainage of other facilities and connections to other drainage systems shall be designed in accordance with the criteria of the respective agency having jurisdiction. Where no local criteria governs, the VDOT Drainage Manual shall be used as the basis of design.

Storm water runoff shall be conveyed to suitable outfall points by gravity flow. Where LRT storm drain sections are below points where gravity outfalls can be provided, pumping stations will be required.

No sanitary sewer discharge shall be permitted to enter the LRT drainage system.

15.4.4 Hydrology and Hydraulics

15.4.4.1 Procedures

The general procedures below shall be used in preparing hydrologic computations:

Pertinent standards include the following:

- VDOT Drainage Manual
- VDOT Road and Bridge Standards
- Department of Environmental Quality (DEQ) Virginia Stormwater Management Handbook
- Local Design Manuals (e.g., the City of Norfolk Stormwater Design Criteria Manual)
- Local Standards and Details (e.g., the City of Norfolk Standard Details)
- DEQ Virginia Erosion and Sediment Control Handbook

In general, the Rational Method shall be used for determining peak discharges for stormwater facilities draining 20 acres or less.

Alternate hydrologic methods shall be evaluated for areas draining larger than 20 acres, including the applicable design storm frequency as defined below using the U.S. Soil Conservation Service TR-55 or TR-20 methods for peak discharge. New stormwater facilities typically require water storage or detention considerations to accommodate either stormwater quantity and/or quality standards.

The hydraulic capacity of open channels, swales, gutters, storm sewer pipe systems, and culverts shall be determined using the Manning equation. Where reference documents are silent on a drainage condition, Figures 15-6 includes typical roughness coefficient values for hydraulic computations. Chapter 6 of the VDOT Drainage Manual also lists rational method runoff coefficients. The most stringent coefficient from either Figure 15-6 of the HRT Criteria Manual or the VDOT Drainage Manual shall be used, unless acceptable to the approving agency or jurisdiction.

The water surface profile in streams shall be determined based on the added runoff due to the LRT construction. A perennial stream is defined by continuous flow in the existing channel. An intermittent stream is defined by a natural channel with a minimum contributing drainage area of 50 acres or less. The water surface profile and flow velocities will be determined using current applicable models.

Drainage structures and specifications are to conform to local or VDOT standards and specifications current at the authorization to proceed for the design contract.

Provisions for channel and flood protection, as outlined in the *DEQ Virginia Stormwater Management Handbook* shall also be accounted for.

15.4.4.2 Storm Frequency

LRT facilities shall be designed to accommodate the storm water discharge based on the following storm frequencies:

- All culverts and drainage facilities crossing the LRT — 10 year
- Track roadbed (to top of subballast) — 10 year

The above frequencies shall be modified if the local jurisdictional agency has more conservative standards. All other design frequencies for storm drain conduits and inlet design shall be in accordance with the *VDOT Drainage Manual*, or meet requirements of the local jurisdiction and/or reviewing agency.

Where impoundments are created behind rail embankment whose overflow elevation from crest to toe of stream exceeds ten feet in height and impounds more than ten acre feet of storage, the embankment will be designed in accordance with the U.S. Army Corps of Engineers design requirements for small dams. These types of embankment conditions shall be avoided wherever possible.

Wherever feasible, the top of rail elevation shall be a minimum of one foot above the 100 year flood elevation.

15.4.4.3 Stormwater Quality

The computed postdevelopment pollutant loading levels shall not exceed the computed predevelopment pollutant loading levels in accordance with the methodology in the *DEQ Virginia Stormwater Management Handbook*, or comparable local jurisdictional document if more restrictive. Water quality calculations shall be performed according to the Runoff Reduction Method as outlined in the *DEQ Virginia Stormwater Management Handbook.*

The roadway track downtown shall not count as redevelopment. Station platform areas will not count as additional impervious area.

Exemptions to stormwater quality shall be in accordance with local jurisdictional codes and state regulations.

Prior developed land uses can be considered as the baseline impervious condition. This is useful if an area has been cleared. Historical aerial photographs or documentation must be provided.

15.4.5 Selection of Drainage Structures

LRT maintained drainage structures shall be selected from the standards of the appropriate jurisdiction. For those cases where the local jurisdictions have no drainage structure design standards, the *VDOT Road and Bridge* Standards shall be used. When conditions occur for which the standard drainage structures are not suitable, the design shall be required to modify these structures or to design special structures, which satisfy required design conditions.

15.4.6 Pipe Materials

All underground storm drains maintained by HRT shall be reinforced concrete pipe, minimum class V, Wall B, with gasketed joints or ductile iron pipe, minimum class 52 conforming to AWWA C151 except for underdrains. All pipe materials designed for other facilities shall conform to the requirements of the local jurisdictional agency

Underdrain pipe shall consist of perforated concrete or plastic pipe, schedule 40.

A minimum 3’-0” height between the top of track and top of pipe is desirable, except for underdrains.

15.4.7 Location of Drains

In the track sections, manholes or drainage inlets shall be provided at maximum spacing for the selected type based on pipe cleaning requirements, access hole spacing maximum distances identified in the VDOT *Drainage Manual,* or the restricting water depth encroachment from the tracks, whichever is less. Drainage structures shallalso be provided at changes in pipe slope, alignment and size, and at multiple pipe intersections.

Underdrain cleanouts shall be provided at maximum 800' centers along all LRT drainage lines. A cleanout is required for each 90 degree bend and for each two 45 degree bends. Minimum pipe size is 8" diameter.

15.4.8 Parking Lots

Parking lots shall be designed so that storm water is removed by overland flow, to a gutter or curb and gutter, then to an inlet where the water will enter either a closed drainage system or an open ditch. Overland flow shall be on at least a 1.0% grade wherever possible, but no less than 0.5%. The maximum permissible spread for gutter flow shall be 12.0', or one half the travel lane width.

The post-development peak runoff discharge rate from 2-year and 10-year frequency storms shall not exceed the respective predevelopment discharge rates for the 2-year and 10-year frequency storms. If this does not occur, and the City approves, the discharge must discharge to an adequate receiving channel as defined by Minimum Standard #19 of the *DEQ Virginia Erosion and Sediment Control Handbook* and the *DEQ Virginia Stormwater Management Handbook*.

15.4.9 Stormwater Management and Erosion & Sediment Control

15.4.9.1 Stormwater Management

Stormwater management design shall be in accordance with the guidelines of the *DEQ Virginia Stormwater Management Handbook* or the appropriate jurisdiction, whichever is most stringent.

15.4.9.2 Erosion & Sediment Control

Erosion and sediment control shall be in accordance with the *DEQ Virginia Erosion and Sediment Control Handbook* and/or standards and specifications of the appropriate jurisdiction, whichever is most stringent.

15.5 SURVEYING AND MAPPING

15.5.1 Survey Control System

15.5.1.1 Horizontal Control

All horizontal controls shall be based on the Virginia State Plane Coordinate System of 1983, High Accuracy Reference Network, US Survey Feet (NAD/83, HARN), Zone 4502, as defined by the National Geodetic Survey. Where applicable and/or where required, local jurisdictional coordinate systems shall prevail in locations that are not contiguous to existing light rail operations. If contiguous to existing light rail operations, any new work shall be tied to existing horizontal control utilized for past projects.

Conversions from legacy metric coordinates shall be made to all monuments and references before survey calculations are performed utilizing the above referenced information

The precision of any Secondary horizontal ground control surveys shall be, as a minimum, 1:50,000.

All subsequent horizontal surveys shall, as a minimum, have a precision of 1:25,000.

15.5.1.2 Vertical Control

Vertical controls for projects shall be based on the National Geodetic Vertical Datum, 1988 General Adjustment (NAVD88). The precision of the vertical ground control and of supporting vertical ground surveys shall be at least Second Order, Class I, as defined by the Federal Geodetic Control Committee and published under the title "Classifications, Standards of Accuracy and General Specification of Geodetic Control Stations," authored by the National Geodetic Survey in February 1974. Where applicable and/or required, local jurisdictional NAVD 88 vertical datum shall prevail in locations that are not contiguous to existing light rail operations. If contiguous to existing light rail operations, any new work shall be tied to existing horizontal control utilized for past projects.

15.5.2 Monumentation

Permanent monuments shall be placed to define the LRT right-of-way, track curve elements, and to serve as horizontal and vertical control points for future surveys and monitoring.

Monuments for right-of-way survey control shall consist of brass discs permanently anchored in concrete. Survey control for track stationing shall consist of non-corrosive metal (brass, stainless steel) anchors in concrete.

15.5.2.1 Right-of-Way

Monuments shall be placed at all tangent line breaks and points of curvature and tangency of curves in the right-of-way line.

15.5.2.2 Track

Track alignment is covered in Section 3.

Monuments shall be placed at points as required along each mainline track to permit re-establishment of track stationing and associated curve points on the alignment. Based on existing light rail construction, the most practical method of establishing these track survey controls in ballasted and embedded trackwork is a post track installation survey and installation of referencing monuments on catenary pole foundations. For direct fixation track on structures, these monuments shall be established at appropriate fixed joint pier locations.

15.5.2.3 Survey Control

Survey control monuments domed brass disks shall be placed within the LRT right-of-way along the mainline track and yard area such that any two monuments would be in clear sight from one another and would not be affected or disturbed by track operations or future construction. Each monument shall be stamped "LRT" with the specific control station designation and date. The maximum distance between any monuments shall be 1,000'.

15.5.2.4 Survey Documentation

Survey documentation to support the design shall be provided to HRT. Depending on the type of survey conducted, the designer or surveyor shall produce copies of all field notes, electronic data (including coordinate output), metafiles, survey plots/mapping, and all other applicable survey information included in the development of the sitework engineering.

As HRT is not the Surveyor of Record for any given project, only copies of the surveying documents are necessary for HRT use. Where proprietary software is utilized to gather survey data, documentation for HRT may include text or portable document format (.pdf) file delivery.

The design plans shall include drawings showing all vertical and horizontal control. All survey control plans, as well as applicable survey documents, shall be sealed by a Professional Surveyor currently licensed in the Commonwealth of Virginia.

15.5.2.5 Boundary Surveys

Where property acquisition is required for project work, either for full parcel takes, partial parcel takes, or establishment of new easements outside of the HRT right-of-way, a boundary survey may be required. Where property acquisitions or adjustments involve adjacent private property owners, a boundary survey shall be required.

Boundary surveys, plats, and plans shall be sealed by a Professional Land Surveyor (P.L.S.) currently licensed in the Commonwealth of Virginia.

The boundary survey shall be performed in conformance with requirements set by the Commonwealth of Virginia. These requirements include a physical metes and bounds property survey, property plats for recordation, and a boundary survey plan to be utilized for property acquisition.

Preliminary boundary survey plans based only on the reconciliation of existing property records shall be clearly marked as a Draft Survey and not sealed. The formal sealed boundary survey shall be based on physical field property surveys conducted by a qualified licensed P.L.S.

Boundary surveys shall include reconciliation adjustment of all adjacent property owner records in accordance with current property survey law and practice.

15.5.2.6 Topographic Surveys

Most engineering design work requires the use of information based on topographic surveys. In general, this data is acquired from the following sources, listed in increasing order of precision and reliability:

- Generally available public mapping sources (USGS maps, Google Earth)
- Private topographic mapping sources (Vargis, utility location plans)
- Existing topographic mapping, metafiles, or surface/topographic electronic files
- New aerial field survey and mapping
- New ground field survey and mapping
- Underground utility and structure location surveys

A combination of survey sources (e.g., aerial and ground survey) is typically utilized for engineering project work.

The level of topographic survey precision required for any individual project varies widely in accordance with the level and type of design being performed. It is not possible for this Design Criteria to cover specific survey requirements for specific cases.

It shall be the responsibility of the Engineer of Record to determine adequacy of topographic survey requirements for a particular project or site design. This includes the determination of requirements for underground utility and structure location. HRT shall always prefer the use of new field survey information for design; if this is not possible or practical, the Engineer shall notify HRT of the use of existing topographic survey information and justification for using such information.

It shall be noted that public utility location services such as Miss Utility and One Call are for imminent construction work only. These firms are not available for use in design work. Moreover, the Engineer shall not use exculpatory drawing or specification language passing responsibility for utility location work to the construction contractor.

Design deficiencies, including inaccurate construction quantity estimates, caused by inadequate topographic survey information or failure to verify conditions in the field, shall be the responsibility of the Engineer to the same extent as if the errors were caused by deficiencies in the design itself.

15.5.2.7 Construction Surveys

Construction projects include both construction layout surveys and as-built surveys. While these tasks are generally not associated with the design engineer, architect, or surveyor, there are some interfacing elements associated with this work.

The Engineer shall include provisions and requirements for construction and as-built surveys in the Construction Contract Specifications. The provision of these surveys is

not an implied requirement of workmanship or good practice provisions of the Construction Contract; they must be specified.

The design shall verify, as part of its quality control and constructability reviews, that the Construction Contractor shall be able to perform its construction survey work without undue inconvenience or obstruction. This verification shall include the provision of adequate and accessible survey control monuments. The design plans shall include sufficient horizontal location and elevation data to clearly convey this information to the Contractor, the construction surveyor, and field inspection personnel.

In some cases, the Engineer shall provide the Construction Contractor with electronic design files for purposes of performing construction surveys. The nature of such files, including identification of the design software used to prepare plans and data, shall be included in the Construction Specifications.

The Surveyor shall provide all necessary information to the Construction Contractor to permit adequate preparation of construction surveys. This includes all survey control, topographic data, and any applicable survey information that is not provided by the Engineer in the conveyance of design files. Information to be made available to the Construction Contractor shall be included in the Construction Specifications.

The Surveyor shall retain adequate information and files to replicate its work in the event of a survey-based construction dispute.

15.6 RIGHT-OF-WAY

15.6.1 General

The right-of-way (ROW) is defined as the composite total requirement of all interests and uses of real property needed to construct, maintain, protect, and operate the LRT transit system. Some ROW requirements are temporary and reversionary in nature, while other requirements are permanent as dictated by operating needs. The intent is to acquire and maintain the minimum ROW required consistent with the requirements of the system. ROW plans are prepared to serve as a basis for acquisition of property and all interests and uses required shall be shown on these ROW plans together with the detailed property dispositions. The total right-of-way envelope is influenced by the topography, drainage, ditches, retaining walls, service roads, utilities, and an adequate area for construction.

Light Rail Transit right-of-way requirements vary according to guideway configuration, which may be at grade, on aerial structure, or in an underground structure. Rights-of-way shall be further classified as exclusive, separate or shared. Exclusive rail transit rights-of-way prohibit entry or crossing by other vehicles or pedestrians and may include tunnels, elevated structures or at-grade alignments depressed or elevated at street crossings. Separate rail transit rights-of-way are those physically protected by curbs or barriers that prevent other vehicles from entering the right-of-way but which allow at-grade crossings.

Separate rail transit rights-of-ways may utilize separation measures such as curbs in existing pavement, curbs with raised track area, vegetation strips or concrete barriers.

Shared right-of-way represents in-street operation in which track areas are also used by other traffic. Operating agreements cover HRT property rights in these areas.

Using field surveys, record information and computations, the design shall provide individual Plats of Survey. The final plats shall comply with the recording requirements of the appropriate jurisdictions.

The LRT right-of-way shall be described by metes and bounds. The right-of-way shall include a survey tie line across the right-of-way in order to create a mathematically closed figure and to tie each side together. The right-of-way description shall include curve data containing the radius, length, delta, tangent, chord, and chord bearing. Two coordinates per plat sheet shall be shown, ensuring that the pertinent portions of all tracts, subdivisions, US lands, parcels, and other areas affected by the right-of-way shall be similarly described and shown on the plats.

In general, property acquisition and easements (temporary and permanent) shall be coordinated with the local governing jurisdiction, as HRT has limited resources and no authority for these functions. For example, HRT has no power of eminent domain in its charter as an operating agency. Also both right-of-way and easements have a cost associated with them that is typically reflected in various project cost agreements.

As with utility relocations, reliance on franchise agreements or assumed use of public right-of-way to adversely impact adjacent property without coordination, alternative access, or compensation represents poor overall management of the project, and will not be relied upon as an alternative to acceptable design practices.

Drainage design shall be in accordance with the standards and practices of the agency in whose jurisdiction each project or section of a project falls. In cases where the local jurisdictions have no codes or standards, *VDOT Road and Bridge Standards* shall be followed. The drainage design criteria provided herein shall be considered a minimum standard for drainage facility reconstruction.

15.10.2 Drainage Facilities

Unless otherwise provided, drainage channels, culverts, and storm sewers shall be designed in accordance with the procedures specified by the *VDOT Drainage Manual* or comparable document.

Drainage requirements and calculations for reconstruction shall be the same as new construction.

For reconstruction, minimum pipe sizes shall meet those listed in the *VDOT Drainage Manual* and the following:

- 15” for culverts under trackways
- 8” for slope drains
- 8” for underdrains

Where existing pipes are smaller than these minimum diameters, the new construction shall not be considered a betterment.

Manholes or storm drain inlets shall be provided at all changes in direction. Access hole spacing requirements shall meet maximum distances identified in the VDOT *Drainage Manual*.

At least a 3’-0” clearance is desirable from the top of track subgrade to the top of all track drainage pipes passing beneath the trackbed, unless otherwise approved by HRT.

Underdrains shall consist only of perforated concrete or perforated plastic pipe at least 8” in diameter. The perforated pipe shall be surrounded by a minimum of 4” of VDOT #57 or #8 aggregate stone material, and placed a minimum of 12” below subgrade. The underdrain system shall also be wrapped with a geotextile drainage filter fabric (minimum weight 4 oz/sq yd) by placing the fabric between the gravel drain material and the surrounding soil.

Necessary replacements of existing storm sewers and appurtenances shall provide services equivalent to existing facilities.

Services to adjoining properties shall be maintained by supporting in place, by providing alternative temporary facilities, or by diverting to other points.

See Section 24 for information regarding corrosion protection of drainage facilities.

Design of replacement of storm sewers shall be based on the Rational Method for computing runoff:

(Eq. 15.10.2-1) $Q = C\ I\ A$

Q = Capacity, not less than that of line replaced (cfs)
C = Coefficient of runoff as per Figure 15-6a
A = Area (acres)
I = Intensity – duration rate (in/hr)

The velocity of flow in culverts shall be no less than 2.5 feet per second as determined by Manning's Equation:

(Eq. 15.10.2-2) $$V = \frac{1.486}{n}\ R^{2/3}\ S^{1/2}$$

V = Velocity of flow (ft per sec)
R = Hydraulic radius (ft)
S = Slope of total head line (ft/ft) (Min. 0.5%)
n = Manning roughness coefficient

Figure 15-6 gives values of "n" for various pipe materials where no other guidance is available.

15.12 REFERENCES

1. Hampton Roads Transit, “Manual of Design Criteria”, Norfolk LRT Project, Draft, HRT, Dec. 2004.
2. See Section 15.3.2, Applicable Standards

Figures

Figure 15-6a: Runoff Coefficients

Figure 15-6b: Manning Roughness Coefficients

RUNOFF COEFFICIENTS

CONDITION	COEFFICIENT
Business:	
Downtown areas	0.70 to 0.95
Neighborhood areas	0.50 to 0.70
Residential:	
Single-family areas	0.30 to 0.50
Multi-units, detached	0.40 to 0.60
Multi-units, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment dwelling areas	0.50 to 0.70
Industrial:	
Light areas	0.50 to 0.80
Heavy areas	0.60 to 0.90
Parks, cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Rail transit, yard areas	0.20 to 0.40
Unimproved areas	0.10 to 0.30
Streets:	
Asphaltic	0.70 to 0.95
Concrete	0.80 to 0.95
Brick	0.70 to 0.85

NOTE: IF STATE (VDOT) OR LOCAL STANDARDS ARE REQUIRED BY THE DESIGN APPROVAL AUTHORITY, THEN MANNING EQUATION ROUGHNESS COEFFICIENT AS PER THE VDOT DRAINAGE MANUAL LOCAL STANDARDS SHALL BE USED.

MANNING ROUGHNESS COEFFICIENTS

	Manning's n Range
I. Closed conduits	
A. Concrete pipe	0.011-0.013
B. Corrugated-metal pipe or pipe arch:	
1. 2-⅔ by ½ in. corrugations (riveted pipe)	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021-0.018
(2) Flow 0.8 depth	0.021-0.016
(3) Flow 0.6 depth	0.019-0.013
2. 6 by 2 in. corrugation (field bolted)	0.03
C. Cast iron pipe	0.013
D. Steel pipe	0.009-0.011
II. Gutters and tunnel inverts	
A. Concrete gutter, troweled finished	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.016
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accoumulate, increase above values of n by 0.002	

NOTE: IF STATE (VDOT) OR LOCAL STANDARDS ARE REQUIRED BY THE DESIGN APPROVAL AUTHORITY, THEN MANNING EQUATION ROUGHNESS COEFFICIENT AS PER THE VDOT DRAINAGE MANUAL LOCAL STANDARDS SHALL BE USED.

SECTION 18
UTILITIES

Introduction

This Section covers new, relocated, and abandoned utilities impacted by Hampton Roads Transit (HRT) construction, and applies to utilities external to system construction only. Internal mechanical and electrical disciplines are covered in separate sections of the Criteria.

In light rail embedded track sections, a major portion of preparatory work for construction consists of utility relocation to avoid future interference with significant utilities under a paved track structure.

18.1 SCOPE

This Section shall govern all new utility construction outside of buildings, and the support, maintenance, relocation, and restoration of utilities affected by HRT construction. Attention shall be given to the needs of the system, the requirements and obligations of the public and private utility owners, and the utility service needs of properties adjacent to the system.

Two external HRT documents shall be utilized in conjunction with the work described in this Section.

For work within HRT right-of-way, particularly within operating track locations, the following document shall govern design and construction: HRT Standard Operating Procedure No. 101.13, June 2009, “Work Performed on the Tide Right of Way”.

For work adjacent to HRT right-of-way, particularly adjacent to operating track locations, the following document shall govern design and construction: Hampton Roads Transit, Adjacent Construction Manual (Draft), latest version. This document defines the zone of influence inside of which proposed construction shall structurally impact the Tide light rail operation.

18.2 PRE-CONSTRUCTION

18.2.1 Objective

A primary objective of design activities is to ensure that pertinent utility information is obtained, properly incorporated into the design process and shown on construction plans. Information to be acquired for utilities in the LRT corridor include owner, type, size, material, location, and existing right-of-way (R/W) or easements for all existing and proposed utility facilities affected by LRT construction.

Interruptions to existing utility service shall be avoided; for temporary relocations, service shall be restored immediately upon completion of work.

Replacements for existing utilities shall be designed to provide service essentially equal to that offered by the existing installations. Utility owners must bring any proposal for betterment to the attention of the Designer and HRT at an early stage of the design. Betterments must be demonstrated to be consistent with current utility standard practice or a replacement of obsolete materials. No betterments shall be included unless specifically approved by HRT prior to final design.

As the design is developed, affected utility companies shall be furnished with preliminary plans and specifications and requested to verify their existing facility types, sizes and locations. Each utility company or agency shall be requested to return marked-up plans or prints of owner's plan sets reflecting required utility information. The design consultant shall then prepare drawings reflecting all assembled information and the latest plan developments. Coordination between the design consultant and the utility agencies shall be a continuing activity during the design phase.

After the Utility agency owner reviews and comments upon the designer's utility relocation recommendations, the design consultant and HRT shall conduct its review and direct the coordination of utility relocations to achieve a satisfactory resolution.

A composite plan of existing utilities and one of relocated utilities shall be developed during design to ensure reasonable coordination between these facilities.

The following information shall be clearly and correctly identified on the final construction drawings:

- Utilities supported and maintained complete in place during construction and continued in service following construction.
- Utilities reconstructed, supported and maintained complete in place.
- Utilities temporarily relocated and maintained, then restored upon completion of the transit system construction.
- Utilities permanently relocated beyond the immediate limits of transit construction.
- Utilities that have been abandoned, or are to be abandoned and removed.
- Existing utility right-of-way and properties to be acquired for their relocation, if any.

Existing utility service shall not be interrupted and, if temporarily relocated, shall be restored upon completion of work.

Replacements for existing sewers or water mains shall be designed to provide service essentially equal to that offered by the existing installations.

General typical placements of new or relocated utilities in relation to the LRT tracks are shown in Figures 18-1 to 18-4.

18.2.2 Overview

The horizontal and vertical alignments, right-of-way and construction easements for the LRT system and affected roadways, and the necessary property lines adjacent to the right-of-way, shall be indicated on the final contract documents. As the design is developed, the affected utility companies shall be furnished with preliminary plans and specifications and be requested to verify their existing facility types, sizes and locations.

Drawings shall show sufficient detail to study conflicts and develop proposed utility relocations, or to prepare alternative relocation schemes to accommodate the transit project. Critical utility elevations and locations shall be determined and checked by field survey. Where existing utility locations are critical to the LRT system design, test pits or probes shall be dug at such locations as recommended by the design and approved by HRT.

Coordination between the design and the affected utility owners shall be a continuing activity during the design phase. Transit alignment changes to alleviate costly or difficult utility relocations shall be considered. The disposition of existing utilities within the right-of-way shall be indicated by labeling those to be removed, abandoned, maintained in place, or relocated in accordance with the utility standard drawings. Any additional right-of-way acquisitions shall be identified to provide the necessary information for acquiring additional right-of-way or easements.

Final engineering design for utilities shall be completed by the designer or utility owner. Design drawings prepared for utilities by others shall be reviewed and approved by the utility owners to ensure that the overall utilities systems shall be comparable to those existing before start of construction and that they shall be compatible with the LRT system. Design drawings prepared by the utility company shall be reviewed and approved by HRT. Any utility lines that are abandoned in place, as is the practice in Norfolk, shall be shown as such on the drawings.

New construction and the support, maintenance, restoration, rearrangement, and relocation of utilities shall be in conformance with the latest criteria defined in the AREMA *Manual for Railway Engineering* and the latest technical specifications and practices of the governing utilities or public agencies.

Standard specifications and standard utility drawings for the various utilities shall be incorporated into the Contract Documents as required. In the event that there are no standards, final design shall be in accordance with the current design criteria and engineering practices for the particular utility agency involved. Satisfactory completion of the work and its acceptance shall be signified through written approval by the responsible utility or owner.

18.3 GAS LINES

18.3.1 General

Permanently relocated gas lines shall be designed, installed and tested in accordance with the current standards of the Virginia Natural Gas Company (VNG) or other applicable utility owner and the following:

- *Minimum Federal Safety Standards for Gas Lines*, Title 49 Code of Federal Regulations, Part 192."
- *ASME Guide for Gas Transmission and Distribution Piping Systems* of the American Society of Mechanical Engineers' Gas Piping Standards Committee.

Construction of temporary and/or permanent gas mains and replacement of mains may be performed by VNG or by HRT's contractor (with proper approval and contractor certification by VNG). The lines to be supported and maintained in place shall be the responsibility of the construction contractor, and the work shall be performed in accordance with applicable construction contracts.

18.3.2 Procedure

The design of temporary and/or permanent gas mains to replace mains affected by construction may be performed by either the owner utility company or by the design as provided in any applicable utility relocation agreement (franchise or project specific) between the utility and HRT or jurisdictional partner. The designer shall consider and recommend the most efficient of these options for the particular project.

Pipes installed within the right-of-way shall be designed to support the dead loads imposed by earth, subbase, pavement, ballast, structures, track, and vehicular loads when the pipe is operated under a range of pressure from maximum internal to zero.

Steel carrier pipe shall be protectively coated and provided with a cathodic protection system in conformance with the corrosion control requirements of the "Minimum Federal Safety Standards for Gas Lines, Title 49 Code of Federal Regulations, Part 192, Subpart I" and the current standards of VNG. Steel pipelines, which are designed to operate at a pressure producing a hoop stress in the pipe equal to 30% Specific Minimum Yield Stress (SMYS) or greater, shall be subjected to a hydrostatic test pressure of at least 1.5 times the maximum allowable operating pressure for a period of at least eight hours.

Inspection of welding on pipelines installed within the LRT right-of-way shall be in conformity with Federal Pipe Line Safety Standards, Title 49 of the Code of Federal Regulations, Part 192, Articles 192.241 and 192.243 and in accordance with the current standards of the owner utility. Steel pipelines of 6" diameter or greater, and operating at a pressure which shall produce a hoop stress of 20% of the SMYS or greater, shall have all girth welds tested nondestructively over their entire circumference.

Testing of pipeline mains and services installed within the ROW shall be in conformity with Title 49-Part 192, Subpart-J - Test Requirements and in accordance with the current standards of VNG or other utility owner. Any other VNG requirements are also applicable and shall generally supersede the provisions of this Section.

18.4 SANITARY SEWERS

All relocations, replacement or extensions of existing sanitary sewer systems shall comply with Hampton Roads Sanitation District (HRSD), city sewer agency, or other local authority standards and the following:

Pipe installed within the right-of-way shall be designed to support the dead loads imposed by earth, subbase, pavement, ballast, track structures, and vehicular loads.

Pipelines installed within the LRT right-of-way shall be subjected to infiltration testing procedures for leakage due to joint failure. The rate of infiltration shall not exceed 100 gallons per day per mile per inch of pipe diameter. Manhole infiltration shall not exceed 4.5 gallons per day per manhole.

When replacement of existing sewers and appurtenances is necessary, services equivalent to those of existing facilities shall be provided, except that no sanitary sewer trunk line shall be replaced with less than 8 inch diameter pipe, and shall be designed with a hydraulic slope that shall provide a mean velocity in the range of 2.0 fps minimum to 10.0 fps maximum when flowing full, based on Manning's formula with a roughness coefficient of n = 0.013.

Storm drain catch basins, utility drains and subsurface drains shall not be connected to sanitary sewers.

Sewers crossing streams or within 10.0’ of a stream embankment or within 100.0’ of a public water supply well or below grade of a water storage reservoir shall be steel, reinforced concrete or ductile iron pipe.

Maximum manhole spacing is as follows:

- 400.0’ for 18” diameter or smaller size pipe
- 500.0’ for pipes greater than 18” diameter

Sanitary sewers, excluding house connections shall be placed a minimum of 10.0’ away from horizontally or 1.50’ below water mains and in separate trenches.

Sanitary sewers shall be designed to carry twice the design flow when flowing 1/2 full.

Manholes shall be vented where required and watertight where subject to flooding or below the 100-year flood elevation.

Relocations or replacement of existing sanitary sewer systems serving other than transit facilities shall comply with all federal, state and local standards, shall be approved by HRT, and shall conform to the requirements herein.

Pipe material, size and appurtenances shall be in accordance with the current standards of the jurisdictional operating and maintenance authority (e.g., Norfolk Department of Utilities).

When replacement of existing sewers and appurtenances is necessary, services equivalent to those of existing facilities shall be provided, except that the minimum size

sewer line installed with be 8" diameter, 6" diameter for force mains. Unless precluded by existing conditions, gravity sewer shall be designed with a hydraulic slope that shall provide a mean velocity between 2.0 fps minimum to 10.0 fps maximum when flowing full, based on Manning's formula with a roughness coefficient of n=.013.

Pipes within the project limits, which are to be abandoned, shall be removed or backfilled in accordance with jurisdictional policy and practice.

Sanitary sewer service to adjoining properties shall be maintained at all times. No sewage shall be discharged into LRT excavations, public streets, storm sewers, or public or private right of way.

Where feasible, ductile iron or cast iron sewers crossing the LRT track shall be replaced with pipes that are non-metallic to a minimum distance of 12.0' from the nearest track centerline.

Pipe replacement shall generally continue to the nearest pipe joint.

Corrosion protection for metallic pipes to remain in service shall be in accordance with Section 24, Corrosion Control.

Existing manholes shall be relocated outside of the track alignment. Manholes shall be provided at all changes in grade, size, alignment, and at multiple pipe intersections.

Manholes shall be vented where required and watertight where subject to flooding or below the 100-year flood elevation.

Sanitary sewers shall be placed in a concrete encasement when the separation from a storm sewer at a crossing is one foot or less.

Sanitary sewers, excluding individual service connections, shall be placed a minimum of 10.0' horizontally and 1.50' vertically from water mains and in separate trenches.

Where these requirements cannot be met, installation shall meet Virginia Department of Health standards.

Sanitary sewers shall be located with a minimum of 30" of cover. Exceptions to these provisions may be made where special material or bedding is provided.

Where feasible, City force mains crossing the LRT track shall be replaced with pipes that are nonmetallic to a minimum distance of 12.0' from the nearest track centerline.

Existing valves shall be relocated outside of the track alignment.

Any other HRSD or City utility department requirements are also applicable and shall generally supersede the provisions of this Section.

18.5 ELECTRIC POWER

All support, maintenance, relocation, and restoration of existing overhead and underground electric lines throughout the LRT system shall be in strict conformance with current practices of the Dominion Virginia Power (DVP) or other electric utility, the requirements of the electrical code of the responsible jurisdictions and agencies, and the National Electrical Safety Code.

The design shall coordinate with the utility company to insure that during the preparation of design drawings and specifications, the method of handling the facilities is the most economical, and is consistent with the needs of LRT service requirements. Additional factors to be considered shall include limitations that may be imposed by system structures and excavation support systems.

Utility relocations, impacts, and protection for electrical facilities must include both the general 10.0' (plus additional distance dependent on voltage) minimum distance restriction from utility lines, and protection for ductbanks and facilities if construction impacts are within the zone of influence of the utility structure. Protection measures shall include consideration of any potential service outages required for the work from construction activities. These protection measures shall be shown on the final design plans.

Electrical relocations along the light rail are typically necessary if the electric line or manholes are located within 12.0' of the track centerline, which represents the lateral fouling distance from light rail track operations. This creates an inherent conflict between the utility and HRT, whereas electrical access and service requires either a light rail service shutdown or utility work only during non-revenue hours.

Electrical utility design shall also show the appropriate service drops from DVP distribution lines to the proposed HRT facility meters. Designs shall not include general notes such as "Electrical Service Drop Locations to Be Determined in the Field."

Design shall be further based on the following:

- Electric facilities shall be maintained complete in place provided that the support system can satisfactorily retain the line and grade of the facility, and that the retention of duct structures is practical within the limitations contained herein.
- Where existing electric facilities conflict with proposed LRT construction, the electric facilities shall be relocated outside the LRT construction limits.
- Electric facilities shall be temporarily supported while being maintained in service until such time as replacement facilities shall be provided, either within or beyond the limits of HRT's construction excavation. Existing duct structures and manholes shall be removed where cables in these facilities are to be kept in service during and after HRT's construction is complete.
- Temporary duct systems and manholes shall be provided to serve the same utility function as existing facilities with respect to accessibility, manhole size, required number of ducts, and structure protection for equipment, cable and service personnel. The number of temporary ducts shall be minimized by coordination with the utility to assure utilization of maximum temporary capacity and exclusion of unnecessary spare ducts.

- Split duct when encased for permanent retention shall be a straight-rigid conduit line, wherever practical, without bends or curves. Generally, split duct shall only be acceptable for retained facilities and for a minimum of four ducts housing secondary, street light and/or traffic signal cables.
- Pipe lines carrying high-voltage lines shall be supported during construction. Upon completion of work, pipes shall be permanently supported on undisturbed material, or well compacted backfill and encased in concrete or surrounded by thermally acceptable sand.
- Owners of the electric facilities shall be consulted during the preparation of design drawings and specifications to assure that the method of handling the facilities is the most economical and is consistent with needs of HRT and service
- requirements. Additional factors to be considered shall include limitations that may be imposed by rail system structures and excavation support systems.
- DVP shall perform all cable work, including removal of existing cable.

The construction contractor shall:

- Where required, maintain and support duct banks, manholes and vaults.
- Install and support temporary ducts, manholes and vaults when existing facilities cannot be maintained.
- Where required, construct new ducts (including split duct to be retained), manholes and vaults.
- Provide concrete foundation beneath facilities maintained in place or constructed on compacted fill.
- Exercise caution when working in the vicinity of, and installing support systems for, pipe-type cables. The supporting system shall be designed to mechanically support these pipes, and to protect the coating around the pipes from puncture and vibrational damage.
- Provide special backfill and concrete encasement around pipe conduit carrying high voltage cable.

Any other DVP requirements are also applicable and shall generally supersede the provisions of this Section.

18.6 TELEPHONE/COMMUNICATIONS

Maintenance, relocation and support of existing telephone and communication lines within system rights-of-way shall be in strict conformance with the current practices of Verizon, AT&T, Cox Communications, Sprint, Level3, and any other owner.

The design shall indicate:

- Communication lines to be maintained complete in place

- New manholes and access ducts to be provided outside the track alignment for the purpose of connecting to and providing access to ducts to remain in service within the track alignment
- Ducts to be removed, cables maintained and supported, and upon completion of HRT work, replaced by a new system of split ducts or new ducts and replacement cable
- Any relocation or new communication line construction.
- Lines to be abandoned shall also be indicated on the drawings.

The owner utility company shall perform all cable work, including removal of existing cable.

Design shall be based on the following:

- Underground communication facilities shall be maintained complete in place provided that the support system can satisfactorily retain the line and grade of the facility, and that the retention of duct structures is practical within the limitations contained herein. Where access manholes are located inside the track alignment or between tracks, new manholes with access ducts shall be provided to connect to the existing ducts, such that at-grade personnel access and ventilation equipment is provided completely outside of the track limits.
- As dictated by space limitations or cost, communications facilities shall be relocated outside the limits of LRT excavation and its system of trench support.
- Underground communication facilities shall be temporarily supported while being maintained in service until such time as replacement facilities shall be provided, either within or beyond the limits of LRT construction.
- Split duct when encased for permanent retention shall be a straight-rigid conduit line, wherever practical, without bends or curves.
- Duct lines carrying fiber optic cables shall be supported during construction. Upon completion of work, ducts shall be permanently supported on undisturbed material, or on well compacted backfill and encased in concrete.

Owners of communications facilities shall be consulted during the preparation of design drawings and specifications to assure that the method of handling the facilities is the most economical and is consistent with needs of HRT and service requirements.

Additional factors to be considered shall include limitations that may be imposed by rail system structures and excavation support systems.

The responsible utility shall perform all cable work, including removal of existing cable.

HRT or utility contractor shall:

- Where required, maintain and support duct banks, manholes and vaults.
- Install and support temporary ducts, manholes and vaults when existing facilities cannot be maintained.

- Where required, construct new ducts (including split duct to be retained), manholes and vaults.
- Provide concrete foundation beneath facilities maintained in place or constructed on compacted fill.
- Exercise caution when working in the vicinity of, and installing support systems for, fiber optic and long line cables. The supporting system shall be designed to mechanically support these ducts.
- Provide special backfill and concrete encasement around pipe conduit carrying communication cables.

The design shall indicate telephone lines to be maintained complete in place, ducts to be removed, cables maintained and supported, and upon completion of LRT work, replaced by a new system of split ducts or new ducts and replacement cable; and any relocation or new telephone line construction. Abandoned lines or those to be abandoned shall also be indicated on the drawings.

18.7 CABLE TELEVISION/COMMUNICATIONS

Maintenance, relocation and support of existing cable lines within the LRT right-of-way shall be in strict conformance with the current practices of Cox Communications, Comcast, and any other owner, and shall include the requirements noted in the previous Section for Telephone/Communications

The design shall indicate cable lines to be maintained complete in place, ducts to be removed, cables maintained and supported, and upon completion of LRT work, replaced by a new system of split ducts or new ducts and replacement cable; and any relocation or new cable line construction. Abandoned lines or those to be abandoned shall also be indicated on the drawings.

18.8 WATER LINES

All new water lines and relocations and rearrangements or extensions of existing water mains shall comply with utility requirements and shall conform to the provisions below:

- Water pipe installed within the LRT right-of-way shall be designed to support the dead loads imposed by earth, subbase, pavement, ballast, track, structures, and vehicular loads when the pipe is operated under ranges of internal pressure from maximum to zero.
- Water mains to be removed from service due to construction shall be replaced by pipe of equal size (usually 8” minimum diameter), except that the diameter of pipe shall meet engineering requirements and comply with latest utility design criteria and standards.

When replacement of existing water mains and appurtenances outside of the HRT right –of-way is necessary, services equivalent to those of existing facilities shall be provided, except that the minimum size water main installed with be 8” diameter.

Service to adjoining properties shall be maintained at all times.

Water mains or fire hydrants shall not be taken out of service without prior approval. Where feasible, water mains crossing the LRT track shall be replaced with pipes that are nonmetallic to a minimum distance of 12.0' from the nearest track centerline.

Replacement shall generally continue to the nearest pipe joint.

Existing valves and fire hydrants shall be relocated outside of the track alignment.

Water mains shall be located with a minimum of 30" of cover. Exceptions to these provisions may be made where special material or bedding is provided.

Construction of water services to abutting properties shall comply with applicable plumbing codes of the local jurisdiction in which the system shall be constructed. Service to adjoining properties shall be maintained by supporting in place, by providing alternate temporary facilities or by connection to other points.

Pipe used for water mains shall be ductile iron pipe with bituminous outside coating and standard interior cement mortar lining with bituminous seal coat.

Straight runs of pipe may be either the mechanical joint or "push-on" type, with gasket. All valves and fittings, however, shall be of the mechanical joint end type, with fittings lined and coated as noted herein. Protection against corrosion control shall be in accordance with the standards developed under Section 24 - Corrosion Control.

Where relocated water mains are to be supported across or in excavations; ductile iron lock type mechanical joint pipe is to be used. If pipe is to be exposed through a winter season it shall be insulated as recommended by the applicable agency.

Any other requirements of the applicable owners or water authorities shall generally supersede the provisions of this Section. This include the following agencies:

- City of Norfolk, Department of Utilities
- City of Virginia Beach, Department of Public Utilities
- City of Portsmouth, Department of Public Utilities
- City of Chespeake, Public Utilities Department
- Newport News Waterworks

18.9 LIQUID-PETROLEUM PIPELINES

Each new liquid-petroleum-products pipeline system and each pipeline in which pipe has been relocated or replaced, or the part of a pipeline system that has been relocated within the right-of-way, shall be designed, installed and tested in accordance with applicable Federal, State, and local standards and applicable sections of the following:

"ANSI Standard for Liquid-Petroleum-Transportation Piping Systems Part B31.4".

"API Recommended Practice for Crossing Highways and Railroads".

US Department of Transportation "Part 195 of Government Requirements for Transportation of Liquids by Pipeline" and shall conform to the following:

- Pipe installed within the LRT right-of-way shall be designed to support the dead loads imposed by earth, subbase, pavement, track, ballast, structures, and vehicular loads thereon when the pipe is operated under all ranges of internal pressure from maximum to zero.
- The pipeline facility shall be provided with a cathodic-protection system as prescribed in Part 195.242, Paragraph 7.8.1(3). Protection against corrosion shall be in accordance with the standards developed under Section 24 - Corrosion Control.

18.10 FIRE ALARM AND POLICE COMMUNICATION SYSTEMS

Maintenance, relocation and support of existing fire alarm and police communication systems within right-of-way shall be in strict conformance with the current standards of the governing agency and/or municipality.

Design shall indicate which emergency communication facilities are to be maintained complete in place, which are to be removed, which are to be maintained and supported, and which are to be temporarily relocated and replaced after LRT work is completed. The lines to be abandoned, or that are already abandoned, shall also be indicated.

18.11 STREET LIGHTS AND TRAFFIC SIGNALS

All relocations, temporary or permanent, and maintenance of municipal street lights and traffic signal equipment shall be in accordance with the requirements of the governing owner agency and/or municipality.

18.12 PARKING METERS/VALIDATORS

The design shall identify all parking meters or validators that are to be removed due to HRT construction. The design shall coordinate with the affected governing owner agency/municipality to determine relocation or restoration procedures to be defined on the design documents after completion of LRT construction.

18.13 VAULTS

Remodeling, abandonment or other work involving existing private vaults extending from adjoining buildings into public space shall be in strict accordance with rules, regulations and practices of the governing municipality, which shall include currently applicable Building Codes, Electrical Codes, Plumbing Codes, and the National Electrical Safety Code.

The design shall determine which vaults shall be affected by construction. Details shall show the portion of each vault to be excavated; new walls required to permit continued

use of vaults outside of construction limits; new walls to accomplish complete abandonment of vaults where required; work required to restore vaults, including delivery chutes and freight elevators; and the area available for permanent occupancy by the original owner upon completion of transit facilities.

The designer shall also determine what goods or facilities, including utility services, are to be removed from the vault, how deliveries shall be made to properties when existing vault entrances must be abandoned, and the construction time required to make alterations and occupy the vault. This information shall be submitted to HRT.

18.14 OVERHEAD UTILITY LINES

The designer shall identify all required abandonment, relocation, restoration, and extension of existing overhead utility lines, poles and appurtenances, including service lines to adjoining properties, due to LRT construction. Work shall be performed by the utility owners in accordance with laws and regulations of the appropriate jurisdiction, utility owners' standards, the National Electrical Safety Code, appropriate railroad overhead wire standards and the appropriate owner utility company.

Plans shall denote the general type of service provided by overhead lines in accordance with the symbols of Utility Standard Drawing "Utility Standard Abbreviations Symbols and General Notes". Certain jurisdictions may restrict the use of overhead lines in some areas. The designer shall reflect these requirements in the project design.

Abandonment, relocation, restoration, maintenance, and extension of existing overhead utility lines, poles and appurtenances, including service lines to adjoining properties, shall be performed by the utility owners in accordance with laws and regulations of the appropriate jurisdiction, utility owners' standards, the National Electrical Safety Code, appropriate railroad overhead wire standards and the appropriate owner utility company.

Protection and support of overhead utility lines, including poles, equipment, appurtenances, and services, that may exist during execution of the work, shall be provided by HRT's contractor during the LRT construction.

Poles supporting overhead facilities may be owned by one party and shared with or rented to others under mutual agreement. Utilities in this common use arrangement are:

- Electric Cables
- Telephone and Communication Cables
- Cable Television
- Railroad Communication Lines
- Police, Fire Alarm and other Government Lines
- Street Lights and Traffic Signals
- Security Firms

As a guideline, plans shall denote the general type of service provided by overhead lines in accordance with the standards and symbols of the Virginia Department of Transportation (VDOT).

Certain jurisdictions may restrict the use of overhead lines in some areas. The designer shall reflect these requirements in the project design.

Clearances shall be in accordance with the standards adopted by the utilities involved. Clearances specified in the National Electrical Safety Code shall be considered the minimum requirements with respect to HRT's R/W crossings and structures.

The designer shall evaluate the need for relocation of existing overhead high-voltage electric lines, including transmission lines, due to hazards from HRT's construction, catenary system, train control, or train operations. Findings and recommendations shall be developed and submitted to the appropriate utility agency for consideration and inclusion in Contract Documents.

Clearances shall be in accordance with the standards adopted by the utilities involved, and those specified in the National Electrical Safety Code shall be considered the minimum requirements with respect to ROW crossings by catenary system, and structures.

The designer shall evaluate the need for relocation of existing overhead high-voltage electric lines, including transmission lines, due to potential hazards from construction or train operations. Findings and recommendations shall be developed and submitted to the appropriate utility agency for consideration and inclusion in the design documents.

18.15 UTILITY MARKERS

The presence of utility lines, including drains and culverts, crossing the right-of-way below, at-grade and along embankment sections, shall be indicated on the site by markers placed at points where the centerline of the utilities intersect the boundaries of the right-of-way. Markers shall identify each utility, its owner, transit system route, survey station, and depth.

Typically, markers shall be located inside of the right-of-way, with the face of targets parallel to and facing the adjoining track. They shall not encroach on safety walks, clearance areas, ditches, and service roads. When circumstances prevent markers from being located on the centerline of the utility, they shall be located as close as practicable with the direction and off-set from marker to utility indicated.

18.16 UTILITY CROSSINGS

Utility lines crossing beneath the LRT track shall conform the "Pipelines" section of the AREMA *Manual for Railway Engineering*.

Casement pipes shall be provided for pipelines carrying oil, gas, petroleum products, or other flammable or volatile substances, or steam, water, or other nonflammable substances under pressure. Electric duct, telephone conduit and drain crossings shall

not require encasement where the strength of the utility line is capable of withstanding transit system loading.

Where the LRT system track shall be located above utilities to be retained in service, the existing facilities shall be uncovered and encased prior to placing track or, if more economical, replaced by a new system with a casement pipe.

18.17 UTILITY PLANS

18.17.1 General

Composite utility drawings for coordination with utility companies or agencies shall be prepared at 1" = 40.0' scale and with sufficient planimetric data as background to show the street and property patterns of the area. The drawings shall include:

- Transit system structure outline and horizontal alignment.
- All existing and proposed utilities crossing or adjacent to construction.
- Size and identification of underground utilities that may be affected by construction.
- Overhead lines that may be affected by construction.

Separate utility plans and profiles must be prepared for proposed utility relocations of the following:

- Water mains, sanitary sewers, and storm drainage facilities (three separate sets of plans)
- Gas
- Electric
- Telephone and communication facilities

In the interests of clarity, separate utility plans shall also be prepared for the following:

- Fire and police alarm systems.
- Street and traffic lights.
- Parking meters.
- Steam tunnels and pipes.
- Communication, protection systems and cable television systems.

Plans shall show relocated facility locations. General instructions such as "Fire Hydrant to be Relocated" without showing the location of the new facility is not permitted.

18.17.2 Field Verification

In the preparation of composite and separate utility drawings, the design shall make a field survey to locate all utilities, which shall determine the following features that may affect the transit system design:

- Location of all manholes, valve boxes, vaults, street and traffic lights and appurtenances, trees, and other improvements.
- Size and invert elevations of all pipes to sewer manholes.
- Size, internal dimensions, cover, and headroom of all manholes on duct lines belonging to electric, telephone and telegraph companies and governmental agencies. Covers shall not be removed or manholes entered without prior approval of the utility owner and accompaniment by the owner's representative.
- Overall dimensions and configuration of all duct lines in manholes on electric, telephone and similar facilities. Depth, position in walls of manholes and the location of cables at manholes shall be determined for all affected duct lines.
- The ownership of all cables which may exist in jointly used utility structures.
- Interior dimensions, depth, cover, elevations, and type of material of private vaults.

18.17.3 Coordination

The design shall consult and coordinate with the appropriate utilities and governmental agencies at all stages of planning and design, and shall reach agreement with the respective owners before detailing drawings. Where designs are prepared by utility owners, the designer shall ascertain that work is compatible with the LRT system and shall include the work on design documents, appropriately labeled.

It is the responsibility of the designer to submit drawings and specifications at various stages of completion for review by the respective utility owners, including government agencies, and to secure and file with HRT the letters of acceptance and approval by the utility owners. Upon completing design, the designer shall submit a list of betterments and shall secure from each affected utility owner a firm estimate of work to be undertaken by the utility.

18.17.4 Utilities - Composite Plans

Information to be shown on the Utilities Composite Plans shall include:

- All utilities, abandoned, existing, to be abandoned, maintained, supported, restored, diverted, and proposed.
- Structure outline, building lines, sidewalks, curbs, trees, poles, public and private vaults, pipelines, tunnels, other surface and subsurface features.
- Abandoned tracks may still be in place and in some instances covered with bituminous pavement. A typical detail of these tracks shall be shown on the design documents and their location shown in street cross sections. The plan shall note clearly the existence of all tracks, defining their limits, including crossovers and switches, and shall indicate pavement limits for any removal.

- Service lines between utilities and adjoining properties must be investigated for maintenance of service but need not be indicated on the drawings unless required by the owner of the utility to which the service is connected. It shall be noted on the drawings that service connections must be maintained by the contractor.
- Detailed dimensions and elevations of roofs and floors of vaults affected by construction shall be shown on an appropriate utility drawing.

18.17.5 Water Mains, Sewers, Electrical Ducts, and Drainage Facilities

Information to be shown shall include:

- Plan, profile and cross sections indicating water mains, sewers, duct systems, drainage lines, catch basins, and appurtenances affected by construction, including facilities to be maintained, relocated, proposed, and abandoned.
- Details of non-standard manholes or other facilities.
- The plan and profile for new work shall be on split plan and profile sheets.
- Any related work to be designed and constructed by others.

18.17.6 Gas

The utility owner shall prepare plans for abandonment of gas mains, for construction of new or temporary mains and services, and for any connection or reconnection of gas mains and service.

All such construction shall be normally performed by the owner, although some temporary relocation work may be performed by HRT's contractor upon specific agreement with the owner.

For work to be installed by the utility, designs prepared by the utility owner shall be included on the design documents and marked "Work to be Done by Others" in accordance with the symbols given in the Utility Standard Drawing, "Utility Standard Abbreviations, Symbols and General Notes". Drawings shall indicate staging of construction and clearly indicate which utilities shall be maintained complete in place during construction.

The design shall consult as required with the utility owner to assure that proposed facilities are compatible with other existing and proposed utilities and transit system installations.

18.17.7 Electric

Construction of duct and vault structures for each project may be performed by the utility owner or as part of the construction, depending on approval by the utility owner. Installation and connection of cables always shall be performed by the utility owner.

Plan, profile and cross sections shall clearly indicate electric conduits, high voltage lines, manholes, and transformer manholes affected by construction. Plans shall indicate facilities to be maintained complete in place, temporary manholes to be constructed and maintained during construction, temporary troughs to be provided and supported, abandoned ducts and manholes to be removed, and special backfill for pipe conduit carrying high voltage cable.

Work by the utility owner such as new ducts and manholes, removal of ducts and manholes on energized electric lines or transfer of cables to temporary troughs shall be indicated. Details of non-standard manholes shall be included on design documents. Each plan sheet shall include a schedule of information concerning existing manholes and ducts (manhole number, size, depth, number of cables and voltage, number of ducts, type, and number of vacant ducts).

Plans shall indicate those lines to be constructed by the utility owner that shall be completed prior to LRT construction as well as those to be installed at other designated stages of construction.

18.17.8 Telephone

Plan, profile and cross sections shall clearly indicate telephone and telegraph lines affected by LRT construction and indicate facilities to be maintained, relocated, proposed, or abandoned.

Details of non-standard manholes or other facilities shall be included on the design documents. Related work to be performed by others shall be indicated.

Each plan sheet shall include a schedule of information addressing existing manholes and ducts (manhole number, size, depth, number of cable pairs, number of ducts, type, and number of vacant ducts). Where new ducts are installed, cable shall be installed and splices made by the utility owner.

All ducts which may be maintained in place during construction and then permanently supported by compacted backfill, or those temporarily supported in troughs during construction, then restored and permanently supported by compacted backfill, shall be identified.

The design shall ascertain if cables belonging to AT&T, U.S. Sprint, MCI, or other communications carrier or coaxial TV cables are affected and, after consultation with the owners, shall include the necessary work in the system design. The design shall ascertain if fiber optic cables are affected.

18.17.9 Fire and Police Alarm Systems

Information to be shown on the drawings shall include:

- Location of existing alarms, call boxes and cable runs, as applicable.
- Facilities to be removed, temporarily relocated and restored, and cables to be supported.

- Information concerning existing manholes and ducts, manhole number, size, depth, number of cables, number of ducts, type, and number of vacant ducts.

Affected facilities may be indicated on telephone/CATV drawings or on separate sheets.

18.17.10 Street Lights and Traffic Signals

The design shall show all street lights and traffic signals in the affected area; those to be continued in service, to be temporarily relocated and restored, temporary installations and new installations; also cable and duct runs, as well as control appurtenances.

Generally, all pole removals/replacements and associated light and signal installation shall be performed as part of the construction. Cable work shall be performed by the local governing municipalities with their own contract or power company forces.

18.17.11 Parking Meters/Validators

The design shall indicate parking meters or validators affected by construction, and disposition to be made by local jurisdictions. The design documents shall define meter/validator posts to be removed, stored and reinstalled and meter/validator heads and coin vaults to be removed and replaced by the local jurisdictions.

18.17.12 Communication, Security and Cable Television Systems

Design documents shall clearly indicate the communication, security agency and cable television systems affected by construction. The drawings also shall indicate which facilities are to be maintained, relocated, proposed, or abandoned.

Details of non-standard manholes or other facilities shall be included on these drawings. Each plan sheet shall include information concerning existing manholes and ducts, overhead poles, manhole number, size, depth, number of cables, number of ducts, type, and number of vacant ducts.

Affected facilities may be indicated on telephone drawings or on separate sheets, with the notation that the specific work item is to be performed by others.

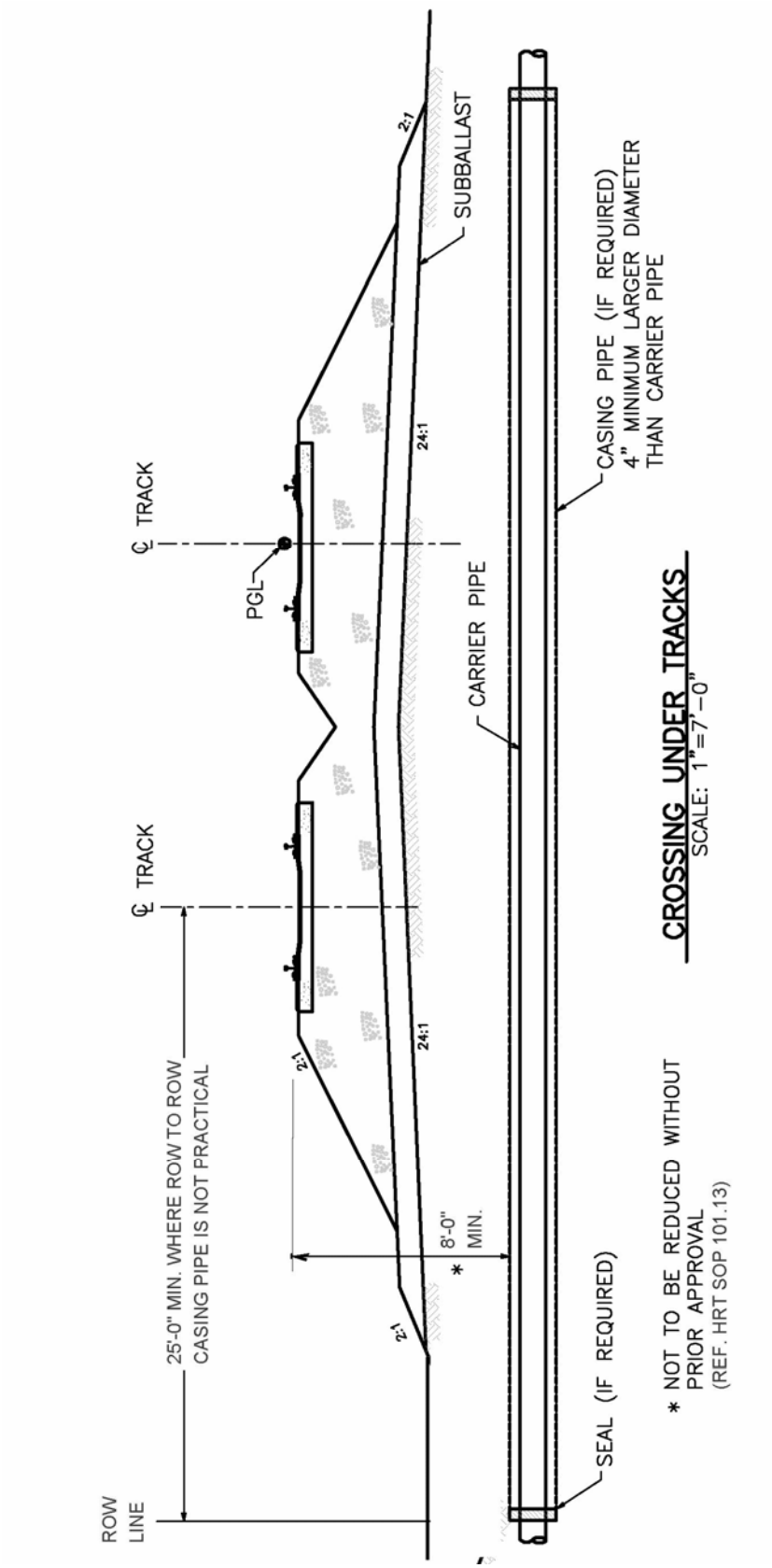
18.18 REFERENCES

1. Hampton Roads Transit, “Manual of Design Criteria”, Norfolk LRT Project, Draft, HRT, Dec. 2004.
2. See Sections 18.1, 18.3, 18.8, and 18.9 for Applicable Utility Standards

Figures

Guideline References and Notes:

One significant impact on utility design involves the use of single wire OCS rather than catenary OCS particularly in downtown streets. The single wire OCS design requires lateral feeders, which increases utility conduit work in these areas.

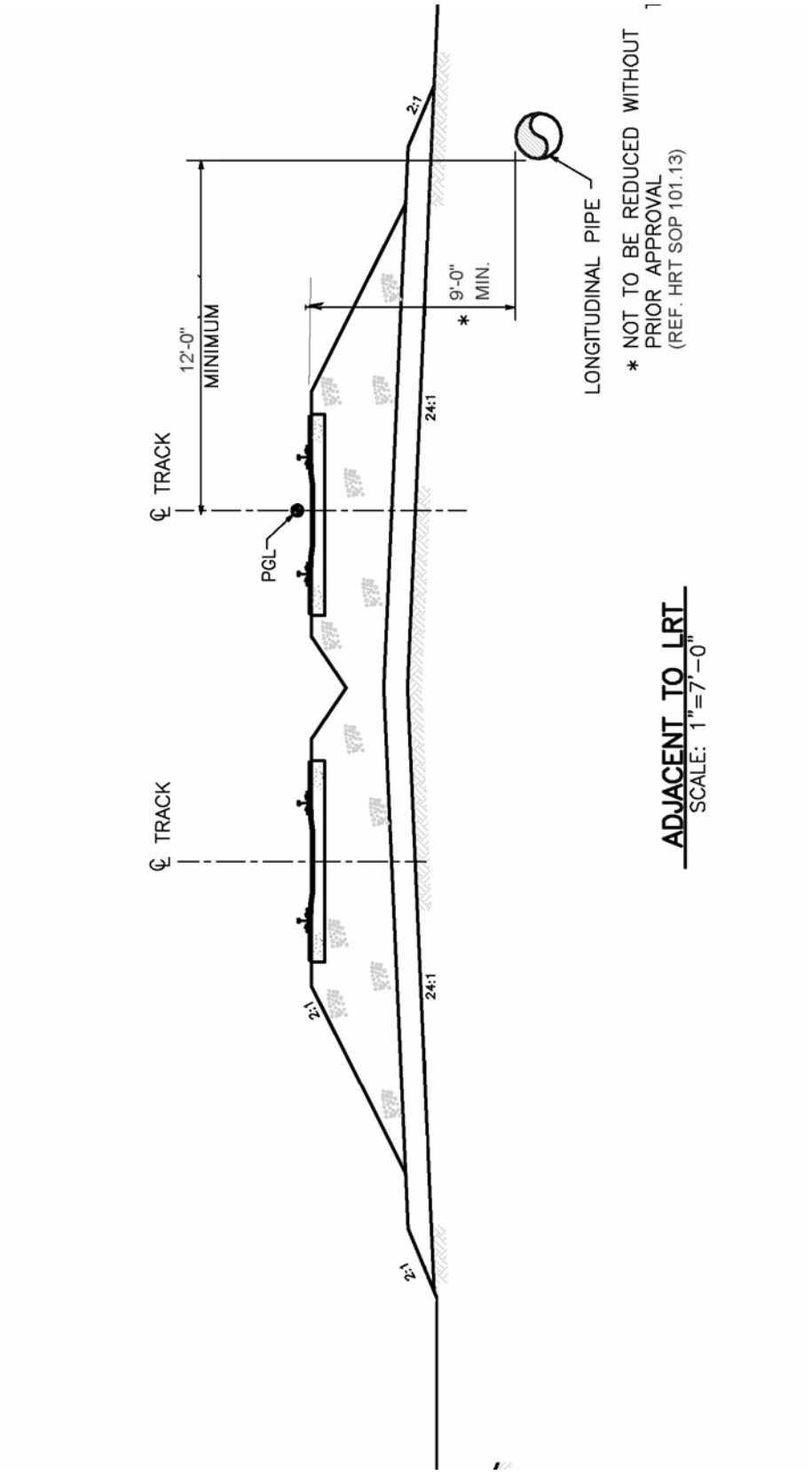


CROSSING UNDER TRACKS
SCALE: 1"=7'-0"

HAMPTON ROADS TRANSIT

TYPICAL UTILITY LOCATIONS, OPEN BALLASTED TRACK SECTION

FIGURE 18-1

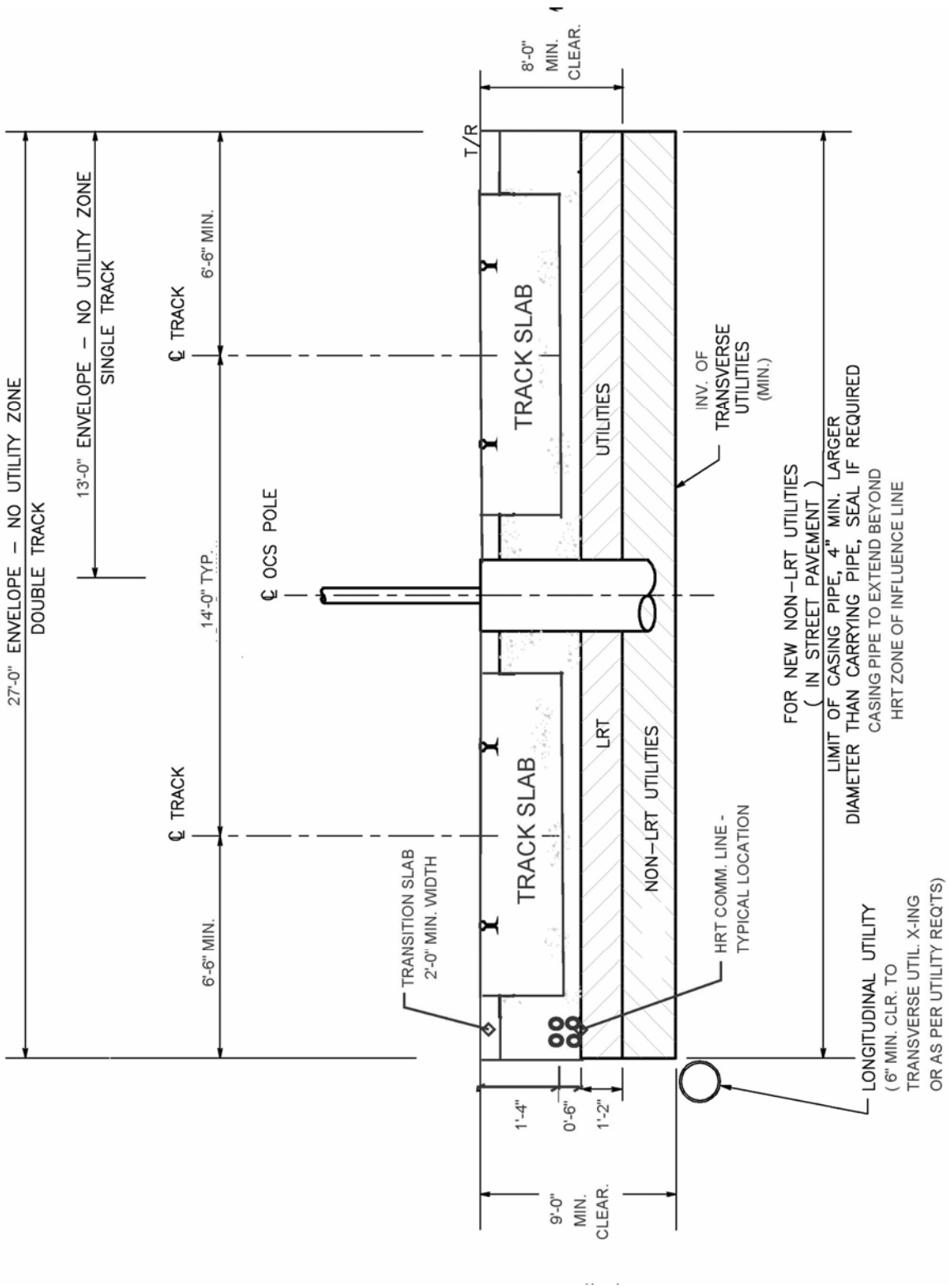


HAMPTON ROADS TRANSIT DESIGN CRITERIA

HAMPTON ROADS TRANSIT

TYPICAL UTILITY CROSSING, OPEN BALLASTED TRACK SECTION

FIGURE 18-2

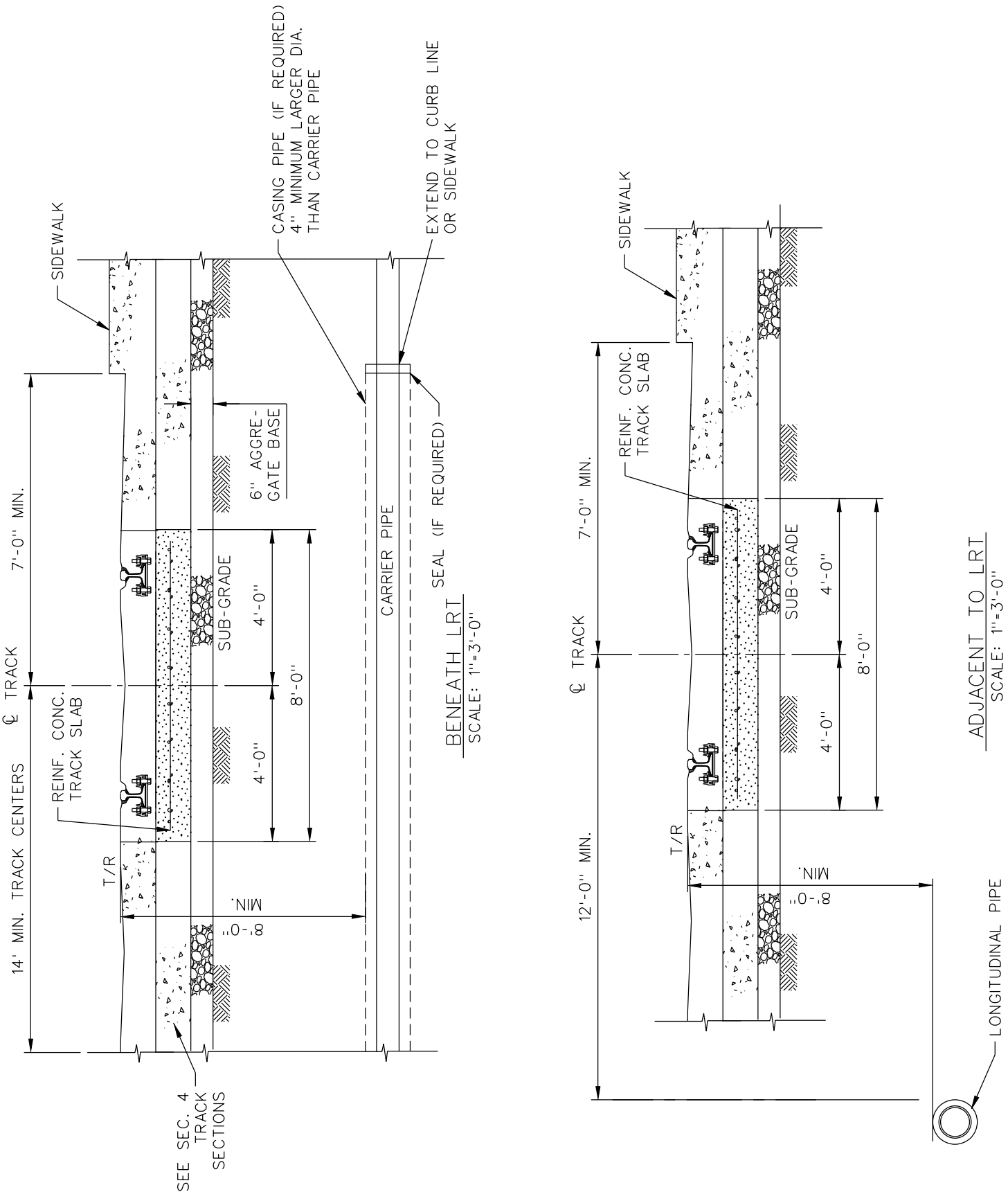


HAMPTON ROADS TRANSIT DESIGN CRITERIA

HAMPTON ROADS TRANSIT

LRT EMBEDDED TRACKS, NO UTILITY ZONE FOR UNDERGROUND UTILITIES

FIGURE 18-3



HAMPTON ROADS TRANSIT

TYPICAL UTILITY LOCATION PAVED TRACK SECTION

FIGURE 18-4

SECTION 24
CORROSION CONTROL

Introduction

This Section provides measures necessary for stray current mitigation and corrosion control protection.

The programmed containment of return current for DC traction power systems has been under discussion since the early 1900's. Early efforts at stray current mitigation centered on protection of the impacted utility or structural member, either by protective coatings or by active cathodic protection. In current design practice, the amount of active protection required for adjacent utilities and structures to install a new light rail in an urban setting would be prohibitive.

In the past 25 years, significant efforts have been made to increase electrical isolation between the traction power return rail (s) and the surrounding track structure (track resistance). This reduces stray current and decreases its negative effect on the LRT surroundings. A side benefit to this design is that less power is lost to ground (i.e., wasted) and more power fed back to regenerative traction power substations.

Because of the impossibility of constructing an LRT with no stray current, the general philosophy for stray current mitigation has been to isolate the rails from ground to the greatest intent practicable without affecting the integrity of the track structure.

The results of this effort are positive, but the actual values of track resistance vary widely among systems. This was found in the study of existing design criteria, where values of required new track resistance range from 50 ohms to 1,000 ohms per 1,000 track feet. Over time, these track resistance values decline, primarily due to surface dirt and debris.

HRT employs track designs that tend to promote high initial track resistance, and thus use criteria at the high end of the typical range of values.

Other corrosion control measures are required near elevator and escalator pits, usually utilizing conventional sacrificial cathodic protection devices.

24.1 GENERAL

This Section shall provide the design basis for stray current and corrosion control for all structures and pipes, storage facilities, and any other facilities where corrosive conditions may occur. Types of corrosion control include stray current mitigation, protective coating, and cathodic protection.

24.2 PURPOSE

These criteria describe design requirements necessary to accomplish stray current and corrosion control measures for light rail transit (LRT) projects. Design factors to consider

for each system include plans to mitigate stray current at the source, prevent premature failures of LRT facilities and prevent degradation of other structures or installations. Mitigation and control measures should be installed, operated, and maintained in a cost effective manner. Corrosion control requirements shall be coordinated with all applicable engineering disciplines.

24.3 SCOPE

24.3.1 General

These criteria in this Section are separated into three distinct areas; stray current corrosion control, soil corrosion control, and atmospheric corrosion control. The design criteria for each of these categories and its implementation shall meet the following objectives:

- Achieve the intended design life of LRT facilities by avoiding premature failure caused by corrosion
- Minimize annual operating and maintenance costs associated with material deterioration
- Ensure continuity of operations by reducing or eliminating corrosion related failures of LRT facilities and subsystems
- Minimize detrimental effects to facilities belonging to others caused by stray earth currents from transit operations.

24.3.2 Stray Current Corrosion Control

Stray current control shall be based on the following principles:

- Increasing the conductivity of the negative return circuit
- Increasing the resistance between the negative return circuit and earth
- Increasing the resistance between the earth and underground structures
- Increasing the resistance of underground structures

Stray current control measures shall be installed on traction power and trackwork systems to mitigate the flow of direct current (DC) stray current into the surrounding environment. Protection measures shall be applied to assure that stray earth currents are maintained within acceptable ranges to avoid deterioration of buried structures. Recording charts shall be obtained during Baseline Stray Current Surveys with cooperating outside agencies and utilities to determine effects/magnitude of possible stray currents on existing utility installations, and to serve as documented references for future investigations.

24.3.3 Soil Corrosion Control

Soil and ground water corrosive characteristics shall be determined and documented during the Baseline Stray Current Surveys. Analysis of the data obtained, or from

supplemental on-site measurements, shall be used as the basis for corrosion control designs. Structures shall be protected against the environmental conditions by use of coatings, insulation, cathodic protection, and electrical continuity as appropriate.

24.3.4 Atmospheric Corrosion Control

The atmospheric corrosion conditions such as temperature, relative humidity, wind direction and velocity, solar radiation, and amount of rainfall shall be determined during the Baseline Stray Current Survey. The areas with corrosive atmospheres (industrial, marine, rural, etc.) shall be identified. Materials selection, designs, and associated coatings shall be based on recommendations of the survey and shall be used to protect structures and hardware from atmospheric corrosion.

24.3.5 Grounding

Due to the natural difference between personnel safety grounding and stray current and corrosion control bonding requirements, the criteria provided herein shall be followed. Grounding designs for traction power substations, passenger stations, shops and yards, aerial structures, and other wayside locations, shall be reviewed by corrosion control engineers to assure that stray current and corrosion control designs are not compromised. Metallic contact or electrical bonding between grounding and corrosion control systems is prohibited.

24.4 INTERFACES

Stray current and corrosion control designs shall be interfaced and coordinated with other engineering disciplines and designs, including the utility, mechanical, civil, structural, electrical, trackwork, traction power, environmental, geotechnical, architectural, signals, communications, and safety and security designs.

24.5 APPLICABILITY OF CRITERIA

Since the LRT system shall be designed and constructed in segments, stray current and corrosion control criteria shall be applicable throughout the design, installation, and start-up process of all segments.

One exception to this Section involves the use of uncoated reinforcing steel in embedded track. Research indicates that it is difficult, if not impossible, to retain the epoxy coating on steel reinforcing bars during this type of construction. Corrosion control efforts in embedded track shall be confined to providing continuity for all steel reinforcing bars or mesh in the structure for directing stray current to controlled grounding locations.

24.6 EXPANSION CAPABILITY

Stray current and corrosion control systems should be easily expandable to the entire system without major reconfiguration, reconstruction, redundancy, and duplication of equipment. Experimental designs, equipment, and prototypes of a research nature are

discouraged and must be reviewed and approved by HRT prior to their implementation and prior to incurring any costs.

24.7 STANDARDS AND CODES

Standards, codes, and recommended practices for stray current and corrosion control include the following publications and/or codes:

- National Association of Corrosion Engineers (NACE) International
- National Fire Protection Association (NFPA)
- American National Standard Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- American Water Works Association (AWWA)
- American Electric Railway Association (AERA, a precursor to APTA no longer in existence)
- Virginia Department of Transportation (VDOT)
- Society for Protective Coatings (SSPC)
- Steel Structures Painting Council (SSPC)
- Institute of Electrical and Electronic Engineers (IEEE)
- Underwriters Laboratories, Inc. (UL)
- Occupational Safety and Health Act (OSHA)
- National Electrical Code (NEC)
- Military Specifications (MIL-SPEC)
- National Electrical Manufacturer's Association (NEMA)
- National Electrical Safety Code (NESC)
- American Railway Engineering and Maintenance of Way Association (AREMA)

State and local codes may also apply. Designers shall consult these publications and provide systems in accordance with the most stringent applicable code, or industry practice.

24.8 SPECIAL DESIGN PROVISIONS

During the pre-design and design phases of the project, the corrosion control design shall identify unique and special design cases such as existing building foundations, paralleling power lines, and unusual soil conditions.

In these cases, the corrosion control design shall evaluate and recommend special design measures as appropriate.

24.9 STRAY CURRENT CORROSION PREVENTION

24.9.1 Purpose

The purpose of this section is to provide criteria for designs to mitigate the corrosion impact of possible stray currents from the LRT, which would impact LRT structures and adjacent structures. By the application of the appropriate design elements the magnitude of stray currents can be reduced to such low levels that their corrosive effect on buried structures is negligible. The basic requirements for stray current control are as follows:

- Under normal conditions, operate the LRT system without direct or indirect electrical connections between the positive or negative traction power distribution circuits and ground.
- Design traction power and trackwork to minimize stray currents from the LRT system during normal revenue operations.
- Ballast shall be clean, well drained, and high resistivity material.

24.9.2 Scope

Structures and systems that may be affected by stray currents shall be identified. Typically these include, but are not limited to:

- Trackwork components
- Traction power system components
- Metallic pipes and casings
- Reinforced concrete structures.

Designs shall be coordinated with appropriate outside agencies through Hampton Roads Transit.

24.10 STRAY CURRENT CORROSION PREVENTION SYSTEMS

The design of stray current corrosion prevention systems shall be based on results of model studies. The studies shall predict magnitude of anticipated stray currents considering the variation of key parameters for the following:

24.10.1 Traction Power Substations

The traction power distribution system shall be separated into three electrically isolated sections: main tracks, yards, and shops.

Traction power substations shall be spaced at intervals such that track-to-earth potentials along main tracks shall be within safe operating levels.

Traction power substations shall include a separate DC traction ground electrode. The DC ground electrode shall be electrically isolated from facilities in the substation.

Substations shall be provided with access to the DC negative bus for stray current monitoring, utilizing corrosion control junction boxes. The location of these boxes shall provide ready access for HRT maintenance and area utility personnel.

24.10.2 Positive Distribution System

24.10.2.1 Resistance-to-Earth Criteria

The positive distribution system shall normally be operated as an electrically continuous bus, with no breaks, except during emergency or fault conditions. Intentional electrical segregation of main track, yard and shop positive distribution systems is the only type of segregation permitted.

24.10.2.2 Electrical Ground Connections, Overhead Contact System (OCS), and Support Poles

For locations other than at aerial structures, electrical ground facilities for OCS support poles shall not be interconnected. This shall eliminate the possible transference of stray earth currents from one portion of the transit system to another due to an electrically continuous ground system.

Where OCS poles are located on aerial structures, they shall be interconnected electrically and connected to a ground electrode.

24.10.3 Negative Distribution System

24.10.3.1 General

Industry-accepted standards for the following shall be included in designs to provide an electrically isolated rail system to control stray current at the source:

- Install continuously welded rail.
- Install rail bond jumpers at mechanical rail connections.
- Utilize insulating pads and clips on concrete ties.
- Use an insulated rail fastening system for wood ties.
- Maintain ballast a minimum of 25 mm (1 in.) below the bottom of the rail.
- Insulate direct fixation fasteners.
- Coat rail with coal tar epoxy at all roadway and pedestrian crossings.
- Encase rail at all roadway and pedestrian crossing with a rubber boot.
- Install cross-bonding cables rail-to-rail and track-to-track to maintain equal potentials on all rails.

- Insulate impedance bond tap connections from the housing case.
- Insulate switch machines at the switch rods.
- Install rail insulating joints prior to bumping posts.
- Install rail insulators to electrically isolate the main line rails from yard, yard from shop and freight sidings or connections to other rail systems.
- Isolate steel reinforcement in invert structures from all rail fixation components.

24.10.3.2 Resistance-to-Earth Criteria

Main tracks running rails, including special trackwork and all ancillary system connections shall be designed to have the following in-service resistance per 1,000 feet of track (2 rails):

- At-grade ballasted track with wood or concrete ties: 300 Ohms
- Ballast deck aerial structures: 300 Ohms
- Direct fixation track: 500 Ohms
- Embedded track: 200 Ohms

Resistance may be attained by use of insulating track fastening devices such as insulated tie plates, rail clips, and direct fixation fasteners.

Supplemental insulated negative return drainage cables shall be considered where extensive utility installations exist, or where major high pressure transmission pipelines are present.

All devices such as switch machines, train signal installations, or other systems shall be electrically insulated from the rails by use of dielectric materials.

24.10.4 Grade Crossings and Embedded Track

Rails, rail fasteners, and related metallic components shall be electrically isolated from ground by insulating components.

24.10.5 Yards

The yard/main track traction power segregation point shall be located such that yard and main tracks are electrically isolated from each other, and from ground connections.

Yard track shall include the following provisions:

- Ballast shall be clean, well drained, high-resistivity material.
- A 1-inch minimum clearance between the ballast and all rail surfaces and electrically connected metallic track components.

- All dead-end tracks shall have insulated joints installed to isolate bumping posts or similar devices that are electrically grounded.

24.10.6 Maintenance Shops

Shop traction power shall be provided by a separate dedicated DC power supply electrically segregated in both the positive and negative circuits from the yard traction power system.

Shop tracks shall be electrically bonded to the shop grounding system in a single location that is clearly identified as the “negative-to-ground” interconnection point.

Shop tracks shall be electrically isolated from yard tracks by the use of insulated rail joints. Actual locations of insulating joints shall be placed such that parked vehicles shall not electrically short the shop and yard separate traction electrification systems for periods of time longer than that required to move a vehicle in or out of the shop.

24.10.7 Water Drainage

Water drainage system shall be designed to prevent water accumulation from contacting the rails, rail insulating joints, rail metallic components, insulators and rail ties.

24.10.8 Railroad Spurs and Maintenance Sidings

Rail insulating joints shall be installed at all track crossings, sidings or other existing railroad interconnection to LRT systems. The insulating joints shall be installed as close to main tracks as practicable and the insulating joints shall be electrically isolated from ground in a manner comparable to main track rails. Electrical detection connections shall be installed on the railroad side of the insulating joints.

The same principles shall apply to HRT maintenance siding tracks that do not have overhead traction power provisions.

24.10.9 Electrical Bonding

24.10.9.1 Aerial Structures

All longitudinal reinforcement bars shall be tack welded at all overlaps to insure electrical continuity.

Collector bars of the same size as the transverse reinforcement shall be tack welded to the longitudinal reinforcement at expansion/contraction joints, ends of construction segments and ends of contractual sections. A steel bonding strap shall be welded between the upper and lower collector bars.

A minimum of two bonding cables shall be installed on each side of an electrical break in the structure.

Structural deck members shall be electrically insulated from support piers and abutments.

A ground system, and related test stations, shall be provided at each end of the structure and at intermediate points as required.

24.10.9.2 Retaining Walls

All longitudinal bar overlaps in both faces of the wall, including the top and bottom bars of the footing, shall be tack welded to insure electrical continuity. Longitudinal bars in the footing shall be made electrically continuous to the longitudinal bars of the walls. Collector bars and bonding cables shall be installed as stated above.

24.10.9.3 Utility Structures

All piping and conduit shall be non-metallic, unless metallic facilities are required for specific design purposes, or are an absolute requirement by the utility company. There are no special corrosion control provisions required if non-metallic materials are used.

To reduce the possible stray current effects on underground utilities, nonmetallic materials such as jackets or high quality coatings may be used. HRT owned and maintained utility structures, such as buried metallic pipes and conduits, shall be provided with electrical continuity. All HRT owned and maintained metallic pressure piping shall have cathodic protection.

All piping that penetrates structural walls shall be electrically insulated from the outside service piping at the first joint above finished floor inside the structure and isolated from all wall sleeves. Dielectric insulation shall be provided with test wires and boxes at a maximum distance of four feet above finished floor on the interior of the structural wall.

Replaced, relocated, and maintained in place utility structures, owned by others, shall be provided with corrosion measures required by individual agreements.

24.10.9.3 Drainage Facilities

The corrosion control design shall provide stray current control at drainage facilities including conduits, manholes, junction boxes, drainage buses, cables, drainage panels and other associated equipment. Substations shall be provided with equipment previously described in this Section.

24.10.9.5 Test Facilities

Test facilities shall be required on all HRT owned and maintained electrically bonded structures to measure and monitor possible stray currents. The corrosion control design shall provide test facilities for individual protected structures.

24.10.9.6 Quality Control

Corrosion control designs shall be coordinated with all other engineering disciplines to ensure that they do not conflict with other installations. Shop drawings, material catalog cuts, and additional information related to the corrosion control designs shall be submitted for review and approval. Testing of materials prior to their delivery from a manufacturer, or during construction, shall be conducted, as required, to ensure compliance with corrosion control designs.

24.10.9.7 Reinforced Slabs

All reinforcement in slabs on grade shall be electrically bonded or epoxy coated where subject to deicing salts. Where reinforcement is electrically bonded, epoxy coated bars are not required.

24.10.9.8 Stray Current Drainage

Each traction power substation shall include six stray current drainage facilities to enable the connection of underground metallic structures to the substation negative bus.

24.11 SOIL CORROSION CONTROL (BURIED STRUCTURES)

24.11.1 General

This subsection provides criteria for the design of systems and measures to prevent corrosion from soils and ground waters on HRT fixed facilities. Designs shall be based on achieving a 50-year design life for buried structures through the following considerations.

All piping (pressure and non-pressure) and conduit shall be non-metallic unless metallic materials are specified elsewhere in these criteria or are required for specific engineering purposes. Use of non-metallic materials shall be supported by structural calculations when used in lieu of metallic materials. Aluminum and its alloys shall not be used for direct burial purposes.

Corrosion control provisions shall be required for all facilities, regardless of location or material, when failure of such facilities caused by corrosion shall affect safety or interrupt continuity of operations.

24.11.2 Scope

The structures which may be affected by soil and water corrosion shall be identified. Typically, these include, but are not limited to the following:

- Ferrous pressure piping (water, fire main, gas, sewage ejectors, etc.)
- Buried and on-grade reinforced concrete structures
- Hydraulic elevator cylinders
- Support pilings

- Underground storage tanks
- Other underground structures

Corrosion control measures for structures owned by others shall be coordinated with the interested owner. This coordination shall be required to resolve design conflicts and to minimize impact of other designs, such as interference with cathodic protection.

All contacts with owners of other structures shall be coordinated through Hampton Roads Transit, as any resultant actions or corrosion control implementation measures may require some form of agreement between HRT and the affected utility.

24.12 SOIL CORROSION PREVENTION SYSTEMS

24.12.1 General

Protection of metal structures shall include, but not be limited to, corrosion control techniques, such as coating, electrical isolation, electrical continuity, and cathodic protection. The corrosion control design shall also coordinate the designs to identify reinforced concrete structures subject to corrosion attack and specify cement types in accordance with ASTM C150. For severe environments, supplemental coatings shall be specified.

24.12.2 Materials and Structures

24.12.2.1 Ferrous Pressure Piping

All HRT owned and maintained buried cast iron, ductile iron and steel pressure piping shall have cathodic protection. Designs shall include the following:

- Application of a protective coating to the external surfaces of the pipe.
- Electrical insulation from interconnecting piping, other structures, and segregation into discrete electrically insulated sections depending upon the total length of the piping.
- Electrical continuity through installation of insulated copper wires across all mechanical joints other than intended insulators.
- Permanent test/access facilities, to allow for verification of continuity, effectiveness of insulators and coatings. Evaluation of protection levels shall be installed at all insulated connections and at intervals not greater than 300 feet. This maximum interval corresponds to maximum spacing of either expansion joints (embedded track) or fixed structure joints (aerial structures).
- Impressed current anodes and rectifier units, or sacrificial anodes; the number of anodes and test facilities shall be determined on an individual structure basis.

24.12.2.2 Reinforced/Prestressed Concrete Pressure Pipe

Design and fabrication of reinforced concrete pipe and steel cylinder prestressed concrete pipe shall include the following:

- Establish a low permeability concrete by controlling the water/cement ratio, ratios of 0.3 for core concrete and 0.25 for mortar are preferred, industry practices may result in significant increases and wide variations to these levels.
- Maximum of 200 ppm chloride concentration in mixing water for concrete.
- Use of Type I Portland Cement is generally preferred for corrosion control purposes. Type II Portland Cement should be used only in selected locations.

24.12.2.3 Reinforced Concrete

Design shall be based on the following for concrete in contact with soils:

- Use of Type I Portland Cement is generally preferred for corrosion control purposes. Type II Portland Cement should be used only in selected locations.
- Maximum water/cement ratio of 0.45 by weight.
- Maximum 200 ppm chloride concentration in mixing water and admixtures combined.
- Minimum two-inch concrete cover on the soil side of all steel reinforcement when the concrete is poured within a form or a minimum three-inch cover when the concrete is poured directly against soils.

24.12.2.4 Support Pilings

Preferred design shall be based on using a steel shell filled with reinforced concrete, with the concrete as the load bearing member for maximum corrosion protection.

Design based on the used of metallic supports exposed to the soil such as H-beams shall consider the use of protective coatings and cathodic protection.

The need for special measures shall be based on the type of structure, analysis of soil borings for the corrosive characteristics of soils and the degree of anticipated structural deterioration caused by corrosion.

Electrical bonding shall be required for all steel piles.

24.12.2.5 Non-Metallic Materials

Plastics, fiberglass and other non-metallic materials for pressurized piping may be appropriate to aid in corrosion control. The corrosion control design shall consider the following characteristics of proposed materials:

- Manufacturer's recommendations
- Mechanical strength and internal pressure limitations
- Elasticity and expansion characteristics

- Comparative costs
- Expected life
- Failure modes
- Local codes
- Prior experiences with the proposed non-metallic material in similar applications

24.12.2.6 Hydraulic Elevator Cylinders

Steel hydraulic elevator cylinders shall be designed, fabricated, and installed to include:

- External protective coating resistant to deterioration by petroleum products (hydraulic fluid).
- Outer concentric fiberglass-reinforced plastic (FRP) casing. Casing thickness, diameter and resistivity shall be designed to prevent moisture intrusion, including through the bottom, and to maximize electrical insulation between the cylinder and earth.
- Sand fill between the cylinder and FRP casing with a minimum resistivity of 25,000 Ohm-cm, a pH between 6.0 and 8.0, and a maximum chloride content of 200 ppm.
- Cathodic protection through the use of sacrificial anodes installed in the sand fill or galvanic ribbon anode wrapped around cylinder.
- Permanent test facilities installed on the cylinder, anodes, and earth reference to permit evalution, activation, and periodic testing of the protection system.
- Removable moisture-proof sealing lid installed on the top of the casing prior to installation of the cylinder.

24.12.2.7 Electric Conduits

Buried metallic conduits shall include the following minimum provisions:

- Galvanized steel with a PVC topcoat or other coating acceptable for direct burial, including coupling and fittings.
- Galvanized steel with a minimum of three inches concrete cover on soil sides within duct banks.
- Electrical continuity through use of standard threaded joints or bond wires installed across non-threaded joints.

24.12.3 Coatings

Buried metal structures requiring coating shall be provided with coal tar mastic, coal tar tape, polyurethane, or coal tar epoxy coating systems having high electrical resistance. Mill-applied coatings shall be specified whenever possible with use of compatible tape coatings for joints and field touch-up. The corrosion control design shall specify surface

preparation, application procedure, primer, number of coats, and minimum dry film thickness for each coating system.

The proposed coating system shall be sufficiently durable to not require special handling or installation measures.

24.12.4 Electrical Insulation

Devices used for electrical insulators for corrosion control shall include non-metallic inserts, insulating flanges, couplings, unions, and concentric support spacers. Devices shall meet the following minimum criteria:

- Devices shall have a minimum of 10 megohms prior to installation and shall have mechanical and temperature rating equivalent to the structure in which it is installed.
- Devices shall have sufficient electrical resistance after insertion into the operating piping system such that no more than two percent of a test current applied across the device flows through the insulator, including flow through conductive fluids if present.
- Devices installed in an underground chamber or otherwise exposed to partial immersion or high humidity shall have a protective coating applied over all components.

The design shall specify the need for, and location of, insulating devices. All devices shall be equipped with permanent test facilities when they are not accessible or when specialized equipment is necessary for access.

Wherever possible, a minimum clearance of twelve inches shall be provided between new and existing structures. When field conditions prohibit a twelve inch clearance, the design shall include special provisions to prevent electrical contact with the existing structure(s).

24.12.5 Electrical Continuity

Electrical continuity shall be provided for all underground non-welded and soldered pipe joints and shall meet the following minimum criteria:

- Use direct burial insulated, stranded copper wires with the minimum length necessary to span the device being bonded.
- Exothermically weld all connections.
- Base wire size on the electrical characteristics of the structure and resulting network to minimize attenuation and allow for cathodic protection.
- Use a minimum of two wires per joint for redundancy.

24.12.6 Cathodic Protection

Cathodic protection systems shall be provided for buried metallic structures consistent with the structure life objectives and applicable NACE standards. Wherever feasible, cathodic protection shall be accomplished by sacrificial galvanic anodes to minimize corrosion interaction with other underground utilities. Impressed current systems shall be used only when sacrificial systems are not technically and economically feasible, and must be approved by HRT. Cathodic protection schemes using forced drainage of transit induced stray DC currents that require connections to the negative system, shall not be used.

Cathodic protection designs shall consider the following:

- Soil environment
- Mutual protection or interference configurations
- Limitations of protection potentials
- Test monitoring facilities

Cathodic protection system design shall be based on theoretical calculations using data from the Baseline Survey and geotechnical data for each system including the following minimum parameters:

- Cathodic current density (minimum 1.0 ma/sq.ft. of bare area)
- Current requirements
- Anticipated current output/anode
- Assumed percentage bare surface area (minimum 1%)
- Indicated total number of anodes, size, spacing
- Anticipated anode life
- Anticipated anode bed resistance

The sum of the anticipated anode life and time to failure based on corrosion rates anticipated at 90 percent cumulative probability level, shall be not less than 50 years.

Impressed current rectifier systems shall be designed using variable voltage and current output rectifiers. Rectifiers shall be rated a minimum 50 percent above calculated operating levels to overcome higher than anticipated ground bed resistance, lower than anticipated coating resistance, or presence of interference bonds. Other conditions which may result in increased voltage and current requirements shall be considered.

24.12.7 Test Facilities and Testing

Test stations consisting of two structure cables, one reference electrode, conduits, and termination boxes shall be designed to permit initial and periodic tests of cathodic protection levels, interference currents, and system components (anodes, insulated fittings, and continuity bonds). The corrosion control design shall specify the locations and types of test facilities for each cathodic protection system.

24.12.8 Water Treatment

For heating and air conditioning systems, chemical treatment of chiller, condenser, and boiler supply and return system shall be designed to minimize internal corrosion and to prevent component fouling. Water treatment systems shall prevent corrosion rates in excess of 2.0 mils per year for steel and 0.1 mil per year for copper. Provisions for corrosion rate measurements shall be made in the return lines. All chemical treatment systems shall comply with environmental protection requirements. The corrosion control design shall include appropriate measures and provide space requirements for treatment equipment.

24.12.9 Casings

Pipeline casings, if required, shall be installed bare, unless coating and cathodic protection is required by the utility owner or HRT. Casing insulators and spacers shall be installed on the carrier pipe to avoid electrical contact between the casing and the carrier pipe. Test leads are required for both the carrier and the casing.

24.13 ATMOSPHERIC CORROSION PREVENTION

24.13.1 General

The purpose of this section is to provide criteria for designs that shall ensure the necessary function and appearance of LRT structures exposed to the environment. Criteria for atmospheric corrosion control are based on prevention of appearance degradation and reduction of maintenance costs. System wide criteria for all areas shall include the following:

- Materials selected shall have established performance records for the service intended.
- Sealants shall be used in crevices to prevent the accumulation of moisture.
- Barrier or sacrificial protective coatings shall be used on steel.
- Use of dissimilar metals shall be avoided.
- Recesses or crevices that might trap moisture shall be avoided.
- Wayside electrical, signal and communication equipment, electrical motors, control panels, switchgear, etc. shall be enclosed in temperature controlled environments or otherwise incorporate design techniques to prevent moisture condensation and corrosion of internal parts.

24.13.2 Scope

The items which may be affected by atmospheric corrosion shall be identified. Typically, these include, but are not limited to:

- Catenary structures and hardware
- Vehicles

- Exposed metal surfaces on aerial and main track structures
- Exposed metal at stations
- Right-of-way and enclosure fences
- Shop and yard exposed metal surfaces
- Electrical, mechanical, signal and communication devices and equipment
- Traction power substation housings

24.14 ATMOSPHERIC CORROSION PREVENTION SYSTEMS

24.14.1 Materials

Metals exposed to the atmospheric environment shall be selected and provided as follows:

Steels and Ferrous Alloys

Carbon steel and cast iron exposed to the atmosphere shall have a coating applied to all external surfaces. Rail and rail fasteners shall not require coatings.

High strength low alloy steels shall be protected similarly to carbon steels except where used as weathering steel. Coating of metallic contacting surfaces, crevice sealing and surface drainage shall be addressed in the designs. Staining of adjacent structures shall be considered.

Series 200 and 300 stainless steels are suitable for use in any exposed situation without protection. Series 400 stainless steels are acceptable, but must be evaluated due to possible staining.

Stainless steel surfaces shall be cleaned and passivated after fabrication.

Aluminum Alloys

Use an anodized finish to provide the best weather resistant surface.

Copper Alloys

Copper and its alloys can be used where exposed to the weather without additional protection. Bimetallic couplings shall be avoided.

Magnesium Alloys

Magnesium alloys shall have a barrier coating applied when long term appearance is critical. Bimetallic coupling shall be avoided.

Zinc Alloys

Zinc alloys can be used without additional protection. Bimetallic coupling shall be avoided.

24.14.2 Coatings

Coatings shall have a proven past performance record and shall be compatible with the metallic surface to be coated. Resistance to chalking, and color and gloss retention shall be satisfactorily established for the life of the coating. The proposed coating system shall be sufficiently durable as to not require special handling or installation measures.

24.14.2.1 Organic Coatings

Organic coating systems shall consist of a wash primer (if substrate requires), a primer, intermediate coat(s) and a finish coat. Acceptable organic coatings for use are:

- Aliphatic polyurethanes
- Vinyl copolymers
- Epoxy as a primer where exposed in the atmosphere or as the complete coating system where protected from direct sunlight
- Acrylic where not exposed to direct sunlight
- Alkyd where not exposed to direct sunlight

24.14.2.2 Metallic Coatings (for Carbon and Alloy Steel)

Acceptable coatings are as follows:

- Zinc (hot dip galvanizing)
- Aluminum
- Aluminum-zinc

24.15 GROUNDING

24.15.1 Purpose

Ensure that grounding and corrosion control requirements do not conflict so as to render either system ineffective. The key to accomplishing complementary systems is proper location of insulation points and proper means of grounding systems.

24.15.2 Scope

Facilities addressed include the following:

- Traction power substations
- Aerial and catenary structures

24.16 DESIGN AND COORDINATION OF GROUNDING SYSTEMS

24.16.1 Aerial and Catenary Structures

Components installed on aerial structures, such as catenary poles, handrails, cable troughs, and other metal components, shall be electrically isolated from the reinforcing steel in the deck. At each end of the structure, insulated cables shall be exothermically welded to the reinforcing steel and terminated in an appropriately sized and conveniently located weatherproof junction box or manhole. Support piers and abutments shall be insulated from the structural deck members.

In order to provide compatible aerial grounding systems and corrosion control systems, the following items shall be coordinated:

- Ground electrode component materials
- Ground electrode locations
- Aerial component electrical continuity details
- Pier support and insulation details

24.16.2 Traction Power Substation

Corrosion control installations shall be coordinated with grounding electrodes, grounding standards, grounding requirements and IEEE Standards.

24.17 REFERENCES

1. Hampton Roads Transit, “Manual of Design Criteria”, Norfolk LRT Project, Draft, HRT, Dec. 2004.
2. See Section 24.7, Standards and Codes.

A.7 Appendix 7 - Abbreviations and Glossary

The abbreviations and glossary in this Appendix are provided for convenience and clarification of acronyms and terms specific to HRT adjacent construction projects. Many of the terms herein are used in this Manual, others may be used in project review comments.

A.7.1 Abbreviations

AASHTO:	American Association of State Highway and Transportation Officials
ACI:	American Concrete Institute
ADA:	Americans with Disabilities Act
AISC:	American Institute of Steel Construction
ANSI:	American National Standards Institute
AREMA:	American Railway Engineering and Maintenance Association
CAD, CADD:	Computer Aided Design (and Drafting)
CCTV:	Closed Circuit Television
CD:	Compact Disk
CFR:	Code of Federal Regulations
CGL:	Commercial General Liability (Insurance)
COE:	United States Army Corps of Engineers
Comm.:	Communications
DVP:	Dominion Virginia Power
FS:	Factor of Safety
HRSD:	Hampton Roads Sanitation District
HRT:	Hampton Roads Transit
LRT:	Light Rail Transit, a.k.a. The Tide
MOW:	Maintenance of Way
MSDS:	Material Safety Data Sheet
MSE:	Mechanically Stabilized Earth (Wall)
NACE:	National Association of Corrosion Engineers
NCCCO:	National Commission for the Certification of Crane Operators
NEC, NESC:	National Electrical (Safety) Code
NFPA:	National Fire Protection Association
OCC:	Operations Control Center
OCS:	Overhead Contact System (Light Rail Traction Power)
OH:	Overhead

OSHA:	Occupational Safety and Health Administration
PDF:	Portable Document Format
PE:	Professional Engineer
PPV:	Peak Particle Velocity
ROW, R/W:	Right-of-Way
SOP:	Standard Operating Procedure
SSWP:	Site Specific Work Plan
TMF, TMS:	The Tide Maintenance Facility, Shop Building
TPSS:	Traction Power Substation
UFAS:	Uniform Federal Accessibility Standards
UG:	Underground
VA:	Commonwealth of Virginia
VAC:	Voltage, Alternating Current
VDC:	Voltage, Direct Current
VDOT:	Virginia Department of Transportation
VNG:	Virginia Natural Gas
ZOI:	Zone of Influence

A.7.2 Glossary

Adjacent Construction: Any project by others that includes or impacts HRT owned or controlled real property, or rights-of-way pursuant to an easement, lease, license, or permit granted by HRT or jurisdiction.

Applicant: The owner, developer, consultant, or contractor responsible for the construction on or adjacent to HRT property.

Automobile Liability Insurance: A commercial automobile insurance policy covering the use of all owned, non-owned, hired, rented, or leased vehicles bearing valid registrations appropriate for the vehicle class.

Builder's Risk Insurance: An insurance policy covering all risk of physical damage to property under construction.

Bus Dispatch: The facility from which HRT buses are stored and deployed into revenue service.

CCTV: Abbreviation for closed circuit television security cameras, located on HRT vehicles and at various facilities.

Chainage or Stationing Marker: Signage located on OCS poles referencing the distance in feet from the western terminus of The Tide light rail line.

Commercial General Liability Insurance: An insurance policy covering the liability of a contractor for all work and operations under or in connection with a construction project, and all obligations assumed by the contractor under the contract.

Construction Inspector, HRT or City: A representative of HRT or jurisdiction that provides oversight of construction and ensures compliance with HRT and/or jurisdictional requirements and regulations.

Construction Work/Sequence/Staging Plan (includes Equipment Plan): A general plan prepared by the Applicant indicating the safe positioning and operation of major construction equipment, particularly cranes, within the HRT zone of influence, or within range of HRT right-of-way and areas of vehicle or pedestrian access.

Cut and Cover: A method of constructing an underground structure, primarily culverts and tunnels, by excavating from the surface, installing the structure, then backfilling and restoring the original surface.

Easement: The right to or an interest in property owned by another for a specific and limited purpose. Examples of easements include those required for access, utilities, construction, embankment slopes, and aerial occupancy. Easements may be for public or private purposes.

Embankment: A raised structure constructed of natural soil from excavation or borrow sources.

Encroachment: Use or occupancy of an existing easement or property without proper authorization.

Engineer of Record: The professional engineer who develops the design criteria and concept for a particular project and discipline, and who prepares or causes to be prepared under his/her immediate supervision the corresponding drawings, specifications, reports, or other documents, shall be designated the Engineer of Record for the project or discipline.

Flag Protection: A method of protecting revenue or non-revenue track using colored flags, lights, and/or radios to notify a train and work crew of impending train arrival.

General Orders, Train Orders: Official HRT documents that lists all approved track or other property rights requests, as well as other conditions affecting train or bus operations.

Geo-Reference: To define points, lines, and objects in a specified coordinate system, specifically to quantitatively locate improvements by an Applicant in or around HRT facilities.

Geotechnical Review: An engineering study of the geology and soils of a site that is submitted to determine the suitability of a site for development and recommends construction procedures designed to ensure structural adequacy or mitigate problem soils.

Milepost Marker: A location marker mounted on catenary poles showing the light rail route mileage from the operating origin point at Newtown Road.

Monitoring and Contingency Plan: A written plan implemented by the Applicant describing how the Applicant plans to provide physical surveillance of HRT facilities potentially impacted by the proposed construction. The plan also outlines the contingency procedure to be followed if strains, deformations, or movements of HRT facilities approach or exceed specified limits.

Monument: A permanent HRT survey marker or benchmark accurately defining a physical reference point by which surrounding HRT structures were located, generally defined by coordinates and elevations.

No Clearance Area: An area where minimum safe distance between all points on a moving vehicle and fixed wayside structure is not sufficient to allow personnel to occupy the area

during passage of the vehicle.

Operations Control Center: The facility from which train control and train supervision is accomplished for The Tide light rail system.

Overhead Contact System (OCS): The OCS describes the overhead wires and supporting structures, including poles, for the transmission and delivery of electrical traction power to light rail vehicles.

Post-Construction Survey: A detailed survey and analysis of HRT facilities and structures that were potentially impacted during adjacent construction, completed after all work is finished or there is no future possibility of impact to HRT. This task must be completed prior to the contractor de-mobilizing from the site.

Pre-Construction Survey: A detailed survey and analysis of HRT facilities and structures that may be potentially impacted by upcoming adjacent construction, completed prior to any work commencing within HRT's zone of influence.

Pre-Development Conference: Initial meeting(s) between the Applicant and HRT, inclusive or separate of other agencies, to determine the extent of impacts to HRT right-of-way, facilities, and operations. The conference supplements permit submittals and other written applications for approval. This provides an opportunity for HRT to provide and clarify any administrative, design, operational, and safety requirements for the Applicant during prosecution of the project work.

Railroad Protective Liability Insurance: An insurance policy issued to HRT for bodily injury and property damage liability of a contractor resulting from performance of project work within 25.0 feet of HRT right-of-way.

Red Tag Outage: For electrified light rail work, this term describes the procedure for full de-energization of traction power in a specified section of the system for purposes of working on the traction power equipment or distribution system, or when construction equipment has the possibility of contacting or working in close proximity of traction power equipment or overhead contact wires.

Revenue Service: Time(s) which HRT runs scheduled bus or rail service.

Right-of-Way: The land occupied by HRT for purposes of conducting its rail and bus operations, maintenance, vehicle storage, equipment storage, and parking.

Site Specific Work Plan: A detailed, time scaled, resource loaded work plan prepared by the Applicant that is specific to HRT property that describes the construction and associated work to be performed at specific locations. The plan outlines all work to be completed during track access or work within HRT's zone of influence.

Supervisory Outage: For electrified light rail work, this term describes the procedure for de-energization of traction power from OCC in a specified section of the system for purposes of working on The Tide light rail right-of-way when construction equipment has little possibility of contacting or working in close proximity of traction power equipment or overhead contact wires.

Surveyor of Record: The professional surveyor who develops the design criteria and concept for a particular project and discipline, and who prepares or causes to be prepared under his/her immediate supervision the corresponding field survey, drawings, specifications, reports, or other documents, shall be designated the Surveyor of Record for the project or discipline.

Technical Submittal: Applicant's submittal of documents required for HRT review of the

proposed construction. The Applicant should confirm that the submittal meets the requirements of this Manual, applicable design criteria, HRT directives, and any agreements specific to the project. For purposes of this Manual, technical submittal contents should be specific to HRT interests and impacts.

Track Rights: Exclusive permission for occupation of a specific section of track, requested through HRT Rail Operations.

Traction Power Outage: For work on The Tide light rail system, a traction power outage is generally required. See Red Tag Outage and Supervisory Outage.

Traction Power Substation: The facility that transforms and rectifies utility high voltage alternating current to 750 VDC propulsion current and supplies it via feeder cables to the OCS and light rail vehicles.

Work Area, Work Zone: The specific location and limits of proposed project work. For purposes of this Manual, the Work Area is limited to that portion of the construction that impacts HRT's right-of-way, operations, and access.

Work Train: Any track vehicle designated for maintenance purposes or to transport non-revenue passengers. A work train is a train or vehicle engaged in railway maintenance, repair work, or support thereof.

Zone of Influence: Designated area adjacent or within specific distance approximate to HRT structures and facilities, on which if construction activities are conducted, are likely cause impact to HRT. The definition of ZOI is provided and illustrated in detail in Appendix 1 of this Manual.