- Include a small kitchenette area with counter space for a small microwave or other small appliances. Kitchenette should include a sink and cabinet or storage space for miscellaneous kitchen supplies.
- No refrigeration equipment is required.
- Provide computer network communication line connected to TriMet's system.

16.5.2.2 Restroom

- Gender separated facilities are preferred in high use locations. Number of water closets and urinals shall be based on expected peak hour use.
- Internal layout to consider door placement and resulting views from other rooms.

16.5.2.3 Janitor/Storage Space

- Provide a mop sink.
- Allow for adequate storage of miscellaneous materials and supplies such as, mop and pail, broom, toilet paper, paper towels, cleaning supplies, etc. A separate storage room may be desirable depending upon the amount of storage space needed. In some cases, lockable cabinets may be all that is necessary. Consult with TriMet's Project Manager.

16.5.2.4 Mechanical and/or Electrical Room

- Provide dedicated room with adequate space for all equipment and the specific servicing requirements.
- Locate area drain near water heater.

16.5.2.5 Vending area

- Allow for adequate room either in the break room or other designated portion of the building for vending machines, such as soda, coffee, and/or snack machines. For help determining the type and number of vending units in a building, refer to the Facilities Maintenance Dept. vending contract manager.
- Provide sufficient receptacles (quad as needed) and other utilities for all the equipment.
- Provide floor drain specific to vending machines, if required.

16.5.3 Comfort Stations at Smaller Transit Centers or Layover Area – These buildings provide a place for TriMet bus and rail operators, supervisors, security personnel, and other TriMet staff to take a designated break, eat lunch, place a phone call, or use the restroom facilities.

These buildings are intended for TriMet personnel only with no public access. No personnel or security officers are permanently stationed in these buildings and no workstations are provided. The break buildings or the personnel within them are not intended to serve a proactive security or oversight role for the Transit Center. They should not encourage public interface.

These buildings experience extreme wear due to many factors including a constantly changing user group and heavy use. The design, layout and choice of materials must reflect the heavy use and provide ease of maintenance.

At some locations, the use of pre-manufactured or modular building systems may be allowed. If a pre-manufactured system is chosen, review Section 16.5.1 with TriMet's Project Manager to determine the applicable criteria before proceeding.

16.5.3.1 Break Area

- Sized to allow for a small table and chairs
- Include a small area with counter space for a small microwave.
- Provide counters of plastic laminate.
- Provide a hardwired space heater.

16.5.3.2 Restroom

- Restroom(s) with water closet and lavatory.
- Provide faucet tap inline with water system under sink, for filling mop bucket.
- Ceiling mounted space heater
- Provide room to store mop bucket.

16.5.3.3 Janitor/Storage and Mechanical/ Electrical Cabinet(s)

- Provide locked closet/cabinet for water heater and electrical panel
- Provide locked closet/cabinet for paper products and cleaning supplies.
- Uses may be combined in one closet/cabinet.

16.5.4 Concession Buildings – These buildings provide a facility for TriMet contracted concessionaires to dispense services such as: food and beverage services, communications services, home and family services, convenient services, public services offices, personal services and entertainment services.

They are intended for concessionaire use only with no public access. One goal of the Concession Program is to provide greater public presence at transit sites, which improves TriMet patron perceptions of safety and security.

Currently the predominant concessionaires provide pre-packaged foods and beverages, but as TriMet's program grows a broader range of customer services will be provided such as video rentals, dry cleaning etc. The interior spaces should be designed to allow for easy modifications.

Separate water shut off and electrical shut off on the outside of the building must be provided and secured. TriMet will not have keys to the concessionaire interior space and may need to shut services off in an emergency.

16.5.4.1 Main Concession Room

- Size to allow for adequate counter top space and storage expected for type of concession to be provided. Typical concession building equipment includes, espresso machine, refrigerator, freezer, ice machine, soda fountain, small microwave, and a blender. For help determining the expected needs for the main concession room area, refer to the Facilities Service Manager.
- Provide counter space and sliding windows on the exterior of the building for serving the public.
- Provide a display case window.
- Windows at service area to slide open and lock.

- No window coverings or blinds are required.
- At a minimum provide two standard phone lines and jacks for concessionaire's use. Some locations may warrant a data link provided for public use.
- Front door access should provide coverage from the elements.
- Provide adequate, separate outlets for multiple appliances.
- Provide cabinet space for storing concessionaire's supplies.

16.5.4.2 Restroom – Provision of a restroom should be evaluated on a site specific/use basis. As a guideline, if a concession facility is in a remote location, or a significant distance from an existing TriMet facility, a restroom should be provided. If provided, the restroom may be combined with mechanical room.

16.5.4.3 Mechanical and/or Electrical Room

- Provide a room with adequate space for all equipment and servicing.
- Locate the area drain near the water heater.

16.5.4.4 Janitor/Storage Space

- Allow for adequate storage of miscellaneous materials and supplies such as toilet paper, paper towels, cleaning supplies, etc. A separate storage room may be desirable depending upon the amount of storage space needed. In some cases, lockable cabinets may be all that is necessary.
- Provide a mop sink.

16.5.5 Security Buildings – These buildings provide a facility for TriMet contracted security personnel use with no public access.

At some locations, the use of pre-manufactured or modular building systems may be allowed. If a pre-manufactured system is chosen, review Section 16.5.1 with TriMet's Project Manager to determine the applicable criteria before proceeding.

16.5.5.1 Break Area

- Size to allow for a small table and chairs.
- Include a small area with counter space for a small microwave.
- Provide a standard phone line.
- Provide counters of plastic laminate.
- Provide a hardwired space heater.

16.5.5.2 Restroom – This should be evaluated on a site specific/use basis. As a guideline, if a security facility is in a remote location, or is a significant distance from an existing TriMet facility, a restroom should be provided. If provided, the restroom may be combined with a mechanical room.

16.5.5.3 Storage and Mechanical/ Electrical Cabinet(s)

- Provide locked closet/cabinet for water heater and electrical panel.
- Provide locked closet/cabinet for paper products and cleaning supplies.
- The above uses may be combined in one closet/cabinet.

16.6 LRT SYSTEM BUILDING DESIGN OBJECTIVES

It is critical that the specific function and performance objectives of the building are understood prior to beginning the design. These buildings receive essential equipment that has specific spacing and access requirements. *Confirm size type and location of these elements during the various stages of design.* Review site requirements and confirm vehicular and pedestrian access requirements to these buildings. Building materials shall be chosen in accordance with Chapter 19. There shall be no windows installed in any of the system buildings, unless directed otherwise. A minimum number of solid glass blocks may be proposed for natural lighting, subject to approval of TriMet's Project Manager. Lighting will only be on at times when occupied by maintenance personnel.

Where possible, combine system uses into one building to reduce land acquisition, project and maintenance costs, and parking spaces. For example, strong consideration should be given to one building shell for co-located signals and communications equipment. If joint-use buildings are designed, a full height partition must separate the uses securely and separate entrances must be provided. Joint-use buildings shall have the capability of separate heating and cooling system control, or shall be provided with separate HVAC systems, for the traction power, signals and/or communications equipment, respectively.

16.6.1 Common System Building Design Requirements

16.6.1.1 General

- The building shall be manufactured of masonry or concrete materials, either modular or CMU.
- Provide a Unistrut system (or approved equal) for hanging equipment and cabling at ceiling height (minimum 9'-6"). Both maximum suspended loads and uniform loads shall be calculated for the system. Coordinate with TriMet's Project Manager.
- The floor shall have a permanent moisture barrier under the concrete floor to prevent moisture from wicking from the soil beneath the slab.
- Floors shall be coated with a concrete floor sealer. Additional floor finish requirements apply to TPSS buildings (See Section 16.6.2.3).
- Provide an in-floor manhole for cable entry into signal and communication buildings. Coordinate the location and structural characteristics wit TriMet.
- If drywall interior is used, studs and framing shall be metal. Wood framing is not acceptable.
- Electrical panels shall be surface mounted.
- At commencement of design, consult TriMet's Project Manager to determine required service voltage, phasing, ampacity and metering. LRT traction power shall be metered separately from all other building and electrical services.
- The building walls and roof shall be insulated to prevent condensation or heat build-up. Insulation shall be fiberglass batt in the walls and solid insulation on the roof.
- Batt insulation shall be specified for use in attic spaces.
- Roof joists or framing shall be non-combustible materials.
- All door locks shall be Schlage type D with blank Primus type cylinders with dead bolt, or approved equal. Final keying will be by TriMet.

- Provide one PBX (Private Business Exchange) phone for each use within a building.
- Refer to grounding requirements in Chapter 11.
- The roof must have enough slope to allow for proper channeling of water.

16.6.1.2 Building Heating and Ventilation

- Sufficient air changes and ventilation openings shall be provided to ensure that the temperature will not exceed 104°F.
- At commencement of design, consult TriMet's Project Manager to determine required ventilation based upon equipment heat load.
- Louvers and fans shall be sized for the specific building use and located where possible to minimize infiltration of dust. Lower depth shall no project beyond the doorjamb to minimize interference with electrical equipment.
- Filters shall be provided to remove particulates from the air. Two-inch disposable filters shall be used with all louvers. Filter life should be at least one month.
- Provide heaters with thermostat as required by Operations and MOW.
- Heaters shall maintain an interior temperature of 50°F minimum.

16.6.1.3 Fire Protection

- Fire suppression will be via hand-held extinguishers.
- Provide smoke detectors connected to SCADA for monitoring at TriMet's Control Center.
- In general, fire sprinklers are not acceptable in LRT systems buildings. Utilize alternative systems as necessary to satisfy local code requirements.
- Satisfy applicable, local fire building code requirements and UBC.

16.6.1.4 Lighting and Receptacles

- Interior lighting plans shall be shall be coordinated with the comprehensive equipment furnishings layouts to minimize shadows from suspended equipment, raceways and equipment racks.
- Receptacle location plans shall be coordinated with equipment layout and requirements.
- Motion sensors shall be installed on interior lighting, location to be coordinated.
- Interior fixtures shall be 4-lamp industrial fluorescents.
- Exterior and interior light levels are specified in Section 11.5.
- Exterior and interior light requirements shall follow Section 16.4.

16.6.1.5 Clearance to Trackway – Buildings shall be located in such a way as to not obstruct the view of the train operators or pedestrians, and to allow clear line of sight and grade crossing equipment.

Buildings, including roofline, etc., shall be placed at least 6 inches outside the dynamic envelope. All attempts shall be made to avoid doorways opening toward the trackway. If this cannot be achieved, railing or other barrier must be installed at least 6 inches outside the dynamic envelope. The barrier shall allow full operation of the doorway and unobstructed access and egress.

16.6.2 Traction Power Substation Building – The substation building contains equipment

that transforms electric power to dc traction power. The building's typical interior dimensions are 42 feet 10 inches L x 20 feet and 2 ½ inches W. A minimum clearance height of 9'-6" shall be dedicated for equipment.

16.6.2.1 Doors – Traction Power Substation buildings shall be fitted with double doors. Doors shall have a clearance height of 9'-0" and a clearance width of 9'0" to allow removal and installation of switchgear.

16.6.2.2 Framing Channel – Framing channel (Unistrut or equal) shall be provided every 4 feet on-center on walls and ceiling for the support of lighting and equipment.

16.6.2.3 Insulated Floor – The substation building floor shall be finished to a flatness standard of FF30 as defined in ACI 302.1R-96. The dc equipment side of the floor shall be coated with an epoxy material in lieu of a concrete sealer to insulate and electrically isolate the dc switchgear from any grounded objects. This coating is normally applied by the switchgear installation contractor.

16.6.2.4 Heating and Ventilation – Exhaust ventilation shall be provide to two single-speed propeller fans set up in a two-stage operation with a two-stage thermostat. Heating shall be provided by15kw electric unit heater, forced air, and thermostat, ceiling-mounted.

The ventilation shall be designed using the following criteria:

- Maximum design outside air temperature 90°F
- Minimum design outside air temperature 24°F
- Substation equipment heat load 35kW
- Minimum permissible inside temperature 40°F (equip. off)
- Maximum permissible inside temperature 104°F*

*Note: The electrical equipment is rated to function in ambient air up to 104°F at 100% of capacity continuously without damage or overheating. Operation above 104°F may shorten equipment life. TriMet recognizes that during extremely hot weather, the substation temperature may rise above 104°F. Air conditioning shall not be used.

The substation ventilation engineer shall provide the following stamped calculations as part of the design:

Calculated fan HP and CFM
Calculated maximum substation inside air temperature given outside ambient of 95°F, 100°F and 105°F.

The heating and ventilation equipment, including starters and thermostats, will be furnished, installed and wired back to the ac panel board.

Ventilation thermostats shall be two-stage and set so that the first stage turns on at 85°F and off at 80°F. The second stage of ventilation will turn on at 95°F. The heating should turn on at 40°F and off at 45°F when the station is unmanned. Thermostats should be

continuously adjustable "manual-to-off" to allow for maintaining comfortable temperature when maintenance personnel are working in the substation.

Two adjustable air dampeners shall be provided within ductwork to adjust the flow of air over the equipment. One dampener shall be located directly across from the side door, and the other near the rectifier cubicle, approximately midway between the side door and the end man door. All ventilation ductwork and fans must be located above the ceiling and not permit entry of moisture during driving rain.

16.6.2.5 Emergency Lighting and Receptacles – Emergency lighting shall be by wall-mounted emergency lighting units with integral battery suitable for 90 minutes minimum operation at rated lamp output. Emergency lighting will be for egress only, and not sized for illumination sufficient for maintenance of equipment. Emergency lighting shall turn on upon loss off power, regardless of whether the substation is manned to provide for illumination in case of an accident within the substation that trips the auxiliary power.

Branch circuits that feed loads not related to the substation loads, such as sprinkler controllers, are not permitted within the substation.

16.6.2.6 Embedded Conduits and Trench – The contractor shall provide embedded and concealed conduits. Type EMT conduits shall be concealed in the walls, or PVC/GRS conduit or epoxy-coated GRS conduit run under the floor slab. Dedicated 18" by 18" trenches shall be provided for both dc and high-voltage ac conductors to allow for different configurations and manufacturers of equipment.

Exterior lighting will be on its own circuit. Interior lighting and interior convenience receptacles will also have separate circuits.

Branch circuits that feed loads not related to the substation loads, such as sprinkler controllers, are not permitted within the substation.

16.6.2.7 Intrusion Detection – Intrusion detection systems must be provided in all substation buildings. This intrusion detection system shall be connected to TriMet's SCADA system. When SCADA connections are provided, no other monitoring shall be used.

16.6.3 Signal Building – The signal building contains all equipment necessary for the operation of the train signals, power switch machines and at-grade crossing protection. The building's typical interior dimensions are 22' L x 11'-6" W. A clearance height of 9'-6" clear height is dedicated for equipment. Additional requirements for signal equipment interfaces and uses are presented in Chapter 12. Specific dimensional requirements must be verified for each structure.

A 6'-4" W x 7'-0" H double door will be provided for access. The door will have louvers installed to increase ventilation. The exterior grade directly adjacent to the double door must be designed to allow installation and removal of equipment with a boom truck. Door thresholds and grading must be adequate to prevent water from entering the building under the door.

Signal rooms shall be equipped with ventilation and heating to achieve a constant temperature within 10 degrees of outside ambient temperature. Vent fans must be provided which are adequate to the building size and heat load. Ventilation thermostats shall be two-stage and set so that the first stage turns on at 85°F and off at 80°F. The second stage of ventilation will turn on at 95°F. Heating shall be provided by a ceiling-mounted forced air electric unit heater with thermostat. The heating should turn on at 40°F and off at 45°F when the signal room is unmanned. Thermostats should be continuously adjustable "manual-to-off" to allow for maintaining comfortable temperature when maintenance personnel are working in the substation.

16.6.4 Communications Building – The communications building contains all equipment necessary for operational communications. The building's typical interior dimensions are 11' L x 10' W. A clearance height of 9'-6" is dedicated for equipment. Additional requirements for equipment interfaces are presented in Chapter 13. Specific dimensional requirements must be verified for each structure.

A 6'-4" W x 7'-0" H double door will be provided for access. The door will have louvers installed to increase ventilation. The exterior grade directly adjacent to the double door must be designed to allow installation and removal of equipment with a boom truck. Door thresholds and grading must be adequate to prevent water from entering the building under the door.

Requirements for doors and HVAC shall have the same as Section 16.6.3 above.

TRIMET

CHAPTER 18

ENVIRONMENTAL AND RECYCLING

CHAPTER 18 – ENVIRONMENTAL AND RECYCLING

18.1 GENERAL

TriMet is committed to being an environmental leader. This commitment includes not only simple compliance with environmental regulations, but also the prevention of pollution and the reduction of our impact on the environment.

This chapter establishes criteria regarding environmental and economic performance of built structures using green industry principles, best practices and standards. The chapter is to be used by designers and stakeholders as a guide for TriMet's green design.

Each section discusses a major design consideration, the design goal(s) for that issue, the guiding TriMet requirements or strategies to achieve the goal, and known applicable state, local and federal requirements to be implemented.

Many terms are used to describe the overarching concept of environmentally sensitive design and construction. This chapter uses the word sustainable, which is intended to encompass all the various topics included within the overarching concept.

Consultants must work closely with TriMet's Project Manager early in project scoping to:

- Identify project budget impacts for sustainable design and construction options.
- Identify specific sustainability goals, potential certifications to be pursued and potential revenue, tax credits or other incentives that may be available to offset initial costs for sustainable construction.
- Establish methodologies for evaluating the life cycle costs and benefits of specification of more costly features and systems.

Several programs exist for certifying a given project as sustainable. Obtaining these certifications requires careful planning and documentation, but certification may result in financial incentives and additional project funding. A partial list of incentive programs are listed at the end of this chapter.

18.2 EROSION AND SEDIMENTATION CONTROL

18.2.1 Goal for erosion control – Design erosion control to reduce negative impacts on water and air quality.

18.2.2 Specific requirements for erosion control – Develop a site sediment and erosion control plan that conforms to best management practices in the EPA's Storm Water Management for Construction Activities, EPA Document No. EPA-833-R-92-001, Chapter 3, OR local Erosion and Sedimentation Control standards and codes like those recommended by Oregon DEQ, whichever is more stringent. The plan must achieve the following benefits:

- Prevent loss of soil during construction by storm water runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse.

- Prevent sedimentation of storm sewer or receiving streams and/or air pollution with dust and particulate matter.

The EPA standard lists numerous measures such as silt fencing, sediment traps, construction phasing, stabilization of steep slopes, maintaining vegetated ground cover and providing ground cover that will meet this prerequisite.

Investigate the use of "green manures" for erosion control and site topsoil improvements. Green manures are plants, usually nitrogen-fixing, that can be installed for erosion control and then tilled into the soil as an amendment where landscapes will be installed. Designers shall thoroughly document permit agency approval in advance of this approach being specified for jurisdictionally required erosion control.

Investigate the use of "compost berms" to meet erosion control requirements. These berms can be used for amendment of landscape area topsoil when erosion control is no longer necessary. Consultants shall thoroughly document permit agency approval in advance of this approach being specified for jurisdictionally required erosion control.

18.2.3 Goal for avoiding development of inappropriate sites – Avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

18.2.4 Specific requirements for avoiding development of inappropriate sites – Avoid development of buildings on portions of sites that meet any of the following criteria:

- Prime agricultural land as defined by the Farmland Trust.
- Land whose elevation is lower than 5 feet above the elevation of the 100-year flood as defined by FEMA.
- Land that provides habitat for any species on the Federal or State threatened or endangered list.
- Within any wetland as defined by 40 CFR, Parts 230-233 and Part 22, OR as defined by local or state rule or law, whichever is more stringent.
- Land that prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner.

Utilize landscape architects, ecologists, environmental engineers, civil engineers and similar professionals for the screening process. New wetlands constructed as part of storm water mitigation or other site restoration efforts are not affected by the restrictions of this section.

18.3 POLLUTION PREVENTION

New sources of pollution can be mitigated or prevented by following the goals and requirements of this section.

18.3.1 Goals for locating development – Aim development toward urban areas with existing infrastructure, protecting greenfields and preserving habitat and natural resources.

18.3.2 Specific requirements locating development – During the site selection process give preference to previously developed sites with urban redevelopment potential.

18.3.3 Goal for rehabilitating damaged sites – Where possible and practical, rehabilitate damaged sites that are complicated by environmental contamination, thereby reducing pressure on undeveloped land.

18.3.4 Specific requirements for rehabilitating damaged sites – Give priority to development on a site classified as a brownfield and provide remediation as required by EPA's Brownfield Redevelopment program requirements. Participate in EPA's Brownfield Redevelopment program. Utilize EPA OSWER Directive 9610.17 and ASTM Standard Practice E1739 for site remediation where required. Gain community support by highlighting the social and urban benefits of brownfield redevelopment. Negotiate with local municipalities and landowners for below-market purchase price for brownfield real estate.

18.3.5 Goal for reducing automobile impacts – Reduce pollution and land development impacts from automobile use.

18.3.6 Specific requirements for reducing automobile impacts – Locate building within ½ mile of a commuter rail, light rail or subway station or ¼ mile of 2 or more bus lines. Provide suitable means for securing bicycles, with convenient changing/shower facilities for use by cyclists, for 5% or more of building occupants.

18.3.7 Goal for reducing impacts to native vegetation – Reduce land development impacts on native vegetation.

18.3.8 Specific requirements for reducing impacts to native vegetation – Reduce building footprints by tightening program needs and stacking floor plans. Establish clearly marked construction and disturbance boundaries. Delineate lay down, recycling, and disposal areas. Use areas to be paved as staging areas. Select indigenous plant species for site restoration and landscaping.

18.3.9 Goal to limit disruption of natural water flows – Limit disruption of natural water flows by minimizing storm water runoff, increasing on-site infiltration and reducing contaminants.

18.3.10 Specific requirements to limit disruption of natural water flows – Implement a storm water management plan that maximizes on-site water infiltration, provides on-site treatment systems designed to lessen total suspended solids (TSS), and total phosphorous (TP). Where feasible, implement Best Management Practices (BMPs) outlines in EPA's Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (EPA 840-B-92-002 1/93).

Where feasible, reduce impervious surfaces, maximize on-site storm water infiltration and retain pervious and vegetated areas. Capture rainwater from impervious areas of the building for groundwater recharge or reuse within building. Consider the use of green/vegetated roofs. Utilize biologically based and innovative storm water management features for pollutant load reduction such as constructed wetlands, stormwater filtering systems, bioswales, bio-retention basins, and vegetated filter strips.

18.4 HEAT MITIGATION

18.4.1 Goal for reducing heat islands – Reduce heat islands (thermal gradient differences between developed and undeveloped areas) to minimize impact on microclimate and human and wildlife habitat.

18.4.2 Specific requirements for reducing heat islands

Site Design

- Provide shade (within 5 years) on at least 30% of non-roof impervious surface on the site, including parking lots, walkways, plazas, etc., OR
- Use light-colored materials for 30% of the site's non-roof impervious surfaces, OR
- Place a minimum of 50% of parking space underground OR
- Maximize the use of an open-grid pavement system

Employ design strategies, materials, and landscaping designs that reduce heat absorption of exterior materials. Include albedo/reflectance requirements in the drawings and specifications. Provide shade (calculated on June 21, noon solar time) using native or climate tolerant trees and large shrubs, vegetated trellises, or other exterior structures supporting vegetation. Substitute vegetated surfaces for hard surfaces. Explore elimination of blacktop and the use of new coatings and integral colorants for asphalt to achieve light colored surfaces.

Roofing – Consider use of an ENERGY STAR Roof compliant, high-reflectance AND low emissive roofing (initial reflectance of at least .65 and three-year-aged reflectance of at least .5 when tested in accordance with ASTM E408) for a minimum of 75% of the roof surface; OR, install a "green" (vegetated) roof for at least 50% of the roof area.

18.5 WATER CONSERVATION

18.5.1 Goal for potable water use for irrigation – Eliminate the use of potable water for landscape irrigation other than during the plant establishment period.

18.5.2 Specific requirements for potable water use for irrigation – See Chapter 5 – Landscaping.

18.5.3 Goal for generation of wastewater – Reduce generation of wastewater and potable water demand.

18.5.4 Specific requirements for reduction of wastewater – Reduce the use of municipally provided potable water for building sewage conveyance.

Consider strategies for decentralized on-site wastewater treatment and reuse systems. Consider the use of non-potable water for sewage conveyance. Non-potable reuse opportunities include, toilet flushing, and landscape irrigation. Consider providing wastewater treatment after use by employing innovative, ecological, on-site technologies including constructed wetlands, a mechanical recirculating sand filter, or aerobic treatment systems.

18.5.5 Goal for maximizing water efficiency – Design for cost-effective, water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems.

18.5.6 Specific requirements for maximizing water efficiency – Specify cost-effective, water conserving plumbing fixtures that exceed Energy Policy Act of 1992 fixture requirements in combination with ultra high efficiency or dry fixture and control technologies. Specify high water efficiency equipment (dishwashers, compressors, cooling towers, etc.). Consider the use of non-potable water for sewage transport water. Consider cost-effective use of recycled or storm water for HVAC/process make up water.

18.6 BUILDING OPERATIONS

18.6.1 Goal for building systems – Ensure that building operational systems are designed, installed and calibrated to operate as intended.

18.6.2 Specific requirements for building systems – Implement the following Building Commissioning procedures:

- Include commissioning requirements in the construction documents
- Develop and utilize a commissioning plan
- Verify installation, functional performance, training and documentation
- Complete a commissioning report

Introduce standards and strategies early in the design process and include the performance requirements in the construction documents. Tie contractor final payments to documented system performance.

18.6.3 Goal for building performance – Verify and ensure that the entire building is designed, constructed, and calibrated to operate as intended.

18.6.4 Specific requirements for building performance –Implement the following performance verification tasks:

- Conduct a focused review of the design prior to the construction documents phase.
- Conduct a selective review of the contractor submittals of commissioned equipment.

Introduce standards and strategies early in the design process and then implement any selected measures by clearly stating target requirements in the construction documents.

18.7 GREENHOUSE GAS REDUCTION

18.7.1 Goal for greenhouse gas reduction – Design for reduction of ozone depletion.

18.7.2 Specific requirements for greenhouse gas reduction – Prohibit use of CFC-based

refrigerants in new base building HVAC&R systems. When reusing existing HVAC equipment, undertake a comprehensive CFC phase out.

18.8 ENERGY EFFICIENCY

18.8.1 Goal for energy efficiency – Achieve increasing levels of energy efficiency above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

18.8.2 Specific requirements for energy efficiency – Reduce energy use in HVAC systems, building envelope, service hot water systems, and lighting.

Perform interactive energy use analysis for selected design elements that affect energy performance and document compliance. Unit of measure for performance shall be annual energy cost expressed in dollars. Annual energy costs shall be determined using rates for purchased energy, such as electricity, gas, oil, and water and approved by the adopting authority, Refer to the LEED Reference Guide, current and applicable version, for a wide variety of energy efficiency resources and strategies including conservation measures, electromechanical energy efficiency technologies, passive heating and cooling strategies, and day lighting.

18.8.3 Building siting and passive solar – Consider building siting, orientations, and forms that take advantage of passive solar energy conservation strategies.

18.9 RECYCLABLES

18.9.1 Goal for waste reduction – Facilitate the reduction of occupant-generated waste that is disposed in landfills.

18.9.2 Specific requirement for waste reduction – Provide an easily accessible area serving the entire building that is dedicated to the separation, collection and storage of materials for recycling including. Recycled materials shall include (at a minimum) paper, glass, plastics, and metals.

Reserve space for recycling functions early in the building occupancy programming and show areas dedicated to collection of recycled materials on space utilization plans. Other recycled materials that may be considered include newspaper, organic waste (food and soiled paper), and dry waste. When collection bins are used, they should be able to accommodate a 75% diversion rate and be easily accessible to custodial staff and recycling collection workers. Bin designs should allow for easy cleaning to avoid health issues and must be covered to reduce storm water impacts.

18.10 BUILDING LIFE CYCLE EXTENSION

18.10.1 Goal for existing building material reuse – Extend the life cycle of existing building stock in order to conserve resources, retain cultural resources, reduce waste, and reduce

environmental impacts of a new building's materials manufacturing and transport.

18.10.2 Specific requirements for existing building material reuse – Where feasible, reuse large portions of existing structures during renovation or redevelopment. Maintain at least 75% of existing building structure and shell (exterior skin and framing excluding window assemblies).

Evaluate retention and adaptive reuse of existing structures. Consider facade preservation, particularly in urban areas. During programming and space planning, consider adjusting needs and occupant use patterns to fit within existing building structure and interior partition configurations. Identify and effectively address energy, structural, and indoor environmental (lead & asbestos) issues in building reuse planning and deconstruction documents. Percentage of reused non-shell building portions will be calculated as the total area (s.f.) of reused walls, floor covering, and ceiling systems, divided by the existing total area (s.f.) of walls, floor covering, and ceiling systems. Perform life cycle cost analysis upon request for windows, HVAC, compressors, boilers and cooling towers.

18.11 CONSTRUCTION RECYCLING – SALVAGEABLE MATERIALS

18.11.1 Goal for construction waste management – Divert construction, demolition, and land clearing debris from landfill disposal. Redirect recyclable material back to the manufacturing process.

18.11.2 Specific requirements for construction waste management – Develop and implement a waste management plan, quantifying material diversion by weight. Recycle and/or salvage much of the construction, demolition, and land clearing waste. Utilize the Metro recycling guide for vendor and contractor contact information.

Develop and specify a waste management plan that:

- Identifies licensed haulers and processors of recyclables
- Identifies markets for salvaged materials
- Employs deconstruction, salvage, and recycling strategies and processes

Source reduction on the job site should be an integral part of the plan. The plan should address recycling of corrugated cardboard, metals, concrete brick, asphalt, land clearing debris (if applicable), beverage containers, clean dimensional wood, plastic, glass, gypsum board, and carpet. The plan should also evaluate the cost-effectiveness of recycling rigid insulation, engineered wood products and other materials. Refer to Metro's Construction Industry Recycling Toolkit (http://www.metro-region.org) for information about recyclers in the Portland area. If the job site is in the City of Portland and permit value exceeds $50,000, construction and demolition debris may be required by ordinance to be recycled.

18.11.3 Goal for use of recycled building material – Extend the life cycle of targeted building materials by using recycled materials, reducing environmental impacts related to materials manufacturing and transport.

18.11.4 Specific requirements for use of recycled building material – Specify salvaged or refurbished materials for a portion of building materials. In particular, consider reuse of

materials that exist on-site and would otherwise be demolished or removed.

Commonly salvaged building materials include wood flooring/paneling/cabinets, doors and frames, mantels, ironwork, decorative lighting fixtures, brick, masonry and heavy timbers. See the LEED Reference Guide for calculation tools and guidelines.

18.11.5 Building Deconstruction – Compare costs for deconstruction/salvage of existing structures to costs for demolition. If deconstruction is more expensive, consult with TriMet's Project Manager to determine if TriMet would be willing to pay a premium for deconstruction and salvage. If deconstruction is less expensive, include deconstruction and salvage requirements in the specifications.

18.12 REUSE OF EXISTING MATERIALS

18.12.1 Goal for reuse of existing or surplus materials – Seek ways to reuse existing on-site materials and off-site surplus materials and equipment. The reuse of existing pavement, sidewalk, buildings, landscaping, etc. and the use of TriMet surplus materials and equipment such as light poles, fixtures, etc. may help to reduce project costs and achieve TriMet's goal of sustainability.

18.12.2 Specific requirements for reuse – Consult with TriMet's Project Engineer for potential available surplus items.

18.13 SUSTAINABILITY RESOURCES

Earth Advantage
Rebates, consulting services
Customized enviro-consulting and design assistance, and rebates based on integrated green features and their cost effectiveness.
Projects must be pre-approved by PGE – the earlier the better – and must pass a post-construction inspection.
www.portlandgeneral.com

Oregon Energy Loan
Low-interest loan
Loans up to $100,000 for environmentally friendly projects within three weeks - larger loans in a month or more – for engineering and design, permitting and project management costs (plus tax credit for some commercial work).
Application fee is .1 percent (up to $2,500) of the dollars requested. Includes and underwriting fee of .5 percent with a $500 minimum and $5,000 maximum.
www.energy.state.or.us

Oregon Business Energy Tax Credit (BETC)
Tax credit
A 35 percent tax credit over five years for investment in green features; eligible project costs of $20,000 or less can take the credit for one year. A pass-through partner or third party can claim the credit and give the project owner a lump sum cash payment.

You must apply for the tax credit before starting construction and can't start until you application is approved.
www.energy.state.or.us

Portland Green Building Initiative
Faster permitting, grants
Portland gives processing priority to green building projects. Builders and developers who follow construction guidelines can apply for a grant.
Fees may be charged to non-green builders to fund the proposed incentive.
www.ci.portland.or.us

TRIMET

CHAPTER 19

ARTS & AMENITIES

CHAPTER 19 – ARTS & AMENITIES

This chapter establishes criteria for public art and customer amenities in TriMet's transit facilities. These criteria have been developed as a technical guide for implementing TriMet's Public Art Program and the standard amenities for TriMet's public transit facilities.

19.1 BASIC GOALS

Arts and Amenities included in TriMet's capital projects are intended to provide effective customer information and enhance the quality of the region's transit experience. When applied consistently and effectively, these factors have a positive impact on TriMet's ability to attract and sustain riders. In an effort to keep project funds in the local economy, strive to provide materials and equipment that can be procured through local or regional manufacturers and fabricators. All elements deployed should endeavor to support TriMet's sustainability goals.

The design and placement of all transit amenities shall comply with the ADA's *Accessibility Guidelines for Transportation Facilities.* See Code of Federal Regulations CFR Title 49, Part 37, *Appendix A – Standards for Accessible Transportation Facilities.*

Category	Goals and Principles
Public Art	Promote increased transit use and community pride by integrating temporary and permanent art works into TriMet's public transit system, thereby celebrating the contributions of public transportation and recognizing the cultural richness in the region. Utilize local, regional and national artists to develop high quality public artwork to enhance the transit environment. Commission artwork that is structurally sound and resistant to theft, vandalism, weathering and excessive maintenance costs. Commission artwork that presents no public safety hazards nor creates any impediment to ADA compliance.
Light Rail Station Amenities	Select amenities from TriMet's existing design alternatives as appropriate for the character of each neighborhood or community. Promote safe, secure, friendly and fun transit facility that is accessible to all, including people with disabilities. Develop systems that use low maintenance materials and minimize life cycle costs. Provide clear and easily understood transit information that can be referenced quickly and that minimizes disorientation.

19.2 JURISDICTIONAL CODES

Transit service travels through numerous local jurisdictions. Each legally defined area has different land use and development regulations and legislative procedures that directly affect

station site planning and design. Each jurisdiction may have special amendments or supplements to codes and standards that apply on a statewide and national basis. As the start of the design:

- Identify the governing jurisdiction for each site at every governmental level
- Locate jurisdictional boundaries
- Review applicable adopted master plans and municipal codes
- Identify code and/or jurisdictional requirements for special inspections and inform TriMet's Project Engineer of special inspections required by those jurisdictions.

In addition to jurisdictional requirements, designs shall comply with the latest edition of the following codes:

- Uniform Building Code
- State of Oregon – *Structural Specialty Code*
- State of Oregon – *National Electrical Code*
- U.S. Department of Transportation's *Transportation for Individuals with Disabilities; Final Rule*, including 49 CFR Parts 27, 37 with Appendix A – *Standards for Accessible Transportation Facilities* and Part 38.

When the code does not provide for particular features of the design — either because transportation and/or transit facilities are not covered or because the provisions made are not applicable or feasible — provide aesthetic, cost-effective solutions.

19.3 PUBLIC ART PROGRAM

In 1997, the TriMet Board of Directors adopted a policy of incorporating public art elements into TriMet's capital projects. TriMet's public art program is funded from portions of selected projects that:

- directly benefit TriMet customers and the general public
- have total budgets greater than $100,000

Each year, the public art manager and capital budget steering committee identify those portions of capital construction budgets that will support the public art program. Funding for art projects is typically 1.5 percent of the construction cost of visible facilities on qualifying projects. Projects that include provision of public art will be identified prior to the beginning of design.

The TriMet Public Art Advisory Committee (TMPAAC), with assistance from the art program manger, oversees the development of the art program, selects artists and approves artwork. This committee is comprised of representatives from the three counties of the district, the arts community, and TriMet. Separate subcommittees are created to oversee the management of art programs for large-scale capital construction projects.

19.3.1 Criteria for Approval – Artwork must meet the following criteria to be approved by TMPAAC (see *TriMet Public Art Advisory Committee Operating Policy*):

- Inherent Quality

- Context – Artwork shall be compatible in scale, material, form and content with its surroundings. Where appropriate, the architectural, historical, geographical and socio-cultural contexts of the site shall be considered.
- Permanence – Artwork shall be structurally sound and is resistant to theft, vandalism, weathering, and excessive maintenance or repair costs.
- Public Safety & Accessibility – Artwork shall not present a hazard to public safety, conflict with ADA standards, or be attractive nuisances that will entice people to enter the operating transit way.

19.3.2 Implementation – Specific details of artwork design and installation are noted below.

Topic	Instructions
Substitution of Standard Amenities	When an artist-designed amenity, such as a bench or railing, is substituted for a standard amenity, it must meet the same design criteria as the standard amenity.
Placement of Art Works	Art elements shall not be placed in the trackway or in other locations which could pose a safety hazard to viewers or patrons or obstruct line-of-sight between train operators and persons. Metal art elements within the catenary wire safety zone shall be grounded (as defined in section 11.6.2)
Permanence of Art Works	Site-specific works shall remain at the site for which they were created, unless circumstances dictate otherwise. See instructions below for procedures on relocating artwork.
Design Review	Alterations to existing artwork or additions of artwork to the TriMet system must be reviewed and approved by the TMPAAC. Functional changes and additions to existing stations or bus stops that do not directly impact art work will reviewed through an internal TriMet process.
Maintenance	TriMet will be responsible for maintaining all works in its public art collection. Artwork should be designed such that regularly required maintenance is minimized and easily accomplished. If planned work will disrupt existing artwork in any way, the designer shall notify the Art Program Manager as soon as possible.
Relocating or Removing Artwork	Design work may lead to a request to relocate artwork. This may arise for several reasons, such as a change in the context or use of the site such that the artwork is no longer compatible. In these cases, the designer shall notify the TriMet Art Program Manager, who will follow an established process for resolution of the request.

19.4 LIGHT RAIL STATION AMENITIES

This section establishes design criteria for light rail station amenities. Refer to Chapter 6 for light rail station design criteria.

19.4.1 Standard Amenities – All amenities shall be functional, vandal and weather resistant, attractive, and economical.

Amenity	Criteria
Seating	Provide benches on the platforms and in bus waiting areas. Coordinate platform benches with the station finish materials. Do not place benches in the vicinity of vertical circulation elements.
Trash Receptacles	Provide 2 TriMet approved trash receptacles at all station platforms and coordinate them with seating. Trash receptacles must be harmonious with the station finish materials. Verify with TriMet whether trash receptacles will be provided as owner finished materials. Trash Receptacles shall: 1. Have a 20 year life expectancy 2. Withstand heavy public use & abuse 3. Not burn or melt 4. Appropriate urban design 5. Graffiti resistant, and allow graffiti removal without degradation using TriMet approved protocol 6. Low maintenance, easy to keep clean (minimize attraction of insects or vermin) 7. Keep rain out with integral cover (minimize use of removable lids) 8. Easily fasten, and secure to floor structure. Immovable by others 9. Allow for ease of pressure washing of floor surface. 10. Minimize opening to limit 'home garbage' or security threats 11. Reduce security threats in general locations, and adapt to high visual accessibility in high security locations 12. Allow for ease of visual security 'sweep's, without disturbing general public 13. Be easy to empty, minimizing ergonomic problems 14. Be of an appropriate size (33 gallon bag typical) 15. Maximize space on platform, station, or sidewalk 16. Attract sponsorships through high quality design and functionality 17. Use common materials & fabrication techniques 18. Be most cost effective: initial investment leverages low life cycle cost
Telephones	Provide a minimum of two coin-operated telephones at each station. At least one must conform to the requirements of Section 4.3.1 of *Standards for Accessible Transportation Facilities*, U.S. Department of Transportation. Do not locate public phones inside or immediately adjacent to shelters. Public phones must be easily visible from the station platforms but located outside of circulation areas where the noise level is acceptable. Provide phone booths when ambient noise levels make sound isolation necessary.
Bicycle Lockers	Provide at each Light rail station minimum storage capability for 8 bicycles. The final quantity and location should be coordinated with the appropriate local municipal transportation department. Lockers may be located adjacent to platforms, but not on them. Specific criteria for locker security are provided in Section 24.4.7. Bike Lockers must: 1. Provide cover from the weather. 2. Provide a secure place to lock the bicycle.

Amenity	Criteria
	3. Be compatible with TriMet's locking mechanism. 4. Be able to be self-managed and self-served. 5. Be sized to comfortably contain one bike 6. Be compact to minimize visual obstruction. 7. Be horizontal and have adjustable mounting for sloped conditions. 8. Be durable and easy to maintain. 9. Allow for visual inspection of the entire interior. 10. Be fire resistant and minimize damage from explosion.

19.4.2 Signage – Design objectives for signage are to:

- Minimize the number of decisions a passenger must make to transfer from mode to mode.
- Arrange and distribute signage so that it is easily visible to passengers and employees who need to see it.
- Standardize materials and construction practices.
- Use materials and construction practices that:
  - minimize initial cost
  - minimize maintenance requirements
  - are compatible with existing TriMet facilities and systems
  - Conform signage to Section 4.30 of *Standards for Accessible Transportation Facilities*, U.S. Department of Transportation and TriMet system-wide graphic standards. Standard signage designs are contained in TriMet's standard drawings.

Instructions for each type of signage are noted below:

Type of Signage	Instructions
Information Pylons	Provide free standing or integrated information pylons in all stations. Pylons shall provide: • customer and system information • tactile way-finding maps for vision impaired users • modules for Real Time Information displays(optional) • convenience outlets Pylons shall contain integral lighting for transit information, line designation and maps. Pylon lighting shall meet the criteria in Chapter 11 – Electrical System. Size pylons to accommodate standard TriMet information materials (e.g. LRT and bus system maps and schedules) and to accommodate internal maintenance that may be required. Locate pylons in the platform half at the front end of the train with one each for in-bound and out-bound platforms. Locate additional pylons at pedestrian entry points, as required, and at circulation confluence points not covered by platform pylons.
Directional Signs	Provide simple and clear directional signage between modes of transportation.

Type of Signage	Instructions
Platform Identification Blade Signs	Provide two blade signs on each platform to identify the system, station and destination. Place the blade signs in areas that are not covered by pylons. Place in illuminated locations or provide integral illumination
Shelter Signage	Provide for station identification signs in passenger shelters.
Shelter Mounted Destination Signs	Shelter mounted signs at center platforms shall indicate destination.
Bus Bay Signs	Bus bay signs are pole-mounted signs that indicate bus route numbers. These signs shall be located at each bus bay or stop.
Park & Ride Monument	At each entry of a park and ride, place a site monument sign that displays the name of the park and ride.
Bus Information Display	A bus information display is a freestanding, two-sided cabinet that displays bus route schedules. Provide one at each transit center and at all bus stops with multiple bus lines. Provide Real Time Information Display (optional)
"Transit Tracker"	Transit tracker is a real time lighted message panel that displays bus or train arrival information. Provide transit tracker initial installations (or provide for future installation as directed by TriMet) at all shelter structures.

19.5 MATERIALS AND FINISHES

The selection of station materials directly affects maintenance requirements and the image of each facility. Simple, durable, readily available, and easily maintained materials can diminish damage and maintenance while enhancing the character and visual quality of each station. Because vandalism is more likely where it already exists, use materials that reduce repair time so that stations do not appear under-used or abandoned.

New materials, systems and finishes of equal performance to and compatible with those previously used are encouraged. Material and installation information, including samples, shall be submitted to TriMet for approval.

When specifying manufactured items or materials, standard off-the-shelf items that are available from more than one supplier are preferred over custom made or single source items. When specifying finish, size, color, pattern or composition, allow slight variations in appearance so that less costly products or materials of equal quality can be used.

19.5.1 Design Objectives

Quality objectives:

- Maximize ease of system use
- Maximize aesthetic quality
- Maximize civic quality
- Maximize safety

Maintenance objectives:

- Maximize ease of construction
- Maximize the use of available materials and finishes
- Maximize the use of durable materials and finishes
- Minimize the number of components & shapes
- Minimize life cycle costs
- Maximize ease of replacement
- Maximize the use of materials that are interchangeable with existing TriMet construction

19.5.2 Performance Standards

Performance Element	Instructions
Durability	Use durable materials that have consistent wear, strength, and weathering qualities. Materials must be capable of good appearance throughout their useful life and be colorfast or integrally colored, as appropriate.
Low Maintenance	Minimize life cycle maintenance costs when evaluating all materials and finishes.
Quality of Appearance	Materials should be appealing and harmonious in appearance and texture. They should reinforce system continuity while relating to the local context.
Cleaning	Use materials that do not soil or stain easily, whose surfaces are easily cleaned in a single operation employing commonly used equipment and cleaning agents. Minor soiling should not be easily visible.
Repair or Replacement	Materials shall be standardized as much as possible for easy repair or replacement without undue disruption of LRT operation. For example, hose bibs, electrical outlets, lighting fixtures and lamps, glass and plastic lights, information panels, signs, shelter materials, etc., shall be standardized on commonly available sizes and finishes for easy inventory stocking and installation.
Non-Slip Surfaces	Entrances, stairways, platforms, platform edge strips, and areas around equipment shall have non-slip properties. Floor finishes must be non-slip even when wet. This is particularly important at stairs, elevators, areas near station entrances and platforms. Use tactile surfaces where directed by TriMet.
Corrosion Resistance	Because of moisture and the electrical currents involved in transit operation, give special consideration to preventing corrosion. Use non-corrosive materials in moisture/current susceptible areas.
Compatibility	Selected materials must suitable for the Portland area climate and compatible with existing materials within the station vicinity. Materials for structures should harmonize with existing facilities on a site-specific basis.
Availability	Select materials that permit multiple competitive bidders. Emphasize regional products and processes over those not locally available.

Performance Element	Instructions
Fire resistance	"Flame spread" ratings must conform to the Oregon State Building Construction Code.
Finish Materials	Dense, hard, nonporous materials are preferred for all applications. Finish materials must be corrosion, acid, and alkali resistant and will be compatible with chemical compounds required for maintenance. All porous finishes subject to public contact must be treated or finished in a manner that allows easy removal of common vandalism.
Detailing	For detailing finishes, avoid unnecessary surfaces that may collect dirt and complicate cleaning. Wall surfaces shall be vertical and flush allowing for texture. All edge and finish materials shall be detailed, incorporating joints & textures that reduce the requirements for true, visually perfect installation over long distances.
Waterproofing	All finish materials in underground spaces will be selected and detailed with proper attention to waterproofing, cavity walls, drainage, and venting. All drainage cavities will have provisions for clean out.
Texture	Materials within reach of passengers must be easily cleaned and have a finish that prevents or conceals scratching, soiling, and minor damage.
Color	In selecting materials, consider harmony of color on a system-wide basis. In selecting color, favor materials that are light and reflective to maintain desired illumination levels. Select materials with integral color or those with surface finishes or veneers. Minimize the use of paint, stains, and coatings that aren't durable or fade resistant.

19.6 TRIMET COLOR PALETTE

TriMet has developed a standard palette of colors for use in capital projects. The standard colors are shown in the table below. Only these colors shall be used unless TriMet approves a specific exception in writing.

If an alternate manufacturer is proposed for one of the standard colors, or for colors with no manufacturer noted, color samples shall be submitted for approval by TriMet.

TRIMET STANDARD COLOR PALETTE

Existing Colors in Use

Color	Material	Manufacturer & Number	Location(s)	Agency Standard	Project Specific
"TriMet" Dark Blue	Abrasion Resistant Coating	Miller Paint Co. M-801	Banfield, City Center, Westside, Interstate	Yes	No
TriMet Dark Blue	Powder Coated galvanized steel	Tiger Drylac, RAL 5011	Parkrose TC, Banfield, City Center	No	Yes – Parkrose TC, Transit Tracker

Color	Material	Manufacturer & Number	Location(s)	Agency Standard	Project Specific
Dark Blue	Coil Coated metal wall/roof panels	Metal Sales: "Tahoe Blue"	Parkrose TC Operator's building	No	Yes – Airport MAX
'Mall Blue'	Abrasion Resistant Coating	Miller Paint Co.	Banfield, City Center	Yes	No
'Turquoise Blue'	Abrasion Resistant Coating	Miller Paint Co.	Westside MAX	Yes	
'TriMet' Historic Black	Abrasion Resistant Coating	Miller Paint Co.	Banfield, City Center, Westside, Interstate	Yes	No
Good Night (light black)	Interior Latex Semi-gloss	Miller Paint Co. 840	Parkrose TC Operator's building	No	Yes – Airport MAX
'Portland Green'	Abrasion Resistant Coating	Wasser Paint Co.	Interstate	Yes (City of Portland)	Yes – Interstate MAX
Banfield Green (Seafoam)	Abrasion Resistant Coating	Miller Paint Co.	Banfield, City Center	Yes	No
'Roasted Pepper'	Abrasion Resistant Coating	Sherwin Williams Paint Co. C116N Roasted Pepper	Interstate MAX	Yes	Yes – Interstate MAX
White	Interior Latex Semi-gloss	Miller Paint Co. 5770W	Westside MAX	No	Yes – Westside MAX, Sunset Transit Center
Panda White	Interior Latex Semi-gloss	Miller Paint Co. 826	Parkrose TC Operator's building	No	Yes – Airport MAX
Concrete Grey	Exterior enamel	Miller Paint Co. S-423-M	Sunset TC	No	Yes – Westside MAX
Black	Powder Coated galvanized steel	Cardinal Industrial Finishes T006-BK05	Banfield, City Center	No	Yes – Transit Tracker
Champagne Metallic	Aluminum wall panel	Reynolds Architectural Products, Colorweld 300 XL	Parkrose TC Operator's building	No	Yes – Airport MAX
#8 Mirror Finish	Stainless Steel	NAAMM standards	Sunset TC	Yes	Yes – Westside MAX
#2B	Stainless Steel	NAAMM standards	Westside, Interstate MAX	Yes	Yes – STC elevator, Interstate MAX shelter roofs
Natural Galvanize Metal	Galvanized Steel	N/A	Banfield, Westside, Airport, Interstate MAX	Yes	No
Galvanize Finish	Zinc/Aluminum Coating for metal roofs/siding	Metal Sales: Galvalum, Zincalum	Interstate MAX	Yes	Yes – Interstate MAX

New TriMet Colors

Primary Colors	Material	Manufacturer & Number	Location(s)	Agency Standard	Project Specific
Red	N/A	Pantone 173 C	N/A	Yes – new	N/A
Blue	N/A	Pantone 653 C	N/A	Yes – new	N/A
Yellow	N/A	Pantone 1215 C	N/A	Yes – new	N/A

Secondary Colors	Material	Manufacturer & Number	Location(s)	Agency Standard	Project Specific
Ochre	N/A	Pantone 1245 C	N/A	Yes – new	N/A
Olive Green	N/A	Pantone 582 C	N/A	Yes – new	N/A
Plum	N/A	Pantone 188 C	N/A	Yes – new	N/A

TRIMET

CHAPTER 20

NOISE AND VIBRATION

CHAPTER 20 – NOISE AND VIBRATION

20.1 GENERAL

Nose and vibration are important concerns for light rail systems, especially when LRT operates near sensitive receptors. This chapter describes minimum standards, and methods for the control of light rail noise and vibration. Although the majority of this chapter is noise and vibration generated by the interaction of wheel and rail from light rail operations, noise and vibration from construction of activities is also discussed.

20.2 NOISE STANDARDS

Noise standards that may be applicable are published by:

- Federal Transit Administration (FTA)
- American Public Transit Association (APTA)
- Federal Highway Administration (FHA)
- Oregon Department of Transportation (ODOT)

The goal for achieving acceptable levels of noise is not to eliminate all potential for noise annoyance, but rather to:

1. Provide a means for objective comparisons of the noise impacts of different alternatives.

2. Identify areas where noise mitigation should be considered and provide designers with fair and impartial method of determining where noise mitigation measures, such as sound walls, should be installed.

3. Ensure all reasonable steps are taken so noise levels in the rail corridor will not be an unreasonable burden on sensitive receptors exposed to the noise. This step defines what type of noise environment will be acceptable to most people.

4. Provide a basis for evaluating isolated individual claims.

The FTA guidance manual "Transit Noise and Vibration Impact Assessment" provides direction for the preparation of noise and vibration analysis in environmental documents for mass transportation projects. Chapter 3 of the FTA manual includes the criteria to be used for analysis of normal LRT operations.

The APTA publication "Guidelines for Design of Rapid Transit Facilities" provides guidelines for maximum airborne noise for light rail transit (LRT) wheel squeal. These criteria, when applicable at the nearest dwelling for the occupied building, are shown in Table 20-1 below and shall be used to analyze noise impact for curves of less than 400 feet in diameter. Refer to the APTA publication for more information regarding the definition of each community category.

TABLE 20–1

APTA Guidelines for Maximum Airborne Noise from LRT Wheel Squeal				
		Maximum Passby Noise Level, dBA		
Community Category		Single-Family Dwellings	Multi-Family Dwellings	Commercial Buildings
I	Low Density Residential	70	75	80
II	Average Residential	75	75	80
III	High Density Residential	75	80	85
IV	Commercial	80	80	85
V	Industrial/Highway	80	85	85

20.3 DESIGN COMMITMENT

The Environmental Impact Statement for a light rail construction project includes a "Noise and Vibration Mitigation Plan." This plan predicts the noise and vibration levels generated from light rail operations over the length of the project. Specific noise and vibration mitigation measures may be committed to via approval of this document. TriMet shall review and approve the "Noise and Vibration Mitigation Plan." All cost associated with the mitigation measures must be included in the project budget.

20.4 LIGHT RAIL OPERATIONS NOISE MITIGATION

20.4.1 General – There are several viable methods of mitigating light rail noise, which are covered in this section. The designer shall identify the type of mitigation best suited for the particular application. New technology that becomes available should be investigated as a possible mitigation option. On-going communication with other transit agencies to learn more about this complex problem is also recommended.

20.4.2 Alignment Design – Experience at TriMet has shown that noise from wheel squeal is often generated from curves of less than a 400 foot radius. Track curvature shall be designed with a radius as large as allowable within the confines of the right-of-way corridor. Provisions shall be made to install rail lubricators in the vicinity of curves with radii less than 400 feet.

20.4.3 Location of Special Trackwork – LRT trains passing over special trackwork such as turnouts, crossovers, and expansion joints are a source of noise and vibration. Whenever possible, special trackwork shall be located in an area not sensitive to noise and vibration.

20.4.4 Special Trackwork Design – Whenever turnouts and crossovers are located in noise sensitive areas, spring frogs should be considered. Spring frogs may be used in locations where trains moving through the diverging side of turnout are infrequent.

20.4.5 Rail Lubrication – Electrically powered rail lubricators shall be installed at all locations where wheel squeal is generated from sharp curves. The purpose of the lubricator is to reduce the level of friction between the light rail wheel and rail sufficiently to eliminate the wheel squeal and yet maintain adequate adhesion for propulsion and braking.

Prior to specifying the details for the lubricator the designer shall review the plan with TriMet. TriMet has experience with several types of rail lubricators and lubricants. Based on this experience, the best-suited lubricator can be specified. All lubricant shall be environmentally friendly and must be biodegradable. The goal is to eliminate the wheel squeal with the least possible amount of lubricant.

Provisions for paved track lubricators include track boxes mounted to the field side of both rails, 3" conduit connecting the track boxes, 3" conduit between one of the track boxes and a lubricator cabinet pole, and 120-volt power to the lubricator pole. Open track lubricators shall have 120-volt power supplied to the lubricator location.

20.4.6 Noise Barriers – Noise barriers can be an effective method of light rail mitigation. Noise barriers can be constructed as walls or earth berms where the right-of-way allows. Noise barriers must be constructed with sufficient height to break the line-of-sight between the noise source (top of rail) and the nose sensitive receiver. Noise walls must be long enough to prevent significant noise intrusion from around the ends.

20.4.7 Sound Absorption Materials – In certain situations it may be necessary to install sound absorptions materials on adjacent wall to absorb noise. In cases where walls may reflect the noise to sensitive receptors, outdoor low maintenance sound absorption material attached to sound walls should be used with approval from TriMet. At the same time, barriers shall not create line-of-sight obstructions between trains and pedestrians. Refer to Chapter 15 for specific criteria.

20.4.8 Sound Installation – In some cases it may be most cost effective to provide sound insulation at the noise receptor. Installation of upgraded windows and doors, storm window, and building insulation are ways to reduce the interior noise in a building. A noise specialist should be consulted to predict the level of noise reduction for each element of sound insulation. A benefit to cost comparison can then be made among the various options.

20.5 CONSTRUCTION NOISE AND VIBRATION

Although the focus of this chapter is the mitigation of noise and vibration generated from light rail operations, construction noise and vibration may also require mitigation. Vibration from demolition of existing concrete and structures, vibratory rollers, and pile drivers are often more severe than that from train operations. When construction is expected to require these activities, the designer may use a noise and vibration specialist to assess the potential for damage from vibration.

Measures should be considered when high noise and vibration construction activities occur at locations with potential for damage:

1. Perform monitoring at high impact locations to verify safe levels of vibration.

2. Install crack monitors over existing cracks to measure the amount of movement or crack widening caused by construction.

3. Sound walls, if included in the design of permanent facilities, should be considered for installation early in the project to help mitigate construction noise.

4. Specifications may require high impact work to be performed only during certain times of the day (at night when businesses are unoccupied; or day time only through residential areas)

In some rare instanced it may be necessary to provide sound insulation to homes and businesses that will experience extreme construction impacts over long periods of construction.

20.6 CONSTRUCTION VIBRATION STANDARDS

The U.S. Department of Transportation (U.S.DOT) has developed guidelines for vibration levels from construction activities. Table 20-2 summarizes the levels of construction vibration and the usual effect on people and buildings.

TABLE 20–2

EFFECTS OF CONSTRUCTION VIBRATION		
Peak Particle Velocity (in/sec)	**Effects on Humans**	**Effects on Buildings**
<0.005	Imperceptible	No effect on buildings
0.005 to 0.015	Barely perceptible	No effect on buildings
0.02 to 0.05	Level at which continuous vibration begin to annoy occupants of buildings	No effect on buildings
0.1 to 0.5	Vibrations considered unacceptable for people exposed to continuous or long-term vibration	Minimal potential for damage to weak or sensitive structures
0.5 to 1.0	Vibration considered bothersome by most people, however tolerable if short term in length	Threshold at which there is a risk of architectural damage to buildings with paltered ceilings and walls; some risk to ancient monuments and ruins

EFFECTS OF CONSTRUCTION VIBRATION		
Peak Particle Velocity (in/sec)	**Effects on Humans**	**Effects on Buildings**
1.0 to 2.0	Vibrations considered unpleasant by most people	U. S. Bureau of Mines data indicated that blasting vibration in this range will not harm most buildings; most construction vibration limits are in this range
>3.0	Vibration is unpleasant	Potential for architectural damage and possible minor structural damage

20.7 LIGHT RAIL OPERATIONS

FTA impact criteria for ground-borne vibration shall be the standard applied to light rail design. These criteria, defined in chapter 8 of the FTA manual "Transit Noise and Vibration Impact Assessment'" establish acceptable levels of ground borne vibration generated from light rail operations for various types of buildings.

20.8 LIGHT RAIL OPERATIONS VIBRATION MITIGATION

20.8.1 Paved Track Vibration Mitigation –TriMet vibration studies have concluded that various types of paved track (rails embedded in elastomer, rail in a rubber boot) perform nearly identically in regards to vibration mitigation. The most effective method of minimizing paved track vibration is the proper maintenance of light rail vehicle (LRV) wheels and rail. LRV wheels should be kept free of flat spots and trued at least every 50,000 miles. Rails shall be kept free of rough spots and corrugation by grinding once every 5 years with an on-track production rail grinder, or more frequently if warranted.

20.8.2 Open track Vibration Mitigation – In sensitive areas where vibration is anticipated to be a problem, vibration mats and/or vibration concrete slabs may be installed under the ballast. When open track special trackwork is located in an area where vibration impacts cannot be avoided, ballast mats and/or concrete vibration slabs shall be installed.

20.9 OTHER LIGHT RAIL NOISE AND VIBRATION RESOURCES

Refer to the following additional resources for more detailed information regarding the cause of and mitigation options for light rail noise and vibration:

1. Transit Noise and Vibration Impact Assessment, April 1995, FTA
2. Guidelines for Design of Rapid Transit Facilities, January 1979, APTA
3. TCRP Report 23, Wheel/Rail Noise Control Manual, 1997

TRIMET

CHAPTER 21

FARE COLLECTION

CHAPTER 21 – FARE COLLECTION

21.1 FARE COLLECTION SCOPE

The fare collection system for the Light Rail Projects shall use a barrier-free, self-service method consistent with the existing system. The fare collection system equipment shall have been proven in transit revenue service. Ticket Vending Machines (TVMs) shall have the capability to vend single-ride and multiple-ride tickets, of various pricing levels. The TVMs shall have the capability to accept United States currency and issue change for overpayment of the ticket. They shall accept credit and debit cards.

Ticket Validators shall validate pre-purchased tickets by stamping an inserted ticket with current date, expiration time, and a station and validator code.

No fare collection equipment shall be on-board MAX light rail vehicles.

21.2 ADVANCED FARE COLLECTION

TriMet is in the process of evaluating advanced electronic fare collection systems, using devices such as smart cards, tag-on/tag-off processes and other means for determining distance based and other specialty fares. This design criteria section will be amended when the system architecture for advanced fare collection systems is finalized.

21.3 SYSTEM DESIGN REQUIREMENTS

Fare collection equipment shall be designed for a minimum service life of 15 years. Equipment shall be operational seven days per week, 24 hours per day. The fare collection equipment shall be continuously operable while exposed to the elements, and ambient temperature ranges of -3°F to 107°F and in relative humidity from 5% to 100% over the given ambient temperature range. This shall include periods of condensation and rainfall. Direct sunlight conditions will cause cabinet temperature to rise considerably above ambient.

Fare collection equipment shall be designed, engineered, and manufactured in accordance with specified standards for serviceability, maintainability, reliability, and human factors. The exterior surfaces of fare collection equipment, including all controls and appurtenances, shall have no sharp edges in areas exposed to patrons.

The fare collection equipment cabinets shall be accessible from the front and shall be made of unpainted stainless steel. The cabinets and components accessible from the exterior shall be built to resist damage due to abuse and vandalism. All metal parts of the machines that can be contacted by patrons or service personnel shall be electrically grounded to the platform ground mat.

The fare collection equipment shall be designed to meet applicable and current sections of the National Electrical Code, National Electrical Safety Code (ANSI/IEEE C2) and National Electric

Code, National Fire Protection Association ANSI/NFPA 70 and the requirements of any and all other authorities having jurisdiction. The equipment shall be operable under electrical interference and shock and vibration conditions present at, and adjacent to, the light rail system.

The fare collection equipment shall accommodate the broad range of patrons that use public transportation. The fare collection equipment shall meet the rules in Title 49, Code of Federal Regulations, Part 37 resulting from the Americans with Disabilities Act. In particular, rules related to Automated Teller Machines (49CFR37, Appendix A, Section 4.34) and appended guidelines for Controls and Operating Mechanisms (Appendix Section A, Section 4.27) shall be addressed in the fare collection equipment design.

21.4 TICKET VENDING MACHINES

Single-ride tickets and multiple-ride tickets shall be sold by self-service TVMs located immediately adjacent to the light rail system, and may be installed at other locations convenient to MAX patrons.

21.4.1 General Requirements – In general, the TVMs shall be designed to sell transit tickets to MAX patrons by coins and bills and credit, debit and cash cards. TVMs shall be capable of printing and issuing various tickets from within the same housing. TVMs shall be serviceable from the front.

The TVMs shall be constructed of modular components that include:

- Push buttons for selection of the appropriate fare by the patron
- A coin slot with verifier and escrow unit
- A bill acceptor, verifier, and escrow unit
- Coin hoppers and coin recirculation
- Ticket stock storage and printing/cutter unit
- A ticket chute for ticket dispensing and returning change
- PC-based microprocessor logic for user interaction, controlling the machine, and monitoring its condition
- Coin vaults
- Bill stackers and vaults
- A security system

- Remote reporting of failure, security, and service indications via communications network
- Real-time authorization and settlement of credit/debit sales transactions, as required

The minimization of transaction time shall be considered in TVM design.

Each TVM shall be equipped with a fluorescent lighting fixture to illuminate the front area of the TVM when the ambient light conditions are low. A photoelectric eye shall control this light. There shall be a light inside the cabinet to aid maintenance and service personnel, and it shall illuminate each time the cabinet door is open.

21.4.2 Fare Selection – A patron purchasing a ticket or pass shall select the type of ticket they require by depressing one or more push buttons. The TVM shall display the amount of fare to be deposited into the TVM to complete the indicated ticket purchase.

The TVM shall have the capability to be programmed by authorized TriMet service personnel to modify the ticket to be printed, fares associated with each button and the Patron Interface Display. Whether or not the ticket is issued already validated shall be modifiable by authorized TriMet service personnel.

21.4.3 Patron Interface Display – A display screen shall be contained on the front of the TVM. The display screen shall be capable of displaying fare amount due in characters at least 0.4" inches in height. The approximate height-to-width ratio of the displayed characters shall be 5:7. The display screen shall be capable of displaying instructions to the patron.

21.4.4 Currency and Credit/Debit/Cash Card Capability – The TVM shall accept, validate and retain United States currency: one, five, ten, and twenty-dollar bills, dollar coins, quarters, dimes and nickels. The coin validator shall reject all other coinage and counterfeits. Bills shall be vaulted separately from the coinage, and stacked. The bill validator shall reject foreign objects. It shall be possible to remove or disable the bill validator from service and allow the TVM to remain in service for coin paid vends.

The TVM shall reject all currency not in acceptable condition, and store all currency that is accepted once the TVM has begun processing a ticket. The TVM shall have change-making capability. Change shall be given in SBA dollars, quarters, dimes and nickels.

The TVM shall have coin recirculation features, and bill escrow units. The maximum amount of change to be returned and the denomination(s) of bills to be accepted shall be modifiable by authorized TriMet personnel.

The TVMs must have the following:

- Capability to display appropriate instructions to the user
- Keypad for entry of personal identification codes
- Card reader
- Capability to print a receipt in accordance with the applicable requirements associated with debit/credit card transactions

- Communications network and control software to process the transaction and guard against fraudulent use of debit/credit/cash cards

A centrally located network controller must also be supplied in order to process each electronic transaction over the banking network.

21.4.5 Ticket Stock – The TVM shall have the capability of printing and dispensing a minimum of five ticket stocks of various sizes, including roll, fan-fold, and/or pre-cut stock. Ticket stock shall be sufficiently stiff to withstand patron handling, humidity, and Ticket Validator requirements. Unvalidated tickets dispensed by the TVMs shall be capable of being validated using TriMet's existing validators.

Two stocks and two printer options may be considered for the ease of maintenance.

21.4.6 User Information – Each TVM shall contain sufficient information to instruct patrons in purchasing of tickets. The TVM shall be arranged to enhance logical step-by-step use by patrons. The information shall be presented in American English and Spanish and by Type II Braille and/or raised letters, to comply with the requirements of ADA. Information presentation must comply with 49 CFR 37.

The front, sides, and back of the TVM may be used for system maps, and further information useful to patrons.

21.4.7 Other Features – The following features shall also be provided for each TVM:

a. Cancel Button – A cancel button shall be located on the operating face of the TVM. When the cancel button is depressed, the TVM shall annul the transaction and return any coins and bills that have been deposited and held in escrow. If the vend has been canceled after ticket selection but before beginning money deposit, the patron shall be allowed to re-commence selection.

b. Automatic Time-Out – If a transaction is not completed within a preset time, the deposited money shall be returned, and the TVM shall return to an idle condition.

c. Clock and Memory Power Supply – A separate power supply with battery back up is required for the internal clock and for protection against loss of memory. The design shall provide for an orderly shutdown.

d. Provisions for PIN pads and Smart Cards

21.4.8 Security – Each TVM shall be designed and mounted to minimize the effects of tampering, removal, thievery and vandalism. High security locks and keys shall be used. All doors shall be locked with at least a three-point latching device with a bascule bolt and a hook locking bar, or equivalent.

Other security features shall include: all latches secure and robust; all external screws and hinges covered; security locks with profile catches; drill-resistant locks, mounted flush with the outside surface of the door; overlapping doors constructed with a joining gap less than or equal to 2mm; other reinforcement as necessary to prevent burglary.

All vaults and cash storage devices require electronically encoded serial numbers. At a minimum, vault access shall be mounted to prevent tampering and shall have the protection of high security locks with controlled keying. Upon opening a TVM, service personnel shall be required to enter a personal identification number as authorization for access to the TVM. Access to the TVM for maintenance shall not provide access to the money vaults.

A connection for TVM contact closures to Central Control via a communications link furnished by others shall be provided.

The integrity of the communications system shall be checked on a periodic basis to confirm that it is functional.

Access to the interior of the equipment enclosure and to the cash vaults shall be restricted to a "need to gain access" basis, as approved by TriMet. The coin and bill vaults shall be protected so that they can only be opened by authorized personnel in the counting room. Cash vaults shall have an exclusive, secured chamber in the TVM assembly or pedestal. A register ticket showing vaulted money shall be available for counting room audit.

21.4.9 Self-Diagnostics – The TVM shall be equipped with self-diagnostic capability to indicate required maintenance and/or servicing actions.

Event recording of each opening of a TVM door is required. Errors caused by telecommunication line and modem (to the extent they are used) problems shall be recorded or errors resulting there from shall be recorded.

Portable test equipment and systems indications internal to each TVM shall assist the service/repair technician in determining appropriate corrective or service action.

21.4.10 Accounting and Registration – Each TVM shall be equipped with an electronic control unit that shall process and store all ticket sales, TVM status, and/or diagnostics in the data memory unit.

The TVM shall be furnished with the capability to send and receive over the communications system all accounting and registration data and information. The TVM shall be able to transfer data nightly to the Central Control fare collection computer in batch.

Service personnel shall be able to access and print out data on "Journal Stock". All accounting and registration information as listed above shall be transferable to a removable solid-state data carrier module, within the TVM. The accounting and registration information stored by the TVM on the floppy disk/data carrier module shall be protected against any unauthorized manipulation.

Accounting software, operable on a desktop IBM-compatible personal computer, shall be provided as part of the TVM procurement and shall convert the above data into reports for TVM, fare collection, and fare policy management.

21.4.11 Dimensions – The maximum dimensions of the TVM, including its mounting base, are the following:

Height:	75"
Width:	38"
Depth:	25"
Range of operable height:	15" to 48" from ground

Within the constraints of ADA, due consideration shall be given to height range of comfortable operable control for ambulatory patrons.

21.5 TICKET VALIDATORS

21.5.1 General Requirements – Ticket Validators shall be stand-alone devices that imprint an inserted ticket with such information as date, ticket expiration time, and station and validator identification code. A validation mark shall be clearly visible on the ticket. Ticket validators shall be furnished with mounting bases.

The Ticket Validator shall be modular in construction and shall permit ready field replacement of inoperative components to return the machine to service in minimal time. Major repair and adjustment shall be affected in shop facilities.

The functions performed by the Ticket Validator shall include the following:

- Printing the following data on inserted tickets:
  - Ticket Validator Machine number
  - Date
  - Time of ticket expiration
  - Station or Zone
- Detection and indication of machine failures to the Status and Alarm System
- Counting and storage of a running total of tickets validated

Ticket insertion and retrieval shall be through a horizontal slot and shall not require downward or upward movement of the ticket to effect ticket validation. The ticket slot face shall be shaped to serve as a guide for inserting a ticket.

21.5.2 Security –Ticket Validators shall be designed and mounted to minimize the effects of tampering, removal, thievery and vandalism.

A connection for Ticket Validator contact closures to Central Control via a communications link shall be provided. The equipment shall provide an out of service indication.

The integrity of the communications system shall be checked on a periodic basis to confirm that it is functional.

21.5.3 Validator Dimensions – Approximate dimensions of the validator without its mounting

post are:

Height:	1½ feet
Width:	9 inches
Depth:	10 inches
Range of operable height:	48 inches from ground maximum

Within the constraints of ADA, due consideration shall be given to height range of comfortable operable control for ambulatory patrons.

21.6 CENTRALIZED INFORMATION/NETWORK REQUIREMENTS

The fare collection equipment shall provide remote indications of the status of the TVM, as described in Sections 21.4.8 and 21.5.2 via the communications systems to Central Control. These basic security functions include: notification of a central control office of machine identification number and location, date and time of reported condition, via dedicated communication line, of a) security violation; b) service entry for normal maintenance, restocking, vault exchange; c) normal servicing request: ticket restocking, out-of-change, etc.; d) malfunctions such as: jammed coin/bill/ticketing mechanism, printer malfunction, other electrical, electronic, and/or mechanical fault condition.

21.6.1 Network Interface – Each TVM shall be connected to the Fare Collection Network computer via the communications network, as described in the communications section.

The network will consist of a 10/100 base F Ethernet, carried over fiber optic cable to a fiber optic network interface card in the ticket vending machine.

21.7 TVM MOUNTING/PEDESTAL

Equipment cabinet mounting to the station platform shall be by means of stainless steel anchor bolts, which shall be embedded in a concrete platform. The fare collection equipment cabinets shall have an integral pedestal with suitable means for leveling the machines upon installation to accommodate the platform slope of up to 5%, longitudinal and transverse. Access to the anchor bolts shall be through the hinged service front door or other access panels, subject to TriMet approval, in a manner that shall prevent unauthorized access.

The mounting pedestal shall contain sufficient room and mounting hardware for:

- Power circuit breaker panel
- Communications network interface
- Convenience outlets

21.8 TVM/VALIDATOR POWER

The fare collection equipment shall be designed to accept 3-wire, 120 volt AC, 60 Hz, single phase. The equipment shall provide its own circuit protection. Power shall enter the machine by way of conduit stubbed up into the pedestal area. In the case where two or more TVMs are

located side by side, the conduit shall enter one of the TVMs from the ground, and the remaining TVMs may be connected by running the electrical supply lines horizontally through the base of the TVMs.

All equipment shall be designed to tolerate ± 10% fluctuation in line voltage without any damage or service interruption. Breaks in the voltage (below 10% of the source voltage) or supply interruptions shall cause shutdown of the TVM. Voltage transient suppression shall be provided.

TRIMET

CHAPTER 22

CLEARANCES

CHAPTER 22 – CLEARANCES

22.1 GENERAL

A fundamental goal of light rail design is to provide clear passage of light rail trains within a minimum width right of way corridor. In order to achieve this goal, the clearance requirements for the light rail vehicle must be well defined and understood. Adequate clearance between the moving light rail vehicle and OCS poles, signal poles, bridge piers, retaining walls, walkways, curbs, and all other trackside facilities is imperative. This chapter provides the detail necessary to calculate adequate clearance for any trackside facility.

22.1.1 Manual Clearance Calculation – Design criteria for clearances are complex and are based on numerous assumptions and interfaces. There are several methods that may be used to determine the required clearance. Manual calculations using the tables and formulas provided in this chapter may be used to assure adequate clearance. Computer spreadsheets are also available to make these calculations. Extra care must be taken to insure that correct input data is used. For example, Attachment 22-A includes Vehicle Dynamic Envelope (VDE) data for both open and paved or Direct Fixation (DF) track. The designer shall select the correct table based on track type: paved and DF use tables showing 0.50 inches of cross level variation while open tie and ballast track tables show 1.00 inch. The designer shall use straight-line interpolation between the values shown in the table and actual values for curve radius and for superelevation. The tedious interpolation calculations may also be performed using spreadsheet programs designed for this purpose.

22.1.2 Computer Generated Clearance Outlines – Computer generated clearance outlines on AutoCAD track alignment drawings are an acceptable method of performing clearance checks. Only TriMet-approved AutoCAD programs that incorporate actual TriMet light rail vehicle data may be used to generate clearance outlines. The input data shall be displayed on the drawing with the clearance outlines.

When used properly, this method produces the most accurate clearance envelope and is less conservative than manual calculations using Attachment 22-A. The remaining sections of this chapter describe in detail all factors that need to be considered to establish the light rail vehicle clearance envelope.

22.1.3 Final Design Clearance Check – To ensure adequate clearances, all elements of design must be coordinated and clearances check by calculation as the design evolves. Additionally, at completion of all final design documents that relate to LRT operations, a final clearance check shall be made. Final clearance check drawings and calculations shall be delivered to TriMet's Project Manager.

22.2 CLEARANCE ENVELOPE

The clearance envelope (CE) is defined as the space occupied by the vehicle dynamic envelope (VDE) plus the effects of other wayside factors (OWF) including construction,

fabrication, and maintenance tolerances for certain track and facilities, plus running clearances (RC). Simplistically, this relationship can be expressed as follows:

$$CE = VDE + OWF + RC$$

Generally speaking, the clearance envelope represents the space into which no physical part of the system may be placed or constructed or may protrude, other than the light rail vehicle itself. The clearance envelope is normally referenced from the theoretical centerline of track at top of rail (TOR), including the effects of superelevation.

22.2.1 VDE - Vehicle Dynamic Envelope – In addition to the car static dimensions, the vehicle dynamic envelope (VDE) includes all possible vehicle movements, vehicle tolerances, and certain closely related rail/track tolerances. More specifically, the VDE is based upon the following assumptions:

- Static geometry of the vehicle
- Roll angle of $\pm 4^{\circ}$
- Suspension lateral travel (per side) of 1.340 in
- Wheel gauge construction tolerance (per side) of 0.031 in
- Lateral wheel wear (per side) of 0.300 in
- Radial wheel wear of 1.000 in
- Rail gauge construction tolerance (per side) of 0.125 in
- Lateral rail wear (per side) of 0.500 in
- Wheel-to-rail side play (per side) of 0.375 in
- Pantograph lateral sway of 1.5 in
- Pantograph dynamic uplift of 3 in above static pantograph height

Attachment 22-A provides further explanation of these assumptions plus the calculated VDE dimensions in tabular form for 28 representative locations on the light rail vehicle cross-section as a function of radius of curve (82 feet to tangent), amount of superelevation (0 in to 6 in), and amount of cross level track variation (0.5 in or 1.0 in). For intermediate curve radii (e.g. 275 feet) or intermediate superelevation values (e.g. 3.5 in) not listed in these tables, straight-line interpolation between adjacent values shall be used.

It is critical that these VDE tables are used correctly in development of the clearance envelope for any given condition.

Figure 8-2 in Section 8 provides a simplified outline of the dynamic envelope of the light rail vehicle. However, this outline is based on nominal track conditions and does not include the effects of other wayside factors (OWF). Figure 8-2 is for car builder use only and shall not be used to calculate the CE.

22.2.1.1 Transition from Tangent to Curve – Clearance calculations for the transition area from tangent to curve are particularly complex.

For outside horizontal curves with spiral transition, the tangent vehicle dynamic envelope from Attachment 22-A shall end 50 feet before the point of tangent-to-spiral (TS) and begin 50 feet after the point of spiral-to-tangent (ST). The full curvature vehicle

dynamic envelope shall begin 25 feet prior to the point of spiral-to-curve (SC) and end 25 feet beyond the point of curve-to-spiral (CS). The horizontal component of the vehicle dynamic envelope between these two offset points (i.e., 50 feet before TS and 25 feet before SC) shall be considered to vary linearly with distance between the two points. Horizontal offsets at intermediate locations shall be calculated with straight-line interpolation.

For outside horizontal curves without spiral transition, the full curvature clearance envelope shall begin 50 feet prior to the point of curvature (PC) and extend to 50 feet beyond the point of tangency (PT).

For inside horizontal curves with or without spirals, the locations at which the tangent vehicle dynamic envelope ends (or begins) and the full curvature vehicle dynamic envelope begins (or ends) are dependent upon the particular point on the vehicle (P22 – P28 in Attachment 22-A) and the radius in question. For each inside point on the vehicle, a "crossover' radius is defined in the table below:

Point on Vehicle	Crossover Radius
P22	750 ft
P23	190 ft
P24	190 ft
P25	750 ft
P26	750 ft
P28	950 ft

For curve radii greater than or equal to the crossover radius with spiral transition, the tangent vehicle dynamic envelope ends at the point of tangent-to-spiral (TS) and begins at the point of spiral-to-tangent (ST). The full curvature vehicle dynamic envelope begins 15 ft after the point of spiral-to-curve (SC) and ends 15 ft after the point of curve-to-spiral (CS). The vehicle dynamic envelope between these two offset points shall be calculated with straight-line interpolation.

For curve radii greater than or equal to the crossover radius without spiral transition, the tangent vehicle dynamic envelope ends at the point-of-curve (PC), and begins at the point-of-tangency (PT). The full curvature vehicle dynamic envelope begins 15 ft after the point-of-curvature (PC) and ends 15 ft before the point-of-tangency (PT). The vehicle dynamic envelope between these two offset points shall be calculated with straight-line interpolation.

For curve radii smaller than the crossover radius with spiral transition, the tangent vehicle dynamic envelope ends 30 ft before the point of tangent-to-spiral (TS) and begins 30 ft after the point of spiral-to-tangent (ST). The full curvature vehicle dynamic envelope begins at the point of spiral-to-curve (SC) and ends at the point of curve-to-spiral (CS). The vehicle dynamic envelope between these two offset points shall be calculated with straight-line interpolation.

For curve radii smaller than the crossover radius without spiral transition, the tangent vehicle dynamic envelope ends 30 ft before the point-of-curve (PC), and begins 30 ft after the point-of-tangency (PT). The full curvature vehicle dynamic envelope begins at

the point-of-curvature (PC) and ends at the point-of-tangency (PT). The vehicle dynamic envelope between these two offset points shall be calculated with straight-line interpolation.

The methods for calculating the vehicle dynamic envelope for the transition area from tangent to curve are summarized in the table below:

	Tangent VDE	**Full Curvature VDE**
Outside Curve **with** Spiral	Ends 50 ft before TS Begins 50 ft after ST	Begins 25 ft before SC Ends 25 ft after CS
Outside Curve **without** Spiral	Ends 50 ft before PC Begins 50 ft after PT	Begins 50 ft before PC Ends 50 ft after PT
Inside Curve **with** Spiral, curve radius **larger** than Crossover radius	Ends at TS Begins at ST	Begins 15 ft after SC Ends 15 ft before CS
Inside Curve **without** Spiral, curve radius **larger** than Crossover radius	Ends at PC Begins at PT	Begins 15 ft after PC Ends 15 ft before PT
Inside Curve **with** Spiral, curve radius **smaller** than Crossover radius	Ends 30 ft before TS Begins 30 ft after ST	Begins at SC Ends at CS
Inside Curve **without** Spiral, curve radius **larger** than Crossover radius	Ends 30 ft before PC Begins 30 ft after PT	Begins at PC Ends at PT

More detailed computer analysis with more precise geometry may be used, subject to TriMet approval, to define the clearance envelope in place of these locations and straight-line interpolations.

The clearance envelope through turnouts shall be calculated based on the turnout centerline radius.

22.2.2 Other Wayside Factors (OWF) –The clearance envelope can be determined by adding other wayside factors (OWF) for certain construction and maintenance tolerances plus running clearance to the vehicle dynamic envelope. Other Wayside Factors is the sum of certain construction tolerances (CT) plus certain maintenance tolerances (MT) plus a chorded wall construction factor (CW) to account for the effects of certain wall construction, all where applicable.

OWF = CT + MT + CW

The following define the Other Wayside Factors and are applicable to and included in the horizontal component of the CE:

CT =Construction tolerances (allowable deviation from design position)

track = 0.5 in open, paved, and direct fixation

plus

poles or signals equipment = 1.0 in, or
walls = 1.0 in, or
tunnel lining = 3.0 in, or
tunnel walkway = 0.5 in

MT = Maintenance tolerances (allowable deviation from design condition)

track = 2.0 in open track, or
track = 0.5 in paved and Direct Fixation track

CW = Additional width for chorded construction of walls to be added only for outside of curves. (See Figure 22-1 and 22-2.)

FIGURE 22-1 ADDITIONAL WIDTH FOR CHORDED CONSTRUCTION

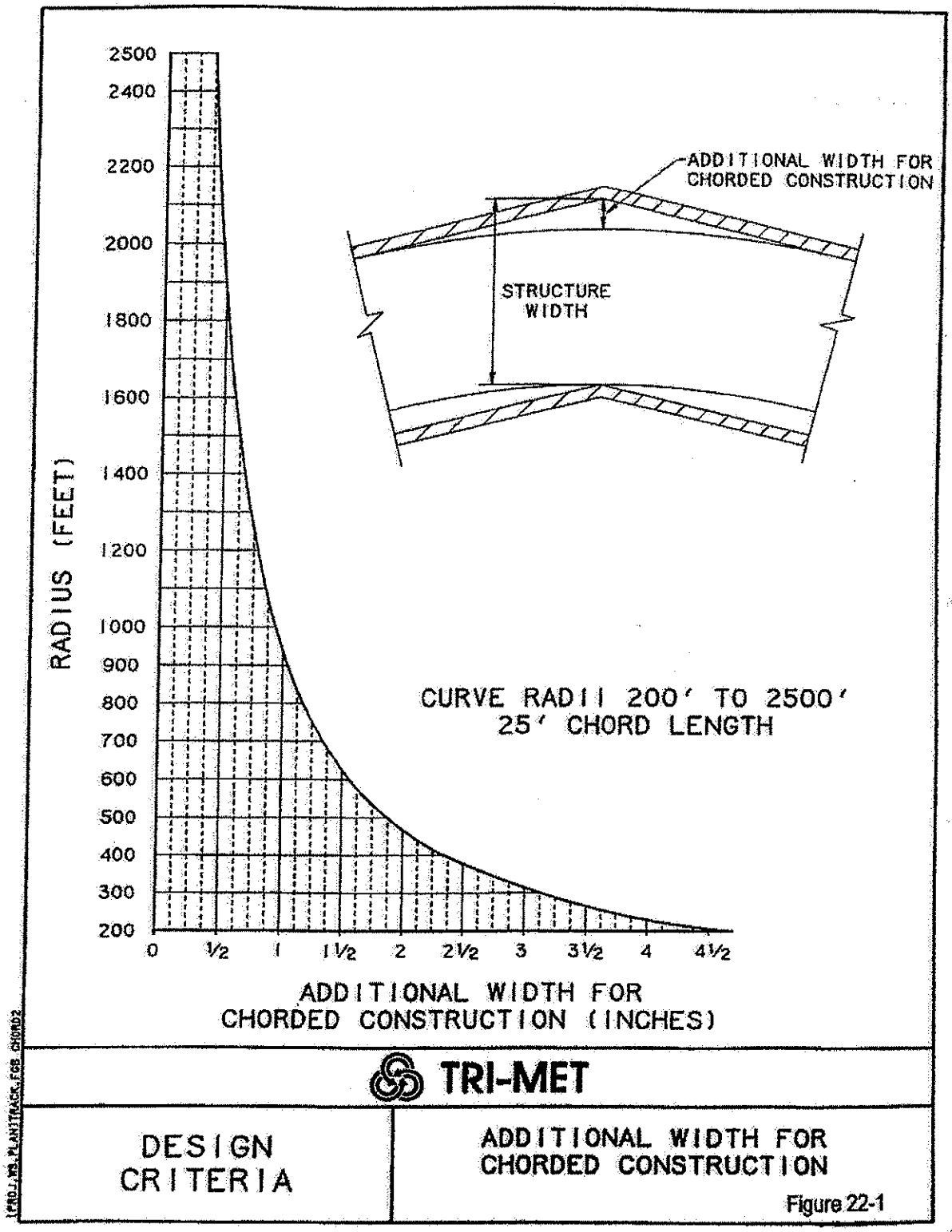
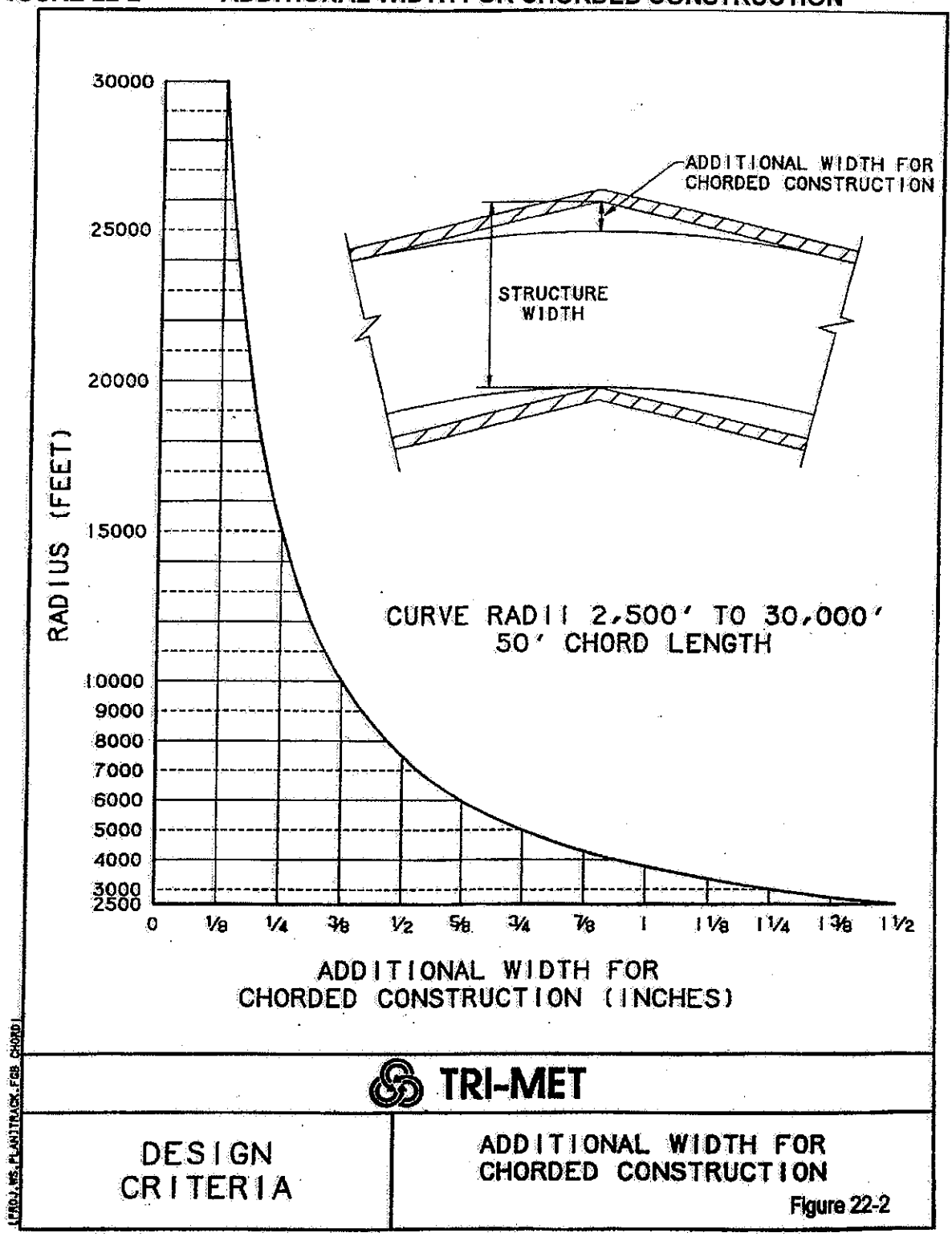


FIGURE 22-2 ADDITIONAL WIDTH FOR CHORDED CONSTRUCTION



22.2.3 Running Clearances (RC) – In addition to the vehicle dynamic envelope and the other wayside factors, the clearance envelope includes an allowance for running clearances (RC). Running clearances can be considered as the TriMet clearance contingency after the inclusion of all factors purporting to define the vehicle, the vehicle tolerances, the ROW construction tolerances, and the ROW maintenance tolerances. Running clearances are specific to the ROW conditions encountered and shall include one of the following in any direction:

2 in	For traction power poles, conduit, signals, signs, and other non-structural members
2 in	For tunnel walkway edge
3 in	For electrical passing clearance beside or above the vehicle pantograph
6 in	For structural members
0 in	For adjacent LRV

A clearance contingency for passing LRVs is not considered necessary.

22.3 SPECIAL CLEARANCE SITUATIONS

In addition to the more routine clearance envelope determinations above, there are several special clearance situations warranting further attention. These special situations include undercar clearances, pantograph clearances in tunnel sections, vehicle interface at station platforms and at safety/maintenance walkways in tunnel sections, and general walkway areas along the ROW where applicable.

22.3.1 Undercar Clearances – The minimum vertical clearance envelope (free space) between the rails shall be 2 inches (50mm). Since the LRV is permitted to extend down to 2 inches above TOR, nothing else may extend above TOR. An exception exists in paved track, where a crown for drainage may extend not more than 0.75 inches above TOR.

Outside of the rails, nothing shall be placed above TOR between points P2 and P26, chosen from the appropriate value in Attachment 22-A.

22.3.2 Above Car Clearances – Special attention must be paid to determining the appropriate vertical and horizontal clearance envelope in tunnels, underpasses and other locations where the rail route passes under a major structure.

The clearance envelope higher than 12' -9" above rail level in tunnels and underpasses, shall be determined in accordance with Attachment 22-B. This portion of the clearance envelope is known as the pantograph clearance envelope.

22.3.3 Platform Offset and Elevation – The station platform offset and elevation shall be as described in Section 6.4.2.

22.3.4 Track Centers with Center Poles – For open track with center traction power poles, the track centers shall be calculated based on the appropriate clearance envelopes, a design width for the traction power poles of 12 in, and lateral deflection due to loading of 0.75 in below 12 feet from TOR and 1.0 in above 12 feet from TOR.

ATTACHMENT 22-A TABLES FOR VEHICLE DYNAMIC ENVELOPE

Dynamic Envelope calculations are based on the conditions and parameters listed below. The points represent a "worst case" composite between the Type 1 and Type 2 cars.

- Lateral motion:

Wheel wear	0.300 in
Lateral suspension motion	1.340 in
Normal sideplay (half)	0.375 in
Wheel gauge tolerance (half)	0.031 in
Rail gauge tolerance (half)	0.125 in
Rail wear on gauge face (each rail)	0.500 in
Lateral pantograph sway	1.500 in
Pantograph dynamic uplift	3.000 in

- Maximum Roll Angle, failed suspension (except mirror points) — 4 degrees

- Static Car Points (refer to Figure 22A-1)

Point	X-Coordinate	Y-Coordinate
P1	00.00	15.00
P2	52.50	8.00
P3	52.50	88.00
P4	60.50	105.00
P5	60.50	118.00
P6	52.50	140.40
P7	36.40	161.00
P8	27.30	168.00
P9	00.00	168.00
P10	36.40	209.00
P11	27.30	216.00
P12	36.40	257.00
P13	27.30	264.00
P14	00.00	264.00
P15	-27.30	264.00
P16	-36.40	257.00
P17	00.00	216.00
P18	-27.30	216.00
P19	-36.40	209.00
P20	-27.30	168.00
P21	-36.40	161.00
P22	-52.50	140.40
P23	-60.50	118.00
P24	-60.50	105.00
P25	-52.50	88.00
P26	-52.50	8.00

Point	X-Coordinate	Y-Coordinate
P27	38.39	153.00
P28	-38.39	153.00

Points are in Cartesian coordinates with the X-axis formed by the top of the rails when level and tangent and the Y-axis formed by the vertical track centerline. Negative X-coordinates indicate points to the left of the track centerline. Negative Y-coordinates indicate points below top of rail.

- Points P2 through P13 and P27 are on the outside of the curve. Points P14 through P26 and P28 are on the inside of the curve.
- Dynamic envelope calculations for mirror points (P4, P5, P23, and P24) are adjusted to result in dynamic mirror envelope equivalent to 2.25-degree maximum roll angle.
- Centerline-to-Centerline Truck Spacing: 29.7 ft.
- Truck Wheel Base: 75 in.
- Cross level variation for paved and direct fixation track: 0.5 in.
  (includes 1/8 inch construction tolerance, plus 3/8 inch maintenance tolerance)
- Cross level variation for open track: 1.0 in.
  (includes 1/8 inch construction tolerance, plus 7/8 inch maintenance tolerance)
- Cross level variations are included in the Dynamic Envelope Tables. Tables 1 through 7 are for 0.5 in cross level variation (paved and direct fixation track). Tables 8 through 14 are for 1 inch cross level variation (open track).
- Superelevation is a rotation around the base of the inside rail.
- The track centerline is stationary under superelevation conditions; it does not rotate with the track.
- Dynamic Envelope is calculated for three different static pantograph heights:

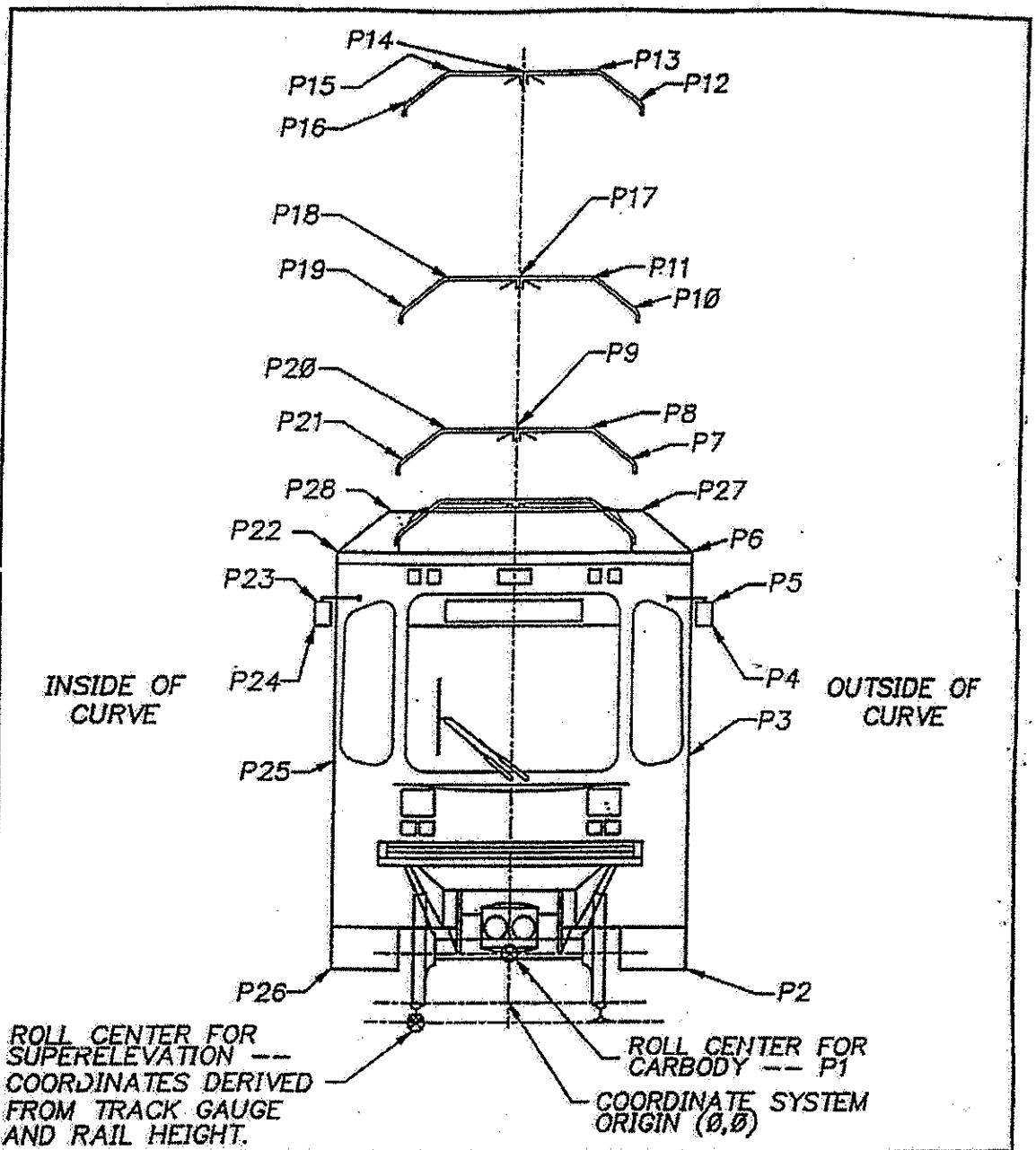
Static Pantograph Height	Points
14 ft	P7, P8, P20, P21
18 ft	P10, P11, P18, P19
22 ft	P12, P13, P14, P15

  If required, points at intermediate static pantograph heights should be calculated by linear interpolation.

- Allowances for wire uplift (3 in) and pantograph sway (1.5 in) are included in the dynamic envelope calculations

Also refer to Attachment 22-B for pantograph clearance in tunnels, underpasses and other structures built above the route.

FIGURE 22A-1 **STATIC CAR POSITION AND TYPICAL POINT LOCATIONS FOR DYNAMIC ENVELOPE CALCULATIONS**



TRI-MET Figure 22A-1

DESIGN CRITERIA	STATIC CAR POSITION AND TYPICAL POINT LOCATIONS FOR DYNAMIC ENVELOPE CALCULATIONS

Curve Offsets for Tri-Met LRVs
(Note that roll offsets do not appear in this sheet)

file:\TM Clearance Tables Rev F.XLS
Rev. F 4/1/2005

Basic Dimensions (inches):		Halves:
Axle Spacing:	74.80	37.40
Truck Spacing:	356.00	178.00
L2	156.00	
L3	127.00	
L4	100.00	
Carbody Width (W1):	105.00	52.50
Carbody Width (W2):	69.00	34.50
Equip. Width (W3):	76.77	38.39
Width at Mirror:	115.00	57.50
Lateral Motion:	2.67	
D3 Skew:	5.01	
D2 Skew:	4.58	
D4 Skew:	4.17	

Lateral motion is composed of:

Wheel wear:	0.300	Inches
Rail wear:	0.500	Inches
Rail gauge tolerance (half):	0.125	Inches
Wheel gauge tolerance (half):	0.031	Inches
Nominal sideplay (half):	0.375	Inches
Lateral suspension motion:	1.340	Inches
Total:	2.671	Inches

Changes in Rev. F:
- Added pantograph lateral sway (1.5 in) and dynamic uplift (3 in)
- Changed static pantograph heights to 14 ft, 18 ft and 22 ft
- Adjusted mirror static points to actual, and moved calculating to table

Radius: (feet)	Radius: (inches)	d	D1	D1e	D2in	D2out	D3in	D3in (mirror)	D3out	D3out (mirror)	D4in	D4out	MAXin	MAXin (mirror)	MAXout	MAXout (mirror)	D4MAXin	D4MAXout
82	984	16.94	72.12	58.00	24.50	84.78	-1.55	20.07	76.79	98.63	18.78	63.34	-72.12	-72.12	84.78	98.63	-58.00	63.34
100	1200	13.86	69.03	54.91	30.62	80.22	5.91	27.99	70.52	92.72	23.23	59.86	-69.03	-69.03	80.22	92.72	-54.91	59.86
150	1800	9.21	64.38	50.27	39.73	72.93	17.25	39.84	60.61	83.24	29.85	54.35	-64.38	-64.38	72.93	83.24	-50.27	54.35
200	2400	6.90	62.07	47.96	44.19	69.12	22.88	45.65	55.48	78.27	33.10	51.50	-62.07	-62.07	69.12	78.27	-47.96	51.50
300	3600	4.60	59.77	45.65	48.57	65.21	28.48	51.38	50.25	73.15	36.31	48.58	-59.77	-59.77	65.21	73.15	-45.65	48.58
400	4800	3.45	58.62	44.50	50.73	63.21	31.26	54.20	47.60	70.54	37.89	47.09	-58.62	-58.62	63.21	70.54	-44.50	47.09
500	6000	2.76	57.93	43.81	52.02	62.00	32.92	55.89	45.99	68.96	38.83	46.20	-57.93	-57.93	62.00	68.96	-43.81	46.20
600	7200	2.30	57.47	43.35	52.87	61.19	34.03	57.00	44.92	67.90	39.46	45.60	-57.47	-57.47	61.19	67.90	-43.35	45.60
700	8400	1.97	57.14	43.03	53.47	60.61	34.81	57.80	44.15	67.14	39.90	45.17	-57.14	-57.80	60.61	67.14	-43.03	45.17
800	9600	1.72	56.89	42.78	53.93	60.17	35.40	58.39	43.58	66.56	40.24	44.84	-56.89	-58.39	60.17	66.56	-42.78	44.84
900	10800	1.53	56.70	42.59	54.28	59.83	35.86	58.85	43.13	66.12	40.50	44.59	-56.70	-58.85	59.83	66.12	-42.59	44.59
1000	12000	1.38	56.55	42.43	54.56	59.56	36.23	59.22	42.77	65.76	40.70	44.39	-56.55	-59.22	59.56	65.76	-42.43	44.39
1200	14400	1.15	56.32	42.20	54.98	59.15	36.78	59.77	42.23	65.22	41.01	44.08	-56.32	-59.77	59.15	65.22	-42.20	44.08
1500	18000	0.92	56.09	41.97	55.40	58.73	37.33	60.32	41.69	64.68	41.32	43.78	-56.09	-60.32	58.73	64.68	-41.97	43.78
2000	24000	0.69	55.86	41.75	55.82	58.32	37.87	60.87	41.14	64.14	41.63	43.47	-55.86	-60.87	58.32	64.14	-41.75	43.47
5000	60000	0.28	55.45	41.33	56.58	57.58	38.86	61.86	40.17	63.16	42.19	42.92	-56.58	-61.86	57.58	63.16	-42.19	42.92
10000	120000	0.14	55.31	41.19	56.83	57.33	39.18	62.18	39.84	62.84	42.37	42.74	-56.83	-62.18	57.33	62.84	-42.37	42.74
50000	600000	0.03	55.20	41.08	57.03	57.13	39.45	62.45	39.58	62.58	42.52	42.59	-57.03	-62.45	57.13	62.58	-42.52	42.59
100000	1200000	0.01	55.18	41.07	57.05	57.10	39.48	62.48	39.54	62.54	42.54	42.57	-57.05	-62.48	57.10	62.54	-42.54	42.57

Track Gauge:	56.50	Inches				
Rail Height:	7.50	Inches				
Roll Angle:	4.00	Degrees		sr_angle		cr_angle
	0.0698	Radians	SIN=	0.06974	COS=	0.99756

Car Points with Pantograph uplift and sway included, and mirror points adjusted for reduced roll:

	X	Y
P1	0.00	15.00
P2	52.50	8.00
P3	52.50	88.00
P4	57.50	105.00
P5	57.50	118.00
P6	52.50	140.40
P7	37.90	164.00
P8	28.80	171.00
P9	0.00	171.00
P10	37.90	212.00
P11	28.80	219.00
P12	37.90	260.00
P13	28.80	267.00
P14	0.00	267.00
P15	-28.80	267.00
P16	-37.90	260.00
P17	0.00	219.00
P18	-28.80	219.00
P19	-37.90	212.00
P20	-28.80	171.00
P21	-37.90	164.00
P22	-52.50	140.40
P23	-57.50	118.00
P24	-57.50	105.00
P25	-52.50	88.00
P26	-52.50	8.00
P27	38.39	153.00
P28	-38.39	153.00

Static Car Points:

	X	Y
P1	0.00	15.00
P2	52.50	8.00
P3	52.50	88.00
P4	60.50	105.00
P5	60.50	118.00
P6	52.50	140.40
P7	36.40	161.00
P8	27.30	168.00
P9	0.00	168.00
P10	36.40	209.00
P11	27.30	216.00
P12	36.40	257.00
P13	27.30	264.00
P14	0.00	264.00
P15	-27.30	264.00
P16	-36.40	257.00
P17	0.00	216.00
P18	-27.30	216.00
P19	-36.40	209.00
P20	-27.30	168.00
P21	-36.40	161.00
P22	-52.50	140.40
P23	-60.50	118.00
P24	-60.50	105.00
P25	-52.50	88.00
P26	-52.50	8.00
P27	38.39	153.00
P28	-38.39	153.00

TABLE 1 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 0.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	0.20	15.25	85.30	3.65	90.55	83.40	105.73	99.95	106.75	122.45	94.66	144.39	52.36	166.77
100	0.20	15.25	80.74	3.65	85.99	83.40	99.81	99.95	100.84	122.45	90.11	144.39	52.36	166.77
150	0.20	15.25	73.46	3.65	78.70	83.40	90.33	99.95	91.35	122.45	82.82	144.39	52.36	166.77
200	0.20	15.25	69.65	3.65	74.89	83.40	85.36	99.95	86.38	122.45	79.01	144.39	52.36	166.77
300	0.20	15.25	65.73	3.65	70.98	83.40	80.24	99.95	81.26	122.45	75.10	144.39	52.36	166.77
400	0.20	15.25	63.74	3.65	68.98	83.40	77.63	99.95	78.65	122.45	73.10	144.39	52.36	166.77
500	0.20	15.25	62.53	3.65	67.77	83.40	76.05	99.95	77.07	122.45	71.89	144.39	52.36	166.77
600	0.20	15.25	61.72	3.65	66.96	83.40	74.99	99.95	76.01	122.45	71.08	144.39	52.36	166.77
700	0.20	15.25	61.14	3.65	66.38	83.40	74.23	99.95	75.25	122.45	70.50	144.39	52.36	166.77
800	0.20	15.25	60.70	3.65	65.94	83.40	73.65	99.95	74.68	122.45	70.06	144.39	52.36	166.77
900	0.20	15.25	60.36	3.65	65.60	83.40	73.21	99.95	74.23	122.45	69.72	144.39	52.36	166.77
1000	0.20	15.25	60.08	3.65	65.33	83.40	72.85	99.95	73.87	122.45	69.45	144.39	52.36	166.77
1200	0.20	15.25	59.67	3.65	64.92	83.40	72.31	99.95	73.33	122.45	69.03	144.39	52.36	166.77
1500	0.20	15.25	59.26	3.65	64.51	83.40	71.77	99.95	72.79	122.45	68.62	144.39	52.36	166.77
2000	0.20	15.25	58.85	3.65	64.09	83.40	71.23	99.95	72.25	122.45	68.21	144.39	52.36	166.77
5000	0.20	15.25	58.10	3.65	63.35	83.40	70.26	99.95	71.28	122.45	67.46	144.39	52.36	166.77
10000	0.20	15.25	57.85	3.65	63.10	83.40	69.93	99.95	70.95	122.45	67.21	144.39	52.36	166.77
50000	0.20	15.25	57.65	3.65	62.90	83.40	69.67	99.95	70.69	122.45	67.01	144.39	52.36	166.77
Tangent	0.20	15.25	57.63	3.65	62.87	83.40	69.64	99.95	70.66	122.45	66.99	144.39	52.36	166.77

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	74.26	155.84
100	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	70.78	155.84
150	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	65.27	155.84
200	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	62.42	155.84
300	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	59.50	155.84
400	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	58.02	155.84
500	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	57.12	155.84
600	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	56.52	155.84
700	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	56.09	155.84
800	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	55.76	155.84
900	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	55.51	155.84
1000	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	55.31	155.84
1200	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	55.01	155.84
1500	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	54.70	155.84
2000	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	54.40	155.84
5000	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	53.85	155.84
10000	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	53.66	155.84
50000	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	53.52	155.84
Tangent	43.84	173.03	15.13	171.24	56.13	214.62	47.61	220.88	59.90	262.47	51.38	268.73	53.50	155.84

TABLE 1A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 0.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
100	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
150	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
200	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
300	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
400	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
500	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
600	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
700	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
800	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
900	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
1000	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
1200	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
1500	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
2000	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
5000	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
10000	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
50000	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03
Tangent	-22.67	267.24	-51.38	268.73	-59.90	262.47	-18.90	219.24	-47.61	220.88	-56.13	214.62	-43.84	173.03

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-52.36	166.77	-82.01	144.39	-80.23	122.45	-79.21	99.95	-77.89	83.40	-72.64	3.65	-68.92	155.84
100	-52.36	166.77	-78.92	144.39	-77.14	122.45	-76.12	99.95	-74.80	83.40	-69.56	3.65	-65.84	155.84
150	-52.36	166.77	-74.27	144.39	-72.50	122.45	-71.48	99.95	-70.16	83.40	-64.91	3.65	-61.19	155.84
200	-52.36	166.77	-71.96	144.39	-70.19	122.45	-69.17	99.95	-67.85	83.40	-62.60	3.65	-58.88	155.84
300	-52.36	166.77	-69.66	144.39	-67.88	122.45	-66.86	99.95	-65.54	83.40	-60.30	3.65	-56.58	155.84
400	-52.36	166.77	-68.51	144.39	-66.73	122.45	-65.71	99.95	-64.39	83.40	-59.15	3.65	-55.43	155.84
500	-52.36	166.77	-67.82	144.39	-66.04	122.45	-65.02	99.95	-63.70	83.40	-58.46	3.65	-54.74	155.84
600	-52.36	166.77	-67.36	144.39	-65.58	122.45	-64.56	99.95	-63.24	83.40	-58.00	3.65	-54.28	155.84
700	-52.36	166.77	-67.03	144.39	-65.91	122.45	-64.89	99.95	-62.91	83.40	-57.67	3.65	-53.95	155.84
800	-52.36	166.77	-66.78	144.39	-66.51	122.45	-65.48	99.95	-62.67	83.40	-57.42	3.65	-53.70	155.84
900	-52.36	166.77	-66.59	144.39	-66.97	122.45	-65.95	99.95	-62.48	83.40	-57.23	3.65	-53.51	155.84
1000	-52.36	166.77	-66.44	144.39	-67.34	122.45	-66.31	99.95	-62.32	83.40	-57.08	3.65	-53.36	155.84
1200	-52.36	166.77	-66.21	144.39	-67.89	122.45	-66.87	99.95	-62.09	83.40	-56.85	3.65	-53.13	155.84
1500	-52.36	166.77	-65.98	144.39	-68.44	122.45	-67.42	99.95	-61.86	83.40	-56.62	3.65	-52.90	155.84
2000	-52.36	166.77	-65.75	144.39	-68.99	122.45	-67.97	99.95	-61.63	83.40	-56.39	3.65	-52.67	155.84
5000	-52.36	166.77	-66.47	144.39	-69.97	122.45	-68.95	99.95	-62.35	83.40	-57.11	3.65	-53.11	155.84
10000	-52.36	166.77	-66.72	144.39	-70.30	122.45	-69.28	99.95	-62.60	83.40	-57.36	3.65	-53.30	155.84
50000	-52.36	166.77	-66.92	144.39	-70.56	122.45	-69.54	99.95	-62.80	83.40	-57.56	3.65	-53.44	155.84
Tangent	-52.36	166.77	-66.94	144.39	-70.59	122.45	-69.57	99.95	-62.83	83.40	-57.58	3.65	-53.46	155.84

TABLE 2 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 1.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-0.20	15.75	84.96	5.06	88.92	84.92	103.81	101.58	104.60	123.80	92.12	145.61	49.38	167.70
100	-0.20	15.75	80.40	5.06	84.37	84.92	97.90	101.58	98.69	123.80	87.56	145.61	49.38	167.70
150	-0.20	15.75	73.12	5.06	77.08	84.92	88.41	101.58	89.20	123.80	80.27	145.61	49.38	167.70
200	-0.20	15.75	69.31	5.06	73.27	84.92	83.44	101.58	84.23	123.80	76.46	145.61	49.38	167.70
300	-0.20	15.75	65.39	5.06	69.36	84.92	78.33	101.58	79.12	123.80	72.55	145.61	49.38	167.70
400	-0.20	15.75	63.40	5.06	67.36	84.92	75.72	101.58	76.51	123.80	70.55	145.61	49.38	167.70
500	-0.20	15.75	62.19	5.06	66.15	84.92	74.13	101.58	74.93	123.80	69.34	145.61	49.38	167.70
600	-0.20	15.75	61.38	5.06	65.34	84.92	73.07	101.58	73.87	123.80	68.53	145.61	49.38	167.70
700	-0.20	15.75	60.80	5.06	64.76	84.92	72.31	101.58	73.10	123.80	67.95	145.61	49.38	167.70
800	-0.20	15.75	60.36	5.06	64.32	84.92	71.74	101.58	72.53	123.80	67.51	145.61	49.38	167.70
900	-0.20	15.75	60.02	5.06	63.98	84.92	71.29	101.58	72.08	123.80	67.17	145.61	49.38	167.70
1000	-0.20	15.75	59.74	5.06	63.71	84.92	70.93	101.58	71.73	123.80	66.90	145.61	49.38	167.70
1200	-0.20	15.75	59.33	5.06	63.30	84.92	70.40	101.58	71.19	123.80	66.49	145.61	49.38	167.70
1500	-0.20	15.75	58.92	5.06	62.88	84.92	69.86	101.58	70.65	123.80	66.07	145.61	49.38	167.70
2000	-0.20	15.75	58.51	5.06	62.47	84.92	69.32	101.58	70.11	123.80	65.66	145.61	49.38	167.70
5000	-0.20	15.75	57.76	5.06	61.72	84.92	68.34	101.58	69.13	123.80	64.92	145.61	49.38	167.70
10000	-0.20	15.75	57.51	5.06	61.48	84.92	68.01	101.58	68.81	123.80	64.67	145.61	49.38	167.70
50000	-0.20	15.75	57.31	5.06	61.28	84.92	67.75	101.58	68.54	123.80	64.47	145.61	49.38	167.70
Tangent	-0.20	15.75	57.29	5.06	61.25	84.92	67.72	101.58	68.51	123.80	64.44	145.61	49.38	167.70

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	71.47	156.79
100	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	67.99	156.79
150	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	62.48	156.79
200	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	59.63	156.79
300	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	56.71	156.79
400	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	55.23	156.79
500	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	54.33	156.79
600	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	53.73	156.79
700	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	53.30	156.79
800	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	52.98	156.79
900	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	52.72	156.79
1000	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	52.52	156.79
1200	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	52.22	156.79
1500	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	51.91	156.79
2000	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	51.61	156.79
5000	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	51.06	156.79
10000	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	50.88	156.79
50000	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	50.73	156.79
Tangent	40.72	173.79	11.97	171.74	52.30	215.47	43.64	221.57	55.22	263.25	46.57	269.34	50.71	156.79

TABLE 2A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **1.00 Inches** **Cross Level Variation =** **0.50 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
100	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
150	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
200	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
300	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
400	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
500	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
600	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
700	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
800	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
900	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
1000	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
1200	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
1500	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
2000	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
5000	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
10000	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
50000	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21
Tangent	-27.52	267.74	-56.19	269.04	-64.57	262.60	-22.90	219.74	-51.57	221.12	-59.95	214.69	-46.95	173.21

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-55.34	166.78	-84.54	144.11	-82.36	122.06	-81.11	99.29	-79.50	82.85	-72.98	3.22	-71.70	155.83
100	-55.34	166.78	-81.46	144.11	-79.28	122.06	-78.03	99.29	-76.41	82.85	-69.89	3.22	-68.62	155.83
150	-55.34	166.78	-76.81	144.11	-74.63	122.06	-73.38	99.29	-71.77	82.85	-65.24	3.22	-63.97	155.83
200	-55.34	166.78	-74.50	144.11	-72.32	122.06	-71.07	99.29	-69.46	82.85	-62.93	3.22	-61.66	155.83
300	-55.34	166.78	-72.19	144.11	-70.02	122.06	-68.77	99.29	-67.15	82.85	-60.63	3.22	-59.36	155.83
400	-55.34	166.78	-71.04	144.11	-68.87	122.06	-67.62	99.29	-66.00	82.85	-59.48	3.22	-58.21	155.83
500	-55.34	166.78	-70.35	144.11	-68.18	122.06	-66.93	99.29	-65.31	82.85	-58.79	3.22	-57.52	155.83
600	-55.34	166.78	-69.90	144.11	-67.72	122.06	-66.47	99.29	-64.85	82.85	-58.33	3.22	-57.06	155.83
700	-55.34	166.78	-69.57	144.11	-68.04	122.06	-66.79	99.29	-64.53	82.85	-58.00	3.22	-56.73	155.83
800	-55.34	166.78	-69.32	144.11	-68.64	122.06	-67.39	99.29	-64.28	82.85	-57.75	3.22	-56.48	155.83
900	-55.34	166.78	-69.13	144.11	-69.10	122.06	-67.85	99.29	-64.09	82.85	-57.56	3.22	-56.29	155.83
1000	-55.34	166.78	-68.98	144.11	-69.47	122.06	-68.22	99.29	-63.94	82.85	-57.41	3.22	-56.14	155.83
1200	-55.34	166.78	-68.75	144.11	-70.02	122.06	-68.77	99.29	-63.71	82.85	-57.18	3.22	-55.91	155.83
1500	-55.34	166.78	-68.52	144.11	-70.57	122.06	-69.32	99.29	-63.48	82.85	-56.95	3.22	-55.68	155.83
2000	-55.34	166.78	-68.29	144.11	-71.12	122.06	-69.87	99.29	-63.25	82.85	-56.72	3.22	-55.45	155.83
5000	-55.34	166.78	-69.00	144.11	-72.11	122.06	-70.85	99.29	-63.96	82.85	-57.44	3.22	-55.89	155.83
10000	-55.34	166.78	-69.25	144.11	-72.43	122.06	-71.18	99.29	-64.21	82.85	-57.69	3.22	-56.08	155.83
50000	-55.34	166.78	-69.45	144.11	-72.69	122.06	-71.44	99.29	-64.41	82.85	-57.89	3.22	-56.22	155.83
Tangent	-55.34	166.78	-69.48	144.11	-72.73	122.06	-71.48	99.29	-64.44	82.85	-57.91	3.22	-56.24	155.83

TABLE 3 Vehicle Dynamic Env[illegible]e to OUTSIDE of Curve

Superelevation = 2.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-0.61	16.24	84.60	6.48	87.28	86.40	101.87	103.17	102.43	125.10	89.54	146.79	46.37	168.57
100	-0.61	16.24	80.04	6.48	82.72	86.40	95.95	103.17	96.52	125.10	84.98	146.79	46.37	168.57
150	-0.61	16.24	72.75	6.48	75.43	86.40	86.47	103.17	87.03	125.10	77.70	146.79	46.37	168.57
200	-0.61	16.24	68.94	6.48	71.62	86.40	81.50	103.17	82.06	125.10	73.89	146.79	46.37	168.57
300	-0.61	16.24	65.03	6.48	67.71	86.40	76.38	103.17	76.95	125.10	69.97	146.79	46.37	168.57
400	-0.61	16.24	63.03	6.48	65.71	86.40	73.77	103.17	74.34	125.10	67.98	146.79	46.37	168.57
500	-0.61	16.24	61.83	6.48	64.50	86.40	72.19	103.17	72.75	125.10	66.77	146.79	46.37	168.57
600	-0.61	16.24	61.01	6.48	63.69	86.40	71.13	103.17	71.69	125.10	65.96	146.79	46.37	168.57
700	-0.61	16.24	60.43	6.48	63.11	86.40	70.37	103.17	70.93	125.10	65.38	146.79	46.37	168.57
800	-0.61	16.24	59.99	6.48	62.67	86.40	69.79	103.17	70.36	125.10	64.94	146.79	46.37	168.57
900	-0.61	16.24	59.65	6.48	62.33	86.40	69.35	103.17	69.91	125.10	64.60	146.79	46.37	168.57
1000	-0.61	16.24	59.38	6.48	62.06	86.40	68.99	103.17	69.55	125.10	64.32	146.79	46.37	168.57
1200	-0.61	16.24	58.97	6.48	61.65	86.40	68.45	103.17	69.01	125.10	63.91	146.79	46.37	168.57
1500	-0.61	16.24	58.56	6.48	61.23	86.40	67.91	103.17	68.47	125.10	63.50	146.79	46.37	168.57
2000	-0.61	16.24	58.14	6.48	60.82	86.40	67.37	103.17	67.93	125.10	63.09	146.79	46.37	168.57
5000	-0.61	16.24	57.40	6.48	60.08	86.40	66.40	103.17	66.96	125.10	62.34	146.79	46.37	168.57
10000	-0.61	16.24	57.15	6.48	59.83	86.40	66.07	103.17	66.63	125.10	62.09	146.79	46.37	168.57
50000	-0.61	16.24	56.95	6.48	59.63	86.40	65.81	103.17	66.37	125.10	61.89	146.79	46.37	168.57
Tangent	-0.61	16.24	56.92	6.48	59.60	86.40	65.78	103.17	66.34	125.10	61.87	146.79	46.37	168.57

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	68.66	157.70
100	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	65.18	157.70
150	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	59.67	157.70
200	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	56.82	157.70
300	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	53.90	157.70
400	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	52.42	157.70
500	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	51.52	157.70
600	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	50.92	157.70
700	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	50.49	157.70
800	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	50.17	157.70
900	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	49.91	157.70
1000	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	49.71	157.70
1200	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	49.41	157.70
1500	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	49.10	157.70
2000	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	48.80	157.70
5000	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	48.25	157.70
10000	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	48.07	157.70
50000	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	47.92	157.70
Tangent	37.58	174.49	8.81	172.19	48.45	216.26	39.66	222.18	50.52	263.95	41.73	269.87	47.90	157.70

TABLE 3A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **2.00 Inches** **Cross Level Variation =** **0.50 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
100	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
150	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
200	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
300	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
400	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
500	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
600	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
700	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
800	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
900	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
1000	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
1200	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
1500	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
2000	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
5000	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
10000	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
50000	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34
Tangent	-32.36	268.15	-60.98	269.25	-69.22	262.65	-26.90	220.17	-55.52	221.30	-63.76	214.70	-50.05	173.34

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-58.30	166.74	-87.06	143.79	-84.48	121.63	-83.00	98.60	-81.10	82.28	-73.30	2.80	-74.47	155.77
100	-58.30	166.74	-83.98	143.79	-81.40	121.63	-79.92	98.60	-78.02	82.28	-70.21	2.80	-71.39	155.77
150	-58.30	166.74	-79.33	143.79	-76.75	121.63	-75.27	98.60	-73.37	82.28	-65.57	2.80	-66.74	155.77
200	-58.30	166.74	-77.02	143.79	-74.44	121.63	-72.96	98.60	-71.06	82.28	-63.26	2.80	-64.43	155.77
300	-58.30	166.74	-74.72	143.79	-72.14	121.63	-70.66	98.60	-68.76	82.28	-60.95	2.80	-62.13	155.77
400	-58.30	166.74	-73.57	143.79	-70.99	121.63	-69.51	98.60	-67.60	82.28	-59.80	2.80	-60.98	155.77
500	-58.30	166.74	-72.88	143.79	-70.30	121.63	-68.82	98.60	-66.92	82.28	-59.11	2.80	-60.29	155.77
600	-58.30	166.74	-72.42	143.79	-69.84	121.63	-68.36	98.60	-66.46	82.28	-58.65	2.80	-59.83	155.77
700	-58.30	166.74	-72.09	143.79	-70.16	121.63	-68.68	98.60	-66.13	82.28	-58.32	2.80	-59.50	155.77
800	-58.30	166.74	-71.84	143.79	-70.76	121.63	-69.28	98.60	-65.88	82.28	-58.08	2.80	-59.25	155.77
900	-58.30	166.74	-71.65	143.79	-71.22	121.63	-69.74	98.60	-65.69	82.28	-57.89	2.80	-59.06	155.77
1000	-58.30	166.74	-71.50	143.79	-71.59	121.63	-70.11	98.60	-65.54	82.28	-57.73	2.80	-58.91	155.77
1200	-58.30	166.74	-71.27	143.79	-72.14	121.63	-70.66	98.60	-65.31	82.28	-57.50	2.80	-58.68	155.77
1500	-58.30	166.74	-71.04	143.79	-72.69	121.63	-71.21	98.60	-65.08	82.28	-57.27	2.80	-58.45	155.77
2000	-58.30	166.74	-70.81	143.79	-73.24	121.63	-71.76	98.60	-64.85	82.28	-57.04	2.80	-58.22	155.77
5000	-58.30	166.74	-71.52	143.79	-74.22	121.63	-72.75	98.60	-65.56	82.28	-57.76	2.80	-58.66	155.77
10000	-58.30	166.74	-71.78	143.79	-74.55	121.63	-73.07	98.60	-65.81	82.28	-58.01	2.80	-58.85	155.77
50000	-58.30	166.74	-71.98	143.79	-74.81	121.63	-73.33	98.60	-66.01	82.28	-58.21	2.80	-58.99	155.77
Tangent	-58.30	166.74	-72.00	143.79	-74.85	121.63	-73.37	98.60	-66.04	82.28	-58.24	2.80	-59.01	155.77

TABLE 4 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 3.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-1.02	16.73	84.21	7.89	85.60	87.86	99.90	104.73	100.23	126.36	86.94	147.91	43.35	169.39
100	-1.02	16.73	79.65	7.89	81.05	87.86	93.98	104.73	94.32	126.36	82.39	147.91	43.35	169.39
150	-1.02	16.73	72.36	7.89	73.76	87.86	84.50	104.73	84.83	126.36	75.10	147.91	43.35	169.39
200	-1.02	16.73	68.55	7.89	69.95	87.86	79.53	104.73	79.86	126.36	71.29	147.91	43.35	169.39
300	-1.02	16.73	64.64	7.89	66.04	87.86	74.41	104.73	74.75	126.36	67.38	147.91	43.35	169.39
400	-1.02	16.73	62.65	7.89	64.04	87.86	71.80	104.73	72.14	126.36	65.38	147.91	43.35	169.39
500	-1.02	16.73	61.44	7.89	62.83	87.86	70.22	104.73	70.55	126.36	64.17	147.91	43.35	169.39
600	-1.02	16.73	60.62	7.89	62.02	87.86	69.16	104.73	69.49	126.36	63.36	147.91	43.35	169.39
700	-1.02	16.73	60.04	7.89	61.44	87.86	68.40	104.73	68.73	126.36	62.78	147.91	43.35	169.39
800	-1.02	16.73	59.61	7.89	61.00	87.86	67.82	104.73	68.16	126.36	62.34	147.91	43.35	169.39
900	-1.02	16.73	59.26	7.89	60.66	87.86	67.38	104.73	67.71	126.36	62.00	147.91	43.35	169.39
1000	-1.02	16.73	58.99	7.89	60.38	87.86	67.02	104.73	67.35	126.36	61.73	147.91	43.35	169.39
1200	-1.02	16.73	58.58	7.89	59.97	87.86	66.48	104.73	66.81	126.36	61.31	147.91	43.35	169.39
1500	-1.02	16.73	58.17	7.89	59.56	87.86	65.94	104.73	66.28	126.36	60.90	147.91	43.35	169.39
2000	-1.02	16.73	57.75	7.89	59.15	87.86	65.40	104.73	65.73	126.36	60.49	147.91	43.35	169.39
5000	-1.02	16.73	57.01	7.89	58.40	87.86	64.43	104.73	64.76	126.36	59.74	147.91	43.35	169.39
10000	-1.02	16.73	56.76	7.89	58.15	87.86	64.10	104.73	64.43	126.36	59.49	147.91	43.35	169.39
50000	-1.02	16.73	56.56	7.89	57.95	87.86	63.84	104.73	64.17	126.36	59.29	147.91	43.35	169.39
Tangent	-1.02	16.73	56.53	7.89	57.93	87.86	63.81	104.73	64.14	126.36	59.27	147.91	43.35	169.39

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	65.83	158.55
100	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	62.35	158.55
150	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	56.85	158.55
200	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	53.99	158.55
300	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	51.07	158.55
400	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	49.59	158.55
500	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	48.69	158.55
600	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	48.09	158.55
700	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	47.66	158.55
800	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	47.34	158.55
900	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	47.09	158.55
1000	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	46.88	158.55
1200	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	46.58	158.55
1500	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	46.27	158.55
2000	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	45.97	158.55
5000	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	45.42	158.55
10000	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	45.24	158.55
50000	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	45.09	158.55
Tangent	34.43	175.13	5.64	172.70	44.58	216.97	35.66	222.72	45.80	264.56	36.89	270.37	45.07	158.55

TABLE 4A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 3.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
100	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
150	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
200	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
300	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
400	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
500	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
600	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
700	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
800	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
900	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
1000	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
1200	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
1500	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
2000	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
5000	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
10000	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
50000	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41
Tangent	-37.20	268.70	-65.75	269.38	-73.85	262.62	-30.90	220.70	-59.45	221.40	-67.55	214.63	-53.15	173.41

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-61.25	166.65	-89.57	143.43	-86.59	121.16	-84.88	97.88	-82.69	81.68	-73.61	2.37	-77.23	155.66
100	-61.25	166.65	-86.48	143.43	-83.50	121.16	-81.79	97.88	-79.60	81.68	-70.53	2.37	-74.14	155.66
150	-61.25	166.65	-81.84	143.43	-78.85	121.16	-77.15	97.88	-74.96	81.68	-65.88	2.37	-69.50	155.66
200	-61.25	166.65	-79.53	143.43	-76.54	121.16	-74.84	97.88	-72.65	81.68	-63.57	2.37	-67.19	155.66
300	-61.25	166.65	-77.22	143.43	-74.24	121.16	-72.53	97.88	-70.34	81.68	-61.27	2.37	-64.88	155.66
400	-61.25	166.65	-76.07	143.43	-73.09	121.16	-71.38	97.88	-69.19	81.68	-60.12	2.37	-63.73	155.66
500	-61.25	166.65	-75.38	143.43	-72.40	121.16	-70.69	97.88	-68.50	81.68	-59.43	2.37	-63.04	155.66
600	-61.25	166.65	-74.92	143.43	-71.94	121.16	-70.23	97.88	-68.04	81.68	-58.97	2.37	-62.58	155.66
700	-61.25	166.65	-74.59	143.43	-72.27	121.16	-70.56	97.88	-67.72	81.68	-58.64	2.37	-62.26	155.66
800	-61.25	166.65	-74.35	143.43	-72.86	121.16	-71.15	97.88	-67.47	81.68	-58.39	2.37	-62.01	155.66
900	-61.25	166.65	-74.16	143.43	-73.32	121.16	-71.62	97.88	-67.28	81.68	-58.20	2.37	-61.82	155.66
1000	-61.25	166.65	-74.00	143.43	-73.69	121.16	-71.98	97.88	-67.12	81.68	-58.05	2.37	-61.67	155.66
1200	-61.25	166.65	-73.77	143.43	-74.24	121.16	-72.54	97.88	-66.89	81.68	-57.82	2.37	-61.44	155.66
1500	-61.25	166.65	-73.54	143.43	-74.79	121.16	-73.09	97.88	-66.66	81.68	-57.59	2.37	-61.21	155.66
2000	-61.25	166.65	-73.31	143.43	-75.34	121.16	-73.63	97.88	-66.44	81.68	-57.36	2.37	-60.98	155.66
5000	-61.25	166.65	-74.03	143.43	-76.33	121.16	-74.62	97.88	-67.15	81.68	-58.08	2.37	-61.42	155.66
10000	-61.25	166.65	-74.28	143.43	-76.65	121.16	-74.95	97.88	-67.40	81.68	-58.33	2.37	-61.60	155.66
50000	-61.25	166.65	-74.48	143.43	-76.92	121.16	-75.21	97.88	-67.60	81.68	-58.53	2.37	-61.75	155.66
Tangent	-61.25	166.65	-74.51	143.43	-76.95	121.16	-75.24	97.88	-67.63	81.68	-58.55	2.37	-61.77	155.66

TABLE 5 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 4.00 Inches **Cross Level Variation =** 0.50 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-1.45	17.20	83.79	9.29	83.91	89.28	97.90	106.24	98.00	127.58	84.32	148.99	40.31	170.15
100	-1.45	17.20	79.24	9.29	79.35	89.28	91.99	106.24	92.09	127.58	79.77	148.99	40.31	170.15
150	-1.45	17.20	71.95	9.29	72.06	89.28	82.50	106.24	82.61	127.58	72.48	148.99	40.31	170.15
200	-1.45	17.20	68.14	9.29	68.25	89.28	77.53	106.24	77.64	127.58	68.67	148.99	40.31	170.15
300	-1.45	17.20	64.23	9.29	64.34	89.28	72.42	106.24	72.52	127.58	64.76	148.99	40.31	170.15
400	-1.45	17.20	62.23	9.29	62.34	89.28	69.81	106.24	69.91	127.58	62.76	148.99	40.31	170.15
500	-1.45	17.20	61.02	9.29	61.13	89.28	68.23	106.24	68.33	127.58	61.55	148.99	40.31	170.15
600	-1.45	17.20	60.21	9.29	60.32	89.28	67.16	106.24	67.27	127.58	60.74	148.99	40.31	170.15
700	-1.45	17.20	59.63	9.29	59.74	89.28	66.40	106.24	66.51	127.58	60.16	148.99	40.31	170.15
800	-1.45	17.20	59.19	9.29	59.30	89.28	65.83	106.24	65.93	127.58	59.72	148.99	40.31	170.15
900	-1.45	17.20	58.85	9.29	58.96	89.28	65.38	106.24	65.49	127.58	59.38	148.99	40.31	170.15
1000	-1.45	17.20	58.58	9.29	58.69	89.28	65.03	106.24	65.13	127.58	59.11	148.99	40.31	170.15
1200	-1.45	17.20	58.17	9.29	58.28	89.28	64.49	106.24	64.59	127.58	58.69	148.99	40.31	170.15
1500	-1.45	17.20	57.75	9.29	57.87	89.28	63.95	106.24	64.05	127.58	58.28	148.99	40.31	170.15
2000	-1.45	17.20	57.34	9.29	57.45	89.28	63.41	106.24	63.51	127.58	57.87	148.99	40.31	170.15
5000	-1.45	17.20	56.59	9.29	56.71	89.28	62.43	106.24	62.53	127.58	57.12	148.99	40.31	170.15
10000	-1.45	17.20	56.35	9.29	56.46	89.28	62.11	106.24	62.21	127.58	56.87	148.99	40.31	170.15
50000	-1.45	17.20	56.15	9.29	56.26	89.28	61.84	106.24	61.95	127.58	56.67	148.99	40.31	170.15
Tangent	-1.45	17.20	56.12	9.29	56.23	89.28	61.81	106.24	61.91	127.58	56.65	148.99	40.31	170.15

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	62.99	159.35
100	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	59.51	159.35
150	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	54.00	159.35
200	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	51.14	159.35
300	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	48.23	159.35
400	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	46.74	159.35
500	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	45.85	159.35
600	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	45.25	159.35
700	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	44.81	159.35
800	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	44.49	159.35
900	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	44.24	159.35
1000	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	44.04	159.35
1200	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	43.73	159.35
1500	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	43.43	159.35
2000	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	43.12	159.35
5000	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	42.57	159.35
10000	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	42.39	159.35
50000	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	42.24	159.35
Tangent	31.26	175.72	2.46	173.20	40.69	217.62	31.64	223.22	41.07	265.08	32.02	270.80	42.22	159.35

TABLE 5A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 4.00 Inches **Cross Level Variation = 0.50 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
100	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
150	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
200	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
300	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
400	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
500	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
600	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
700	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
800	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
900	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
1000	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
1200	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
1500	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
2000	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
5000	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
10000	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
50000	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43
Tangent	-42.03	269.20	-70.50	269.42	-78.46	262.50	-34.89	221.20	-63.37	221.43	-71.32	214.50	-56.23	173.43

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-64.19	166.50	-92.06	143.02	-88.67	120.66	-86.74	97.12	-84.26	81.05	-73.92	1.94	-79.97	155.50
100	-64.19	166.50	-88.97	143.02	-85.58	120.66	-83.65	97.12	-81.18	81.05	-70.83	1.94	-76.89	155.50
150	-64.19	166.50	-84.32	143.02	-80.94	120.66	-79.00	97.12	-76.53	81.05	-66.19	1.94	-72.24	155.50
200	-64.19	166.50	-82.01	143.02	-78.63	120.66	-76.69	97.12	-74.22	81.05	-63.88	1.94	-69.93	155.50
300	-64.19	166.50	-79.71	143.02	-76.32	120.66	-74.39	97.12	-71.92	81.05	-61.57	1.94	-67.63	155.50
400	-64.19	166.50	-78.56	143.02	-75.17	120.66	-73.24	97.12	-70.77	81.05	-60.42	1.94	-66.48	155.50
500	-64.19	166.50	-77.87	143.02	-74.48	120.66	-72.55	97.12	-70.08	81.05	-59.73	1.94	-65.79	155.50
600	-64.19	166.50	-77.41	143.02	-74.02	120.66	-72.09	97.12	-69.62	81.05	-59.27	1.94	-65.33	155.50
700	-64.19	166.50	-77.08	143.02	-74.35	120.66	-72.42	97.12	-69.29	81.05	-58.95	1.94	-65.00	155.50
800	-64.19	166.50	-76.84	143.02	-74.95	120.66	-73.01	97.12	-69.04	81.05	-58.70	1.94	-64.75	155.50
900	-64.19	166.50	-76.64	143.02	-75.41	120.66	-73.47	97.12	-68.85	81.05	-58.51	1.94	-64.56	155.50
1000	-64.19	166.50	-76.49	143.02	-75.77	120.66	-73.84	97.12	-68.70	81.05	-58.35	1.94	-64.41	155.50
1200	-64.19	166.50	-76.26	143.02	-76.33	120.66	-74.39	97.12	-68.47	81.05	-58.13	1.94	-64.18	155.50
1500	-64.19	166.50	-76.03	143.02	-76.88	120.66	-74.94	97.12	-68.24	81.05	-57.90	1.94	-63.95	155.50
2000	-64.19	166.50	-75.80	143.02	-77.43	120.66	-75.49	97.12	-68.01	81.05	-57.67	1.94	-63.72	155.50
5000	-64.19	166.50	-76.52	143.02	-78.41	120.66	-76.48	97.12	-68.73	81.05	-58.38	1.94	-64.16	155.50
10000	-64.19	166.50	-76.77	143.02	-78.74	120.66	-76.81	97.12	-68.98	81.05	-58.63	1.94	-64.34	155.50
50000	-64.19	166.50	-76.97	143.02	-79.00	120.66	-77.07	97.12	-69.18	81.05	-58.83	1.94	-64.49	155.50
Tangent	-64.19	166.50	-76.99	143.02	-79.03	120.66	-77.10	97.12	-69.20	81.05	-58.86	1.94	-64.51	155.50

TABLE 6 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = **5.00 Inches** **Cross Level Variation =** **0.50 Inches** Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-1.88	17.67	83.36	10.68	82.19	90.68	95.88	107.72	95.76	128.75	81.68	150.01	37.25	170.86
100	-1.88	17.67	78.80	10.68	77.63	90.68	89.97	107.72	89.85	128.75	77.13	150.01	37.25	170.86
150	-1.88	17.67	71.51	10.68	70.34	90.68	80.49	107.72	80.36	128.75	69.84	150.01	37.25	170.86
200	-1.88	17.67	67.70	10.68	66.54	90.68	75.52	107.72	75.39	128.75	66.03	150.01	37.25	170.86
300	-1.88	17.67	63.79	10.68	62.62	90.68	70.40	107.72	70.28	128.75	62.12	150.01	37.25	170.86
400	-1.88	17.67	61.79	10.68	60.63	90.68	67.79	107.72	67.67	128.75	60.12	150.01	37.25	170.86
500	-1.88	17.67	60.58	10.68	59.42	90.68	66.21	107.72	66.08	128.75	58.91	150.01	37.25	170.86
600	-1.88	17.67	59.77	10.68	58.61	90.68	65.15	107.72	65.02	128.75	58.10	150.01	37.25	170.86
700	-1.88	17.67	59.19	10.68	58.03	90.68	64.39	107.72	64.26	128.75	57.52	150.01	37.25	170.86
800	-1.88	17.67	58.75	10.68	57.59	90.68	63.81	107.72	63.69	128.75	57.08	150.01	37.25	170.86
900	-1.88	17.67	58.41	10.68	57.25	90.68	63.37	107.72	63.24	128.75	56.74	150.01	37.25	170.86
1000	-1.88	17.67	58.14	10.68	56.97	90.68	63.01	107.72	62.88	128.75	56.47	150.01	37.25	170.86
1200	-1.88	17.67	57.73	10.68	56.56	90.68	62.47	107.72	62.35	128.75	56.05	150.01	37.25	170.86
1500	-1.88	17.67	57.32	10.68	56.15	90.68	61.93	107.72	61.81	128.75	55.64	150.01	37.25	170.86
2000	-1.88	17.67	56.90	10.68	55.74	90.68	61.39	107.72	61.27	128.75	55.23	150.01	37.25	170.86
5000	-1.88	17.67	56.16	10.68	54.99	90.68	60.42	107.72	60.29	128.75	54.48	150.01	37.25	170.86
10000	-1.88	17.67	55.91	10.68	54.74	90.68	60.09	107.72	59.96	128.75	54.23	150.01	37.25	170.86
50000	-1.88	17.67	55.71	10.68	54.54	90.68	59.83	107.72	59.70	128.75	54.04	150.01	37.25	170.86
Tangent	-1.88	17.67	55.68	10.68	54.52	90.68	59.80	107.72	59.67	128.75	54.01	150.01	37.25	170.86

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	60.12	160.09
100	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	56.65	160.09
150	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	51.14	160.09
200	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	48.28	160.09
300	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	45.36	160.09
400	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	43.88	160.09
500	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	42.99	160.09
600	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	42.38	160.09
700	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	41.95	160.09
800	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	41.63	160.09
900	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	41.38	160.09
1000	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	41.17	160.09
1200	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	40.87	160.09
1500	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	40.57	160.09
2000	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	40.26	160.09
5000	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	39.71	160.09
10000	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	39.53	160.09
50000	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	39.38	160.09
Tangent	28.08	176.25	-0.71	173.66	36.79	218.19	27.62	223.69	36.32	265.58	27.16	271.24	39.36	160.09

TABLE 6A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **5.00 Inches** **Cross Level Variation =** **0.50 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
100	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
150	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
200	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
300	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
400	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
500	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
600	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
700	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
800	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
900	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
1000	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
1200	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
1500	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
2000	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
5000	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
10000	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
50000	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39
Tangent	-46.83	269.66	-75.23	269.38	-83.04	262.29	-38.86	221.66	-67.26	221.38	-75.07	214.30	-59.29	173.39

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-67.10	166.30	-94.52	142.56	-90.73	120.11	-88.58	96.33	-85.82	80.40	-74.22	1.51	-82.70	155.29
100	-67.10	166.30	-91.44	142.56	-87.65	120.11	-85.49	96.33	-82.74	80.40	-71.13	1.51	-79.61	155.29
150	-67.10	166.30	-86.79	142.56	-83.00	120.11	-80.84	96.33	-78.09	80.40	-66.49	1.51	-74.96	155.29
200	-67.10	166.30	-84.48	142.56	-80.69	120.11	-78.53	96.33	-75.78	80.40	-64.18	1.51	-72.65	155.29
300	-67.10	166.30	-82.18	142.56	-78.39	120.11	-76.23	96.33	-73.48	80.40	-61.87	1.51	-70.35	155.29
400	-67.10	166.30	-81.03	142.56	-77.24	120.11	-75.08	96.33	-72.32	80.40	-60.72	1.51	-69.20	155.29
500	-67.10	166.30	-80.34	142.56	-76.55	120.11	-74.39	96.33	-71.64	80.40	-60.03	1.51	-68.51	155.29
600	-67.10	166.30	-79.88	142.56	-76.09	120.11	-73.93	96.33	-71.18	80.40	-59.57	1.51	-68.05	155.29
700	-67.10	166.30	-79.55	142.56	-76.42	120.11	-74.26	96.33	-70.85	80.40	-59.24	1.51	-67.72	155.29
800	-67.10	166.30	-79.30	142.56	-77.01	120.11	-74.85	96.33	-70.60	80.40	-59.00	1.51	-67.48	155.29
900	-67.10	166.30	-79.11	142.56	-77.47	120.11	-75.31	96.33	-70.41	80.40	-58.81	1.51	-67.28	155.29
1000	-67.10	166.30	-78.96	142.56	-77.84	120.11	-75.68	96.33	-70.26	80.40	-58.65	1.51	-67.13	155.29
1200	-67.10	166.30	-78.73	142.56	-78.39	120.11	-76.23	96.33	-70.03	80.40	-58.42	1.51	-66.90	155.29
1500	-67.10	166.30	-78.50	142.56	-78.94	120.11	-76.78	96.33	-69.80	80.40	-58.19	1.51	-66.67	155.29
2000	-67.10	166.30	-78.27	142.56	-79.49	120.11	-77.33	96.33	-69.57	80.40	-57.96	1.51	-66.44	155.29
5000	-67.10	166.30	-78.99	142.56	-80.48	120.11	-78.32	96.33	-70.28	80.40	-58.68	1.51	-66.88	155.29
10000	-67.10	166.30	-79.24	142.56	-80.80	120.11	-78.65	96.33	-70.53	80.40	-58.93	1.51	-67.07	155.29
50000	-67.10	166.30	-79.44	142.56	-81.07	120.11	-78.91	96.33	-70.73	80.40	-59.13	1.51	-67.22	155.29
Tangent	-67.10	166.30	-79.46	142.56	-81.10	120.11	-78.94	96.33	-70.76	80.40	-59.15	1.51	-67.24	155.29

TABLE 7 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 6.00 Inches **Cross Level Variation = 0.50 Inches** Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-2.31	18.13	82.90	12.06	80.45	92.03	93.85	109.16	93.49	129.88	79.03	150.98	34.19	171.50
100	-2.31	18.13	78.34	12.06	75.90	92.03	87.94	109.16	87.58	129.88	74.47	150.98	34.19	171.50
150	-2.31	18.13	71.05	12.06	68.61	92.03	78.45	109.16	78.10	129.88	67.18	150.98	34.19	171.50
200	-2.31	18.13	67.24	12.06	64.80	92.03	73.48	109.16	73.13	129.88	63.37	150.98	34.19	171.50
300	-2.31	18.13	63.33	12.06	60.89	92.03	68.37	109.16	68.01	129.88	59.46	150.98	34.19	171.50
400	-2.31	18.13	61.33	12.06	58.89	92.03	65.76	109.16	65.40	129.88	57.46	150.98	34.19	171.50
500	-2.31	18.13	60.12	12.06	57.68	92.03	64.17	109.16	63.82	129.88	56.25	150.98	34.19	171.50
600	-2.31	18.13	59.31	12.06	56.87	92.03	63.11	109.16	62.76	129.88	55.44	150.98	34.19	171.50
700	-2.31	18.13	58.73	12.06	56.29	92.03	62.35	109.16	62.00	129.88	54.86	150.98	34.19	171.50
800	-2.31	18.13	58.29	12.06	55.85	92.03	61.78	109.16	61.42	129.88	54.42	150.98	34.19	171.50
900	-2.31	18.13	57.95	12.06	55.51	92.03	61.33	109.16	60.98	129.88	54.08	150.98	34.19	171.50
1000	-2.31	18.13	57.68	12.06	55.24	92.03	60.97	109.16	60.62	129.88	53.81	150.98	34.19	171.50
1200	-2.31	18.13	57.27	12.06	54.83	92.03	60.44	109.16	60.08	129.88	53.40	150.98	34.19	171.50
1500	-2.31	18.13	56.85	12.06	54.41	92.03	59.90	109.16	59.54	129.88	52.99	150.98	34.19	171.50
2000	-2.31	18.13	56.44	12.06	54.00	92.03	59.36	109.16	59.00	129.88	52.57	150.98	34.19	171.50
5000	-2.31	18.13	55.70	12.06	53.25	92.03	58.38	109.16	58.03	129.88	51.83	150.98	34.19	171.50
10000	-2.31	18.13	55.45	12.06	53.01	92.03	58.05	109.16	57.70	129.88	51.58	150.98	34.19	171.50
50000	-2.31	18.13	55.25	12.06	52.81	92.03	57.79	109.16	57.44	129.88	51.38	150.98	34.19	171.50
Tangent	-2.31	18.13	55.22	12.06	52.78	92.03	57.76	109.16	57.41	129.88	51.35	150.98	34.19	171.50

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	57.25	160.78
100	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	53.77	160.78
150	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	48.26	160.78
200	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	45.41	160.78
300	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	42.49	160.78
400	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	41.01	160.78
500	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	40.11	160.78
600	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	39.51	160.78
700	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	39.08	160.78
800	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	38.76	160.78
900	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	38.50	160.78
1000	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	38.30	160.78
1200	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	38.00	160.78
1500	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	37.69	160.78
2000	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	37.39	160.78
5000	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	36.84	160.78
10000	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	36.65	160.78
50000	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	36.51	160.78
Tangent	24.90	176.75	-3.89	174.07	32.88	218.69	23.59	224.08	31.57	266.02	22.28	271.74	36.49	160.78

TABLE 7A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 6.00 Inches **Cross Level Variation = 0.50 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
100	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
150	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
200	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
300	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
400	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
500	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
600	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
700	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
800	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
900	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
1000	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
1200	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
1500	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
2000	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
5000	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
10000	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
50000	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29
Tangent	-51.62	270.04	-79.93	269.25	-87.59	262.01	-42.82	222.06	-71.13	221.27	-78.80	214.03	-62.33	173.29

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-70.00	166.04	-96.97	142.05	-92.78	119.53	-90.39	95.52	-87.36	79.72	-74.51	1.08	-85.40	155.03
100	-70.00	166.04	-93.88	142.05	-89.69	119.53	-87.31	95.52	-84.28	79.72	-71.42	1.08	-82.32	155.03
150	-70.00	166.04	-89.24	142.05	-85.04	119.53	-82.66	95.52	-79.63	79.72	-66.77	1.08	-77.67	155.03
200	-70.00	166.04	-86.93	142.05	-82.73	119.53	-80.35	95.52	-77.32	79.72	-64.46	1.08	-75.36	155.03
300	-70.00	166.04	-84.62	142.05	-80.43	119.53	-78.05	95.52	-75.02	79.72	-62.16	1.08	-73.05	155.03
400	-70.00	166.04	-83.47	142.05	-79.28	119.53	-76.90	95.52	-73.87	79.72	-61.01	1.08	-71.90	155.03
500	-70.00	166.04	-82.78	142.05	-78.59	119.53	-76.21	95.52	-73.18	79.72	-60.32	1.08	-71.21	155.03
600	-70.00	166.04	-82.32	142.05	-78.13	119.53	-75.75	95.52	-72.72	79.72	-59.86	1.08	-70.76	155.03
700	-70.00	166.04	-81.99	142.05	-78.46	119.53	-76.08	95.52	-72.39	79.72	-59.53	1.08	-70.43	155.03
800	-70.00	166.04	-81.75	142.05	-79.05	119.53	-76.67	95.52	-72.14	79.72	-59.29	1.08	-70.18	155.03
900	-70.00	166.04	-81.56	142.05	-79.51	119.53	-77.13	95.52	-71.95	79.72	-59.09	1.08	-69.99	155.03
1000	-70.00	166.04	-81.40	142.05	-79.88	119.53	-77.50	95.52	-71.80	79.72	-58.94	1.08	-69.84	155.03
1200	-70.00	166.04	-81.17	142.05	-80.43	119.53	-78.05	95.52	-71.57	79.72	-58.71	1.08	-69.61	155.03
1500	-70.00	166.04	-80.94	142.05	-80.98	119.53	-78.60	95.52	-71.34	79.72	-58.48	1.08	-69.38	155.03
2000	-70.00	166.04	-80.71	142.05	-81.53	119.53	-79.15	95.52	-71.11	79.72	-58.25	1.08	-69.15	155.03
5000	-70.00	166.04	-81.43	142.05	-82.52	119.53	-80.14	95.52	-71.82	79.72	-58.97	1.08	-69.59	155.03
10000	-70.00	166.04	-81.68	142.05	-82.85	119.53	-80.46	95.52	-72.07	79.72	-59.22	1.08	-69.77	155.03
50000	-70.00	166.04	-81.88	142.05	-83.11	119.53	-80.73	95.52	-72.27	79.72	-59.42	1.08	-69.92	155.03
Tangent	-70.00	166.04	-81.90	142.05	-83.14	119.53	-80.76	95.52	-72.30	79.72	-59.44	1.08	-69.94	155.03

TABLE 8 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 0.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	0.39	15.50	85.46	2.94	91.35	82.63	106.67	99.13	107.81	123.13	95.93	145.00	53.84	167.24
100	0.39	15.50	80.90	2.94	86.79	82.63	100.76	99.13	101.90	123.13	91.37	145.00	53.84	167.24
150	0.39	15.50	73.62	2.94	79.50	82.63	91.27	99.13	92.41	123.13	84.08	145.00	53.84	167.24
200	0.39	15.50	69.81	2.94	75.69	82.63	86.31	99.13	87.44	123.13	80.27	145.00	53.84	167.24
300	0.39	15.50	65.89	2.94	71.78	82.63	81.19	99.13	82.33	123.13	76.36	145.00	53.84	167.24
400	0.39	15.50	63.90	2.94	69.78	82.63	78.58	99.13	79.72	123.13	74.36	145.00	53.84	167.24
500	0.39	15.50	62.69	2.94	68.57	82.63	77.00	99.13	78.13	123.13	73.15	145.00	53.84	167.24
600	0.39	15.50	61.88	2.94	67.76	82.63	75.94	99.13	77.07	123.13	72.34	145.00	53.84	167.24
700	0.39	15.50	61.30	2.94	67.18	82.63	75.18	99.13	76.31	123.13	71.76	145.00	53.84	167.24
800	0.39	15.50	60.86	2.94	66.74	82.63	74.60	99.13	75.74	123.13	71.32	145.00	53.84	167.24
900	0.39	15.50	60.52	2.94	66.40	82.63	74.16	99.13	75.29	123.13	70.98	145.00	53.84	167.24
1000	0.39	15.50	60.24	2.94	66.13	82.63	73.80	99.13	74.93	123.13	70.71	145.00	53.84	167.24
1200	0.39	15.50	59.83	2.94	65.72	82.63	73.26	99.13	74.40	123.13	70.30	145.00	53.84	167.24
1500	0.39	15.50	59.42	2.94	65.31	82.63	72.72	99.13	73.86	123.13	69.89	145.00	53.84	167.24
2000	0.39	15.50	59.01	2.94	64.89	82.63	72.18	99.13	73.32	123.13	69.47	145.00	53.84	167.24
5000	0.39	15.50	58.26	2.94	64.15	82.63	71.20	99.13	72.34	123.13	68.73	145.00	53.84	167.24
10000	0.39	15.50	58.01	2.94	63.90	82.63	70.88	99.13	72.01	123.13	68.48	145.00	53.84	167.24
50000	0.39	15.50	57.81	2.94	63.70	82.63	70.62	99.13	71.75	123.13	68.28	145.00	53.84	167.24
Tangent	0.39	15.50	57.79	2.94	63.67	82.63	70.58	99.13	71.72	123.13	68.25	145.00	53.84	167.24

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	75.64	156.32
100	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	72.16	156.32
150	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	66.66	156.32
200	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	63.80	156.32
300	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	60.88	156.32
400	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	59.40	156.32
500	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	58.50	156.32
600	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	57.90	156.32
700	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	57.47	156.32
800	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	57.15	156.32
900	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	56.90	156.32
1000	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	56.69	156.32
1200	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	56.39	156.32
1500	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	56.09	156.32
2000	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	55.78	156.32
5000	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	55.23	156.32
10000	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	55.05	156.32
50000	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	54.90	156.32
Tangent	45.39	173.42	16.70	171.47	58.03	215.05	49.58	221.23	62.23	262.87	53.78	269.05	54.88	156.32

TABLE 8A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 0.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
100	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
150	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
200	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
300	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
400	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
500	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
600	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
700	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
800	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
900	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
1000	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
1200	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
1500	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
2000	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
5000	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
10000	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
50000	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42
Tangent	-25.09	267.46	-53.78	269.05	-62.24	262.87	-20.90	219.46	-49.59	221.23	-58.04	215.05	-45.40	173.42

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-53.85	167.24	-83.28	145.00	-81.30	123.13	-80.16	99.13	-78.70	82.63	-72.81	2.94	-70.32	156.32
100	-53.85	167.24	-80.19	145.00	-78.21	123.13	-77.08	99.13	-75.61	82.63	-69.72	2.94	-67.23	156.32
150	-53.85	167.24	-75.54	145.00	-73.57	123.13	-72.43	99.13	-70.96	82.63	-65.08	2.94	-62.58	156.32
200	-53.85	167.24	-73.23	145.00	-71.26	123.13	-70.12	99.13	-68.65	82.63	-62.77	2.94	-60.27	156.32
300	-53.85	167.24	-70.93	145.00	-68.95	123.13	-67.82	99.13	-66.35	82.63	-60.46	2.94	-57.97	156.32
400	-53.85	167.24	-69.78	145.00	-67.80	123.13	-66.67	99.13	-65.20	82.63	-59.31	2.94	-56.82	156.32
500	-53.85	167.24	-69.09	145.00	-67.11	123.13	-65.98	99.13	-64.51	82.63	-58.62	2.94	-56.13	156.32
600	-53.85	167.24	-68.63	145.00	-66.65	123.13	-65.52	99.13	-64.05	82.63	-58.16	2.94	-55.67	156.32
700	-53.85	167.24	-68.30	145.00	-66.98	123.13	-65.84	99.13	-63.72	82.63	-57.84	2.94	-55.34	156.32
800	-53.85	167.24	-68.05	145.00	-67.57	123.13	-66.44	99.13	-63.48	82.63	-57.59	2.94	-55.09	156.32
900	-53.85	167.24	-67.86	145.00	-68.04	123.13	-66.90	99.13	-63.28	82.63	-57.40	2.94	-54.90	156.32
1000	-53.85	167.24	-67.71	145.00	-68.40	123.13	-67.27	99.13	-63.13	82.63	-57.25	2.94	-54.75	156.32
1200	-53.85	167.24	-67.48	145.00	-68.96	123.13	-67.82	99.13	-62.90	82.63	-57.02	2.94	-54.52	156.32
1500	-53.85	167.24	-67.25	145.00	-69.51	123.13	-68.37	99.13	-62.67	82.63	-56.79	2.94	-54.29	156.32
2000	-53.85	167.24	-67.02	145.00	-70.05	123.13	-68.92	99.13	-62.44	82.63	-56.56	2.94	-54.06	156.32
5000	-53.85	167.24	-67.74	145.00	-71.04	123.13	-69.90	99.13	-63.16	82.63	-57.27	2.94	-54.50	156.32
10000	-53.85	167.24	-67.99	145.00	-71.37	123.13	-70.23	99.13	-63.41	82.63	-57.52	2.94	-54.69	156.32
50000	-53.85	167.24	-68.19	145.00	-71.63	123.13	-70.49	99.13	-63.61	82.63	-57.72	2.94	-54.83	156.32
Tangent	-53.85	167.24	-68.21	145.00	-71.66	123.13	-70.53	99.13	-63.63	82.63	-57.75	2.94	-54.85	156.32

TABLE 9 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 1.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	0.00	16.00	85.14	4.36	89.74	84.16	104.77	100.77	105.68	124.45	93.39	146.20	50.87	168.14
100	0.00	16.00	80.58	4.36	85.18	84.16	98.86	100.77	99.77	124.45	88.84	146.20	50.87	168.14
150	0.00	16.00	73.29	4.36	77.89	84.16	89.37	100.77	90.28	124.45	81.55	146.20	50.87	168.14
200	0.00	16.00	69.48	4.36	74.08	84.16	84.40	100.77	85.31	124.45	77.74	146.20	50.87	168.14
300	0.00	16.00	65.57	4.36	70.17	84.16	79.29	100.77	80.20	124.45	73.83	146.20	50.87	168.14
400	0.00	16.00	63.57	4.36	68.18	84.16	76.68	100.77	77.59	124.45	71.83	146.20	50.87	168.14
500	0.00	16.00	62.36	4.36	66.97	84.16	75.10	100.77	76.00	124.45	70.62	146.20	50.87	168.14
600	0.00	16.00	61.55	4.36	66.15	84.16	74.03	100.77	74.94	124.45	69.81	146.20	50.87	168.14
700	0.00	16.00	60.97	4.36	65.57	84.16	73.27	100.77	74.18	124.45	69.23	146.20	50.87	168.14
800	0.00	16.00	60.53	4.36	65.14	84.16	72.70	100.77	73.61	124.45	68.79	146.20	50.87	168.14
900	0.00	16.00	60.19	4.36	64.79	84.16	72.25	100.77	73.16	124.45	68.45	146.20	50.87	168.14
1000	0.00	16.00	59.92	4.36	64.52	84.16	71.90	100.77	72.80	124.45	68.18	146.20	50.87	168.14
1200	0.00	16.00	59.51	4.36	64.11	84.16	71.36	100.77	72.26	124.45	67.76	146.20	50.87	168.14
1500	0.00	16.00	59.09	4.36	63.70	84.16	70.82	100.77	71.73	124.45	67.35	146.20	50.87	168.14
2000	0.00	16.00	58.68	4.36	63.28	84.16	70.28	100.77	71.18	124.45	66.94	146.20	50.87	168.14
5000	0.00	16.00	57.94	4.36	62.54	84.16	69.30	100.77	70.21	124.45	66.19	146.20	50.87	168.14
10000	0.00	16.00	57.69	4.36	62.29	84.16	68.98	100.77	69.88	124.45	65.94	146.20	50.87	168.14
50000	0.00	16.00	57.49	4.36	62.09	84.16	68.71	100.77	69.62	124.45	65.74	146.20	50.87	168.14
Tangent	0.00	16.00	57.46	4.36	62.07	84.16	68.68	100.77	69.59	124.45	65.72	146.20	50.87	168.14

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	72.87	157.25
100	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	69.39	157.25
150	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	63.88	157.25
200	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	61.03	157.25
300	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	58.11	157.25
400	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	56.63	157.25
500	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	55.73	157.25
600	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	55.13	157.25
700	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	54.70	157.25
800	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	54.37	157.25
900	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	54.12	157.25
1000	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	53.92	157.25
1200	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	53.62	157.25
1500	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	53.31	157.25
2000	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	53.01	157.25
5000	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	52.46	157.25
10000	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	52.27	157.25
50000	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	52.12	157.25
Tangent	42.28	174.15	13.55	172.00	54.22	215.88	45.63	221.88	57.57	263.61	48.98	269.62	52.11	157.25

y

TABLE 9A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 1.00 **Inches** **Cross Level Variation =** 1.00 **Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
100	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
150	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
200	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
300	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
400	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
500	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
600	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
700	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
800	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
900	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
1000	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
1200	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
1500	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
2000	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
5000	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
10000	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
50000	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63
Tangent	-29.94	268.00	-58.58	269.39	-66.90	263.05	-24.90	220.00	-53.54	221.51	-61.86	215.16	-48.50	173.63

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-56.82	167.28	-85.80	144.76	-83.43	122.76	-82.06	98.45	-80.30	82.07	-73.14	2.51	-73.09	156.34
100	-56.82	167.28	-82.72	144.76	-80.34	122.76	-78.97	98.45	-77.22	82.07	-70.05	2.51	-70.00	156.34
150	-56.82	167.28	-78.07	144.76	-75.69	122.76	-74.33	98.45	-72.57	82.07	-65.41	2.51	-65.36	156.34
200	-56.82	167.28	-75.76	144.76	-73.38	122.76	-72.02	98.45	-70.26	82.07	-63.10	2.51	-63.05	156.34
300	-56.82	167.28	-73.46	144.76	-71.08	122.76	-69.71	98.45	-67.96	82.07	-60.79	2.51	-60.74	156.34
400	-56.82	167.28	-72.31	144.76	-69.93	122.76	-68.56	98.45	-66.81	82.07	-59.64	2.51	-59.59	156.34
500	-56.82	167.28	-71.62	144.76	-69.24	122.76	-67.87	98.45	-66.12	82.07	-58.95	2.51	-58.90	156.34
600	-56.82	167.28	-71.16	144.76	-68.78	122.76	-67.41	98.45	-65.66	82.07	-58.49	2.51	-58.44	156.34
700	-56.82	167.28	-70.83	144.76	-69.11	122.76	-67.74	98.45	-65.33	82.07	-58.16	2.51	-58.12	156.34
800	-56.82	167.28	-70.58	144.76	-69.70	122.76	-68.34	98.45	-65.08	82.07	-57.92	2.51	-57.87	156.34
900	-56.82	167.28	-70.39	144.76	-70.16	122.76	-68.80	98.45	-64.89	82.07	-57.73	2.51	-57.68	156.34
1000	-56.82	167.28	-70.24	144.76	-70.53	122.76	-69.17	98.45	-64.74	82.07	-57.57	2.51	-57.52	156.34
1200	-56.82	167.28	-70.01	144.76	-71.08	122.76	-69.72	98.45	-64.51	82.07	-57.34	2.51	-57.29	156.34
1500	-56.82	167.28	-69.78	144.76	-71.63	122.76	-70.27	98.45	-64.28	82.07	-57.11	2.51	-57.07	156.34
2000	-56.82	167.28	-69.55	144.76	-72.18	122.76	-70.82	98.45	-64.05	82.07	-56.88	2.51	-56.84	156.34
5000	-56.82	167.28	-70.27	144.76	-73.17	122.76	-71.80	98.45	-64.76	82.07	-57.60	2.51	-57.28	156.34
10000	-56.82	167.28	-70.52	144.76	-73.49	122.76	-72.13	98.45	-65.01	82.07	-57.85	2.51	-57.46	156.34
50000	-56.82	167.28	-70.72	144.76	-73.76	122.76	-72.39	98.45	-65.21	82.07	-58.05	2.51	-57.61	156.34
Tangent	-56.82	167.28	-70.74	144.76	-73.79	122.76	-72.42	98.45	-65.24	82.07	-58.08	2.51	-57.63	156.34

TABLE 10 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 2.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-0.40	16.50	84.78	5.77	88.10	85.66	102.84	102.38	103.52	125.74	90.83	147.35	47.88	168.99
100	-0.40	16.50	80.23	5.77	83.55	85.66	96.93	102.38	97.61	125.74	86.27	147.35	47.88	168.99
150	-0.40	16.50	72.94	5.77	76.26	85.66	87.44	102.38	88.12	125.74	78.99	147.35	47.88	168.99
200	-0.40	16.50	69.13	5.77	72.45	85.66	82.47	102.38	83.15	125.74	75.18	147.35	47.88	168.99
300	-0.40	16.50	65.22	5.77	68.54	85.66	77.36	102.38	78.04	125.74	71.26	147.35	47.88	168.99
400	-0.40	16.50	63.22	5.77	66.54	85.66	74.75	102.38	75.43	125.74	69.27	147.35	47.88	168.99
500	-0.40	16.50	62.01	5.77	65.33	85.66	73.17	102.38	73.84	125.74	68.06	147.35	47.88	168.99
600	-0.40	16.50	61.20	5.77	64.52	85.66	72.10	102.38	72.78	125.74	67.25	147.35	47.88	168.99
700	-0.40	16.50	60.62	5.77	63.94	85.66	71.34	102.38	72.02	125.74	66.67	147.35	47.88	168.99
800	-0.40	16.50	60.18	5.77	63.50	85.66	70.77	102.38	71.45	125.74	66.23	147.35	47.88	168.99
900	-0.40	16.50	59.84	5.77	63.16	85.66	70.32	102.38	71.00	125.74	65.89	147.35	47.88	168.99
1000	-0.40	16.50	59.57	5.77	62.89	85.66	69.97	102.38	70.64	125.74	65.61	147.35	47.88	168.99
1200	-0.40	16.50	59.15	5.77	62.47	85.66	69.43	102.38	70.10	125.74	65.20	147.35	47.88	168.99
1500	-0.40	16.50	58.74	5.77	62.06	85.66	68.89	102.38	69.57	125.74	64.79	147.35	47.88	168.99
2000	-0.40	16.50	58.33	5.77	61.65	85.66	68.35	102.38	69.02	125.74	64.38	147.35	47.88	168.99
5000	-0.40	16.50	57.58	5.77	60.90	85.66	67.37	102.38	68.05	125.74	63.63	147.35	47.88	168.99
10000	-0.40	16.50	57.33	5.77	60.65	85.66	67.05	102.38	67.72	125.74	63.38	147.35	47.88	168.99
50000	-0.40	16.50	57.13	5.77	60.45	85.66	66.78	102.38	67.46	125.74	63.18	147.35	47.88	168.99
Tangent	-0.40	16.50	57.11	5.77	60.43	85.66	66.75	102.38	67.43	125.74	63.16	147.35	47.88	168.99

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	70.07	158.13
100	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	66.59	158.13
150	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	61.08	158.13
200	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	58.23	158.13
300	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	55.31	158.13
400	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	53.83	158.13
500	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	52.93	158.13
600	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	52.33	158.13
700	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	51.90	158.13
800	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	51.57	158.13
900	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	51.32	158.13
1000	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	51.12	158.13
1200	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	50.82	158.13
1500	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	50.51	158.13
2000	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	50.21	158.13
5000	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	49.66	158.13
10000	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	49.47	158.13
50000	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	49.33	158.13
Tangent	39.15	174.82	10.39	172.47	50.38	216.63	41.65	222.46	52.88	264.26	44.15	270.10	49.31	158.13

TABLE 10A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 2.00 Inches **Cross Level Variation = 1.00 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
100	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
150	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
200	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
300	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
400	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
500	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
600	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
700	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
800	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
900	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
1000	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
1200	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
1500	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
2000	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
5000	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
10000	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
50000	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78
Tangent	-34.78	268.46	-63.37	269.65	-71.54	263.14	-28.90	220.46	-57.48	221.72	-65.66	215.20	-51.60	173.78

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-59.78	167.27	-88.32	144.46	-85.54	122.35	-83.94	97.74	-81.90	81.48	-73.46	2.09	-75.85	156.31
100	-59.78	167.27	-85.23	144.46	-82.45	122.35	-80.86	97.74	-78.81	81.48	-70.37	2.09	-72.77	156.31
150	-59.78	167.27	-80.59	144.46	-77.80	122.35	-76.21	97.74	-74.16	81.48	-65.72	2.09	-68.12	156.31
200	-59.78	167.27	-78.28	144.46	-75.49	122.35	-73.90	97.74	-71.85	81.48	-63.42	2.09	-65.81	156.31
300	-59.78	167.27	-75.97	144.46	-73.19	122.35	-71.60	97.74	-69.55	81.48	-61.11	2.09	-63.51	156.31
400	-59.78	167.27	-74.82	144.46	-72.04	122.35	-70.45	97.74	-68.40	81.48	-59.96	2.09	-62.36	156.31
500	-59.78	167.27	-74.13	144.46	-71.35	122.35	-69.76	97.74	-67.71	81.48	-59.27	2.09	-61.67	156.31
600	-59.78	167.27	-73.67	144.46	-70.89	122.35	-69.30	97.74	-67.25	81.48	-58.81	2.09	-61.21	156.31
700	-59.78	167.27	-73.34	144.46	-71.22	122.35	-69.62	97.74	-66.92	81.48	-58.48	2.09	-60.88	156.31
800	-59.78	167.27	-73.10	144.46	-71.81	122.35	-70.22	97.74	-66.68	81.48	-58.24	2.09	-60.63	156.31
900	-59.78	167.27	-72.91	144.46	-72.27	122.35	-70.68	97.74	-66.49	81.48	-58.05	2.09	-60.44	156.31
1000	-59.78	167.27	-72.75	144.46	-72.64	122.35	-71.05	97.74	-66.33	81.48	-57.89	2.09	-60.29	156.31
1200	-59.78	167.27	-72.52	144.46	-73.19	122.35	-71.60	97.74	-66.10	81.48	-57.66	2.09	-60.06	156.31
1500	-59.78	167.27	-72.29	144.46	-73.74	122.35	-72.15	97.74	-65.87	81.48	-57.43	2.09	-59.83	156.31
2000	-59.78	167.27	-72.06	144.46	-74.29	122.35	-72.70	97.74	-65.64	81.48	-57.20	2.09	-59.60	156.31
5000	-59.78	167.27	-72.78	144.46	-75.28	122.35	-73.68	97.74	-66.36	81.48	-57.92	2.09	-60.04	156.31
10000	-59.78	167.27	-73.03	144.46	-75.61	122.35	-74.01	97.74	-66.61	81.48	-58.17	2.09	-60.23	156.31
50000	-59.78	167.27	-73.23	144.46	-75.87	122.35	-74.27	97.74	-66.81	81.48	-58.37	2.09	-60.37	156.31
Tangent	-59.78	167.27	-73.26	144.46	-75.90	122.35	-74.31	97.74	-66.83	81.48	-58.39	2.09	-60.39	156.31

TABLE 11 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 3.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-0.81	16.99	84.41	7.18	86.44	87.14	100.88	103.95	101.33	126.98	88.25	148.45	44.86	169.78
100	-0.81	16.99	79.85	7.18	81.88	87.14	94.97	103.95	95.42	126.98	83.69	148.45	44.86	169.78
150	-0.81	16.99	72.56	7.18	74.60	87.14	85.49	103.95	85.93	126.98	76.40	148.45	44.86	169.78
200	-0.81	16.99	68.75	7.18	70.79	87.14	80.52	103.95	80.96	126.98	72.59	148.45	44.86	169.78
300	-0.81	16.99	64.84	7.18	66.87	87.14	75.40	103.95	75.85	126.98	68.68	148.45	44.86	169.78
400	-0.81	16.99	62.84	7.18	64.88	87.14	72.79	103.95	73.24	126.98	66.68	148.45	44.86	169.78
500	-0.81	16.99	61.63	7.18	63.67	87.14	71.21	103.95	71.66	126.98	65.47	148.45	44.86	169.78
600	-0.81	16.99	60.82	7.18	62.86	87.14	70.15	103.95	70.59	126.98	64.66	148.45	44.86	169.78
700	-0.81	16.99	60.24	7.18	62.28	87.14	69.39	103.95	69.83	126.98	64.08	148.45	44.86	169.78
800	-0.81	16.99	59.80	7.18	61.84	87.14	68.81	103.95	69.26	126.98	63.64	148.45	44.86	169.78
900	-0.81	16.99	59.46	7.18	61.50	87.14	68.37	103.95	68.81	126.98	63.30	148.45	44.86	169.78
1000	-0.81	16.99	59.19	7.18	61.22	87.14	68.01	103.95	68.46	126.98	63.03	148.45	44.86	169.78
1200	-0.81	16.99	58.78	7.18	60.81	87.14	67.47	103.95	67.92	126.98	62.62	148.45	44.86	169.78
1500	-0.81	16.99	58.37	7.18	60.40	87.14	66.93	103.95	67.38	126.98	62.20	148.45	44.86	169.78
2000	-0.81	16.99	57.95	7.18	59.99	87.14	66.39	103.95	66.84	126.98	61.79	148.45	44.86	169.78
5000	-0.81	16.99	57.21	7.18	59.24	87.14	65.41	103.95	65.86	126.98	61.05	148.45	44.86	169.78
10000	-0.81	16.99	56.96	7.18	58.99	87.14	65.09	103.95	65.54	126.98	60.80	148.45	44.86	169.78
50000	-0.81	16.99	56.76	7.18	58.79	87.14	64.83	103.95	65.27	126.98	60.60	148.45	44.86	169.78
Tangent	-0.81	16.99	56.73	7.18	58.77	87.14	64.79	103.95	65.24	126.98	60.57	148.45	44.86	169.78

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	67.25	158.95
100	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	63.77	158.95
150	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	58.26	158.95
200	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	55.41	158.95
300	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	52.49	158.95
400	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	51.01	158.95
500	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	50.11	158.95
600	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	49.51	158.95
700	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	49.08	158.95
800	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	48.75	158.95
900	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	48.50	158.95
1000	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	48.30	158.95
1200	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	48.00	158.95
1500	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	47.69	158.95
2000	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	47.39	158.95
5000	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	46.84	158.95
10000	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	46.65	158.95
50000	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	46.51	158.95
Tangent	36.01	175.43	7.23	172.94	46.51	217.30	37.66	222.96	48.17	264.83	39.31	270.62	46.49	158.95

TABLE 11A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **3.00 Inches** **Cross Level Variation =** **1.00 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
100	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
150	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
200	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
300	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
400	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
500	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
600	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
700	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
800	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
900	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
1000	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
1200	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
1500	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
2000	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
5000	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
10000	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
50000	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88
Tangent	-39.61	268.94	-68.13	269.83	-76.16	263.14	-32.89	220.94	-61.41	221.86	-69.44	215.17	-54.69	173.88

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-62.72	167.20	-90.82	144.12	-87.63	121.90	-85.81	97.00	-83.48	80.87	-73.77	1.66	-78.60	156.22
100	-62.72	167.20	-87.73	144.12	-84.54	121.90	-82.72	97.00	-80.39	80.87	-70.68	1.66	-75.52	156.22
150	-62.72	167.20	-83.08	144.12	-79.90	121.90	-78.08	97.00	-75.75	80.87	-66.04	1.66	-70.87	156.22
200	-62.72	167.20	-80.77	144.12	-77.59	121.90	-75.77	97.00	-73.44	80.87	-63.73	1.66	-68.56	156.22
300	-62.72	167.20	-78.47	144.12	-75.28	121.90	-73.46	97.00	-71.13	80.87	-61.42	1.66	-66.26	156.22
400	-62.72	167.20	-77.32	144.12	-74.13	121.90	-72.31	97.00	-69.98	80.87	-60.27	1.66	-65.11	156.22
500	-62.72	167.20	-76.63	144.12	-73.44	121.90	-71.62	97.00	-69.29	80.87	-59.58	1.66	-64.42	156.22
600	-62.72	167.20	-76.17	144.12	-72.98	121.90	-71.16	97.00	-68.83	80.87	-59.12	1.66	-63.96	156.22
700	-62.72	167.20	-75.84	144.12	-73.31	121.90	-71.49	97.00	-68.50	80.87	-58.79	1.66	-63.63	156.22
800	-62.72	167.20	-75.59	144.12	-73.91	121.90	-72.09	97.00	-68.26	80.87	-58.55	1.66	-63.38	156.22
900	-62.72	167.20	-75.40	144.12	-74.37	121.90	-72.55	97.00	-68.07	80.87	-58.36	1.66	-63.19	156.22
1000	-62.72	167.20	-75.25	144.12	-74.74	121.90	-72.91	97.00	-67.91	80.87	-58.20	1.66	-63.04	156.22
1200	-62.72	167.20	-75.02	144.12	-75.29	121.90	-73.47	97.00	-67.68	80.87	-57.97	1.66	-62.81	156.22
1500	-62.72	167.20	-74.79	144.12	-75.84	121.90	-74.02	97.00	-67.45	80.87	-57.74	1.66	-62.58	156.22
2000	-62.72	167.20	-74.56	144.12	-76.39	121.90	-74.57	97.00	-67.22	80.87	-57.51	1.66	-62.35	156.22
5000	-62.72	167.20	-75.28	144.12	-77.37	121.90	-75.55	97.00	-67.94	80.87	-58.23	1.66	-62.79	156.22
10000	-62.72	167.20	-75.53	144.12	-77.70	121.90	-75.88	97.00	-68.19	80.87	-58.48	1.66	-62.98	156.22
50000	-62.72	167.20	-75.73	144.12	-77.96	121.90	-76.14	97.00	-68.39	80.87	-58.68	1.66	-63.12	156.22
Tangent	-62.72	167.20	-75.75	144.12	-77.99	121.90	-76.17	97.00	-68.42	80.87	-58.71	1.66	-63.14	156.22

TABLE 12 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 4.00 Inches **Cross Level Variation = 1.00 Inches** Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-1.23	17.47	84.00	8.59	84.76	88.58	98.90	105.49	99.12	128.17	85.64	149.50	41.83	170.51
100	-1.23	17.47	79.45	8.59	80.20	88.58	92.99	105.49	93.21	128.17	81.08	149.50	41.83	170.51
150	-1.23	17.47	72.16	8.59	72.91	88.58	83.50	105.49	83.72	128.17	73.79	149.50	41.83	170.51
200	-1.23	17.47	68.35	8.59	69.10	88.58	78.53	105.49	78.75	128.17	69.98	149.50	41.83	170.51
300	-1.23	17.47	64.44	8.59	65.19	88.58	73.42	105.49	73.64	128.17	66.07	149.50	41.83	170.51
400	-1.23	17.47	62.44	8.59	63.19	88.58	70.81	105.49	71.03	128.17	64.07	149.50	41.83	170.51
500	-1.23	17.47	61.23	8.59	61.99	88.58	69.23	105.49	69.44	128.17	62.86	149.50	41.83	170.51
600	-1.23	17.47	60.42	8.59	61.17	88.58	68.16	105.49	68.38	128.17	62.05	149.50	41.83	170.51
700	-1.23	17.47	59.84	8.59	60.59	88.58	67.40	105.49	67.62	128.17	61.47	149.50	41.83	170.51
800	-1.23	17.47	59.40	8.59	60.15	88.58	66.83	105.49	67.05	128.17	61.03	149.50	41.83	170.51
900	-1.23	17.47	59.06	8.59	59.81	88.58	66.38	105.49	66.60	128.17	60.69	149.50	41.83	170.51
1000	-1.23	17.47	58.79	8.59	59.54	88.58	66.03	105.49	66.24	128.17	60.42	149.50	41.83	170.51
1200	-1.23	17.47	58.38	8.59	59.13	88.58	65.49	105.49	65.71	128.17	60.01	149.50	41.83	170.51
1500	-1.23	17.47	57.96	8.59	58.72	88.58	64.95	105.49	65.17	128.17	59.59	149.50	41.83	170.51
2000	-1.23	17.47	57.55	8.59	58.30	88.58	64.41	105.49	64.63	128.17	59.18	149.50	41.83	170.51
5000	-1.23	17.47	56.80	8.59	57.56	88.58	63.43	105.49	63.65	128.17	58.44	149.50	41.83	170.51
10000	-1.23	17.47	56.56	8.59	57.31	88.58	63.11	105.49	63.32	128.17	58.19	149.50	41.83	170.51
50000	-1.23	17.47	56.36	8.59	57.11	88.58	62.84	105.49	63.06	128.17	57.99	149.50	41.83	170.51
Tangent	-1.23	17.47	56.33	8.59	57.08	88.58	62.81	105.49	63.03	128.17	57.96	149.50	41.83	170.51

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	64.41	159.73
100	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	60.93	159.73
150	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	55.42	159.73
200	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	52.57	159.73
300	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	49.65	159.73
400	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	48.17	159.73
500	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	47.27	159.73
600	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	46.67	159.73
700	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	46.24	159.73
800	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	45.92	159.73
900	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	45.66	159.73
1000	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	45.46	159.73
1200	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	45.16	159.73
1500	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	44.85	159.73
2000	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	44.55	159.73
5000	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	44.00	159.73
10000	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	43.81	159.73
50000	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	43.67	159.73
Tangent	32.85	175.99	4.05	173.44	42.63	217.91	33.65	223.46	43.44	265.31	34.46	271.10	43.65	159.73

TABLE 12A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **4.00 Inches** **Cross Level Variation =** **1.00 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
100	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
150	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
200	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
300	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
400	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
500	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
600	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
700	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
800	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
900	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
1000	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
1200	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
1500	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
2000	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
5000	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
10000	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
50000	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93
Tangent	-44.43	269.43	-72.87	269.91	-80.76	263.07	-36.88	221.44	-65.32	221.92	-73.20	215.07	-57.76	173.93

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-65.65	167.08	-93.29	143.73	-89.71	121.42	-87.66	96.23	-85.05	80.23	-74.07	1.23	-81.34	156.09
100	-65.65	167.08	-90.21	143.73	-86.62	121.42	-84.57	96.23	-81.96	80.23	-70.98	1.23	-78.25	156.09
150	-65.65	167.08	-85.56	143.73	-81.97	121.42	-79.93	96.23	-77.31	80.23	-66.34	1.23	-73.60	156.09
200	-65.65	167.08	-83.25	143.73	-79.66	121.42	-77.62	96.23	-75.00	80.23	-64.03	1.23	-71.29	156.09
300	-65.65	167.08	-80.95	143.73	-77.36	121.42	-75.31	96.23	-72.70	80.23	-61.72	1.23	-68.99	156.09
400	-65.65	167.08	-79.80	143.73	-76.21	121.42	-74.16	96.23	-71.55	80.23	-60.57	1.23	-67.84	156.09
500	-65.65	167.08	-79.11	143.73	-75.52	121.42	-73.47	96.23	-70.86	80.23	-59.88	1.23	-67.15	156.09
600	-65.65	167.08	-78.65	143.73	-75.06	121.42	-73.01	96.23	-70.40	80.23	-59.42	1.23	-66.69	156.09
700	-65.65	167.08	-78.32	143.73	-75.39	121.42	-73.34	96.23	-70.07	80.23	-59.10	1.23	-66.36	156.09
800	-65.65	167.08	-78.07	143.73	-75.98	121.42	-73.93	96.23	-69.82	80.23	-58.85	1.23	-66.12	156.09
900	-65.65	167.08	-77.88	143.73	-76.44	121.42	-74.40	96.23	-69.63	80.23	-58.66	1.23	-65.92	156.09
1000	-65.65	167.08	-77.73	143.73	-76.81	121.42	-74.76	96.23	-69.48	80.23	-58.50	1.23	-65.77	156.09
1200	-65.65	167.08	-77.50	143.73	-77.36	121.42	-75.32	96.23	-69.25	80.23	-58.27	1.23	-65.54	156.09
1500	-65.65	167.08	-77.27	143.73	-77.91	121.42	-75.87	96.23	-69.02	80.23	-58.05	1.23	-65.31	156.09
2000	-65.65	167.08	-77.04	143.73	-78.46	121.42	-76.41	96.23	-68.79	80.23	-57.82	1.23	-65.08	156.09
5000	-65.65	167.08	-77.75	143.73	-79.45	121.42	-77.40	96.23	-69.51	80.23	-58.53	1.23	-65.52	156.09
10000	-65.65	167.08	-78.00	143.73	-79.77	121.42	-77.73	96.23	-69.76	80.23	-58.78	1.23	-65.71	156.09
50000	-65.65	167.08	-78.20	143.73	-80.04	121.42	-77.99	96.23	-69.96	80.23	-58.98	1.23	-65.86	156.09
Tangent	-65.65	167.08	-78.23	143.73	-80.07	121.42	-78.02	96.23	-69.98	80.23	-59.01	1.23	-65.88	156.09

TABLE 13 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 5.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-1.66	17.94	83.58	9.98	83.05	89.98	96.90	106.99	96.88	129.32	83.01	150.50	38.78	171.19
100	-1.66	17.94	79.02	9.98	78.49	89.98	90.98	106.99	90.97	129.32	78.45	150.50	38.78	171.19
150	-1.66	17.94	71.73	9.98	71.20	89.98	81.50	106.99	81.49	129.32	71.16	150.50	38.78	171.19
200	-1.66	17.94	67.92	9.98	67.40	89.98	76.53	106.99	76.52	129.32	67.35	150.50	38.78	171.19
300	-1.66	17.94	64.01	9.98	63.48	89.98	71.41	106.99	71.40	129.32	63.44	150.50	38.78	171.19
400	-1.66	17.94	62.02	9.98	61.49	89.98	68.80	106.99	68.79	129.32	61.44	150.50	38.78	171.19
500	-1.66	17.94	60.81	9.98	60.28	89.98	67.22	106.99	67.21	129.32	60.23	150.50	38.78	171.19
600	-1.66	17.94	59.99	9.98	59.47	89.98	66.16	106.99	66.15	129.32	59.42	150.50	38.78	171.19
700	-1.66	17.94	59.41	9.98	58.89	89.98	65.40	106.99	65.39	129.32	58.84	150.50	38.78	171.19
800	-1.66	17.94	58.98	9.98	58.45	89.98	64.83	106.99	64.81	129.32	58.40	150.50	38.78	171.19
900	-1.66	17.94	58.63	9.98	58.11	89.98	64.38	106.99	64.37	129.32	58.06	150.50	38.78	171.19
1000	-1.66	17.94	58.36	9.98	57.83	89.98	64.02	106.99	64.01	129.32	57.79	150.50	38.78	171.19
1200	-1.66	17.94	57.95	9.98	57.42	89.98	63.48	106.99	63.47	129.32	57.38	150.50	38.78	171.19
1500	-1.66	17.94	57.54	9.98	57.01	89.98	62.94	106.99	62.93	129.32	56.96	150.50	38.78	171.19
2000	-1.66	17.94	57.12	9.98	56.60	89.98	62.40	106.99	62.39	129.32	56.55	150.50	38.78	171.19
5000	-1.66	17.94	56.38	9.98	55.85	89.98	61.43	106.99	61.41	129.32	55.81	150.50	38.78	171.19
10000	-1.66	17.94	56.13	9.98	55.60	89.98	61.10	106.99	61.09	129.32	55.56	150.50	38.78	171.19
50000	-1.66	17.94	55.93	9.98	55.40	89.98	60.84	106.99	60.83	129.32	55.36	150.50	38.78	171.19
Tangent	-1.66	17.94	55.91	9.98	55.38	89.98	60.81	106.99	60.79	129.32	55.33	150.50	38.78	171.19

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	61.56	160.44
100	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	58.08	160.44
150	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	52.57	160.44
200	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	49.72	160.44
300	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	46.80	160.44
400	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	45.31	160.44
500	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	44.42	160.44
600	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	43.82	160.44
700	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	43.39	160.44
800	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	43.06	160.44
900	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	42.81	160.44
1000	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	42.61	160.44
1200	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	42.30	160.44
1500	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	42.00	160.44
2000	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	41.69	160.44
5000	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	41.14	160.44
10000	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	40.96	160.44
50000	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	40.81	160.44
Tangent	29.67	176.49	0.87	173.94	38.74	218.45	29.63	223.96	38.70	265.83	29.59	271.49	40.79	160.44

TABLE 13A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = 5.00 Inches **Cross Level Variation = 1.00 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
100	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
150	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
200	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
300	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
400	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
500	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
600	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
700	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
800	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
900	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
1000	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
1200	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
1500	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
2000	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
5000	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
10000	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
50000	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91
Tangent	-49.23	269.94	-77.59	269.91	-85.32	262.91	-40.84	221.94	-69.20	221.91	-76.94	214.91	-60.81	173.91

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-68.55	166.91	-95.75	143.29	-91.76	120.89	-89.49	95.43	-86.60	79.56	-74.36	0.79	-84.05	155.91
100	-68.55	166.91	-92.66	143.29	-88.67	120.89	-86.40	95.43	-83.51	79.56	-71.28	0.79	-80.97	155.91
150	-68.55	166.91	-88.02	143.29	-84.03	120.89	-81.75	95.43	-78.86	79.56	-66.63	0.79	-76.32	155.91
200	-68.55	166.91	-85.71	143.29	-81.72	120.89	-79.44	95.43	-76.55	79.56	-64.32	0.79	-74.01	155.91
300	-68.55	166.91	-83.40	143.29	-79.41	120.89	-77.14	95.43	-74.25	79.56	-62.02	0.79	-71.71	155.91
400	-68.55	166.91	-82.25	143.29	-78.26	120.89	-75.99	95.43	-73.10	79.56	-60.87	0.79	-70.56	155.91
500	-68.55	166.91	-81.56	143.29	-77.57	120.89	-75.30	95.43	-72.41	79.56	-60.18	0.79	-69.87	155.91
600	-68.55	166.91	-81.10	143.29	-77.11	120.89	-74.84	95.43	-71.95	79.56	-59.72	0.79	-69.41	155.91
700	-68.55	166.91	-80.77	143.29	-77.44	120.89	-75.17	95.43	-71.62	79.56	-59.39	0.79	-69.08	155.91
800	-68.55	166.91	-80.53	143.29	-78.03	120.89	-75.76	95.43	-71.37	79.56	-59.14	0.79	-68.83	155.91
900	-68.55	166.91	-80.34	143.29	-78.50	120.89	-76.22	95.43	-71.18	79.56	-58.95	0.79	-68.64	155.91
1000	-68.55	166.91	-80.18	143.29	-78.86	120.89	-76.59	95.43	-71.03	79.56	-58.80	0.79	-68.49	155.91
1200	-68.55	166.91	-79.95	143.29	-79.42	120.89	-77.14	95.43	-70.80	79.56	-58.57	0.79	-68.26	155.91
1500	-68.55	166.91	-79.72	143.29	-79.97	120.89	-77.69	95.43	-70.57	79.56	-58.34	0.79	-68.03	155.91
2000	-68.55	166.91	-79.49	143.29	-80.52	120.89	-78.24	95.43	-70.34	79.56	-58.11	0.79	-67.80	155.91
5000	-68.55	166.91	-80.21	143.29	-81.50	120.89	-79.23	95.43	-71.06	79.56	-58.82	0.79	-68.24	155.91
10000	-68.55	166.91	-80.46	143.29	-81.83	120.89	-79.56	95.43	-71.31	79.56	-59.07	0.79	-68.42	155.91
50000	-68.55	166.91	-80.66	143.29	-82.09	120.89	-79.82	95.43	-71.51	79.56	-59.27	0.79	-68.57	155.91
Tangent	-68.55	166.91	-80.69	143.29	-82.12	120.89	-79.85	95.43	-71.53	79.56	-59.30	0.79	-68.59	155.91

TABLE 14 Vehicle Dynamic Env e to OUTSIDE of Curve

Superelevation = 6.00 Inches **Cross Level Variation =** 1.00 Inches Rev. F 4/1/2005

Radius:	P1		P2		P3		P4		P5		P6		P7	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-2.09	18.40	83.13	11.37	81.32	91.36	94.87	108.45	94.63	130.42	80.36	151.45	35.72	171.81
100	-2.09	18.40	78.57	11.37	76.77	91.36	88.96	108.45	88.72	130.42	75.80	151.45	35.72	171.81
150	-2.09	18.40	71.28	11.37	69.48	91.36	79.47	108.45	79.23	130.42	68.51	151.45	35.72	171.81
200	-2.09	18.40	67.47	11.37	65.67	91.36	74.50	108.45	74.26	130.42	64.70	151.45	35.72	171.81
300	-2.09	18.40	63.56	11.37	61.76	91.36	69.39	108.45	69.15	130.42	60.79	151.45	35.72	171.81
400	-2.09	18.40	61.57	11.37	59.76	91.36	66.78	108.45	66.54	130.42	58.79	151.45	35.72	171.81
500	-2.09	18.40	60.36	11.37	58.55	91.36	65.19	108.45	64.95	130.42	57.58	151.45	35.72	171.81
600	-2.09	18.40	59.55	11.37	57.74	91.36	64.13	108.45	63.89	130.42	56.77	151.45	35.72	171.81
700	-2.09	18.40	58.96	11.37	57.16	91.36	63.37	108.45	63.13	130.42	56.19	151.45	35.72	171.81
800	-2.09	18.40	58.53	11.37	56.72	91.36	62.80	108.45	62.56	130.42	55.75	151.45	35.72	171.81
900	-2.09	18.40	58.18	11.37	56.38	91.36	62.35	108.45	62.11	130.42	55.41	151.45	35.72	171.81
1000	-2.09	18.40	57.91	11.37	56.11	91.36	61.99	108.45	61.75	130.42	55.14	151.45	35.72	171.81
1200	-2.09	18.40	57.50	11.37	55.70	91.36	61.46	108.45	61.22	130.42	54.73	151.45	35.72	171.81
1500	-2.09	18.40	57.09	11.37	55.28	91.36	60.92	108.45	60.68	130.42	54.32	151.45	35.72	171.81
2000	-2.09	18.40	56.68	11.37	54.87	91.36	60.38	108.45	60.14	130.42	53.90	151.45	35.72	171.81
5000	-2.09	18.40	55.93	11.37	54.13	91.36	59.40	108.45	59.16	130.42	53.16	151.45	35.72	171.81
10000	-2.09	18.40	55.68	11.37	53.88	91.36	59.07	108.45	58.83	130.42	52.91	151.45	35.72	171.81
50000	-2.09	18.40	55.48	11.37	53.68	91.36	58.81	108.45	58.57	130.42	52.71	151.45	35.72	171.81
Tangent	-2.09	18.40	55.46	11.37	53.65	91.36	58.78	108.45	58.54	130.42	52.68	151.45	35.72	171.81

Radius:	P8		P9		P10		P11		P12		P13		P27	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	58.69	161.10
100	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	55.21	161.10
150	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	49.70	161.10
200	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	46.85	161.10
300	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	43.93	161.10
400	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	42.45	161.10
500	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	41.55	161.10
600	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	40.95	161.10
700	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	40.52	161.10
800	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	40.19	161.10
900	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	39.94	161.10
1000	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	39.74	161.10
1200	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	39.44	161.10
1500	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	39.13	161.10
2000	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	38.83	161.10
5000	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	38.28	161.10
10000	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	38.09	161.10
50000	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	37.95	161.10
Tangent	26.49	176.99	-2.30	174.38	34.83	218.91	25.61	224.39	33.95	266.31	24.72	271.96	37.93	161.10

TABLE 14A Vehicle Dynamic Envelope to INSIDE of Curve

Superelevation = **6.00 Inches** **Cross Level Variation =** **1.00 Inches** Rev. F 4/1/2005

Radius:	P14		P15		P16		P17		P18		P19		P20	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
100	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
150	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
200	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
300	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
400	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
500	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
600	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
700	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
800	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
900	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
1000	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
1200	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
1500	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
2000	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
5000	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
10000	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
50000	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84
Tangent	-54.00	270.36	-82.27	269.83	-89.86	262.66	-44.79	222.37	-73.06	221.84	-80.65	214.67	-63.85	173.84

Radius:	P21		P22		P23		P24		P25		P26		P28	
(feet)	x	y	x	y	x	y	x	y	x	y	x	y	x	y
82	-71.44	166.68	-98.18	142.81	-93.79	120.32	-91.30	94.60	-88.13	78.87	-74.65	0.36	-86.75	155.67
100	-71.44	166.68	-95.09	142.81	-90.70	120.32	-88.21	94.60	-85.04	78.87	-71.56	0.36	-83.66	155.67
150	-71.44	166.68	-90.45	142.81	-86.06	120.32	-83.56	94.60	-80.39	78.87	-66.91	0.36	-79.01	155.67
200	-71.44	166.68	-88.14	142.81	-83.75	120.32	-81.25	94.60	-78.08	78.87	-64.60	0.36	-76.70	155.67
300	-71.44	166.68	-85.83	142.81	-81.44	120.32	-78.95	94.60	-75.78	78.87	-62.30	0.36	-74.40	155.67
400	-71.44	166.68	-84.68	142.81	-80.29	120.32	-77.80	94.60	-74.63	78.87	-61.15	0.36	-73.25	155.67
500	-71.44	166.68	-83.99	142.81	-79.60	120.32	-77.11	94.60	-73.94	78.87	-60.46	0.36	-72.56	155.67
600	-71.44	166.68	-83.53	142.81	-79.14	120.32	-76.65	94.60	-73.48	78.87	-60.00	0.36	-72.10	155.67
700	-71.44	166.68	-83.21	142.81	-79.47	120.32	-76.98	94.60	-73.15	78.87	-59.67	0.36	-71.77	155.67
800	-71.44	166.68	-82.96	142.81	-80.07	120.32	-77.57	94.60	-72.91	78.87	-59.43	0.36	-71.52	155.67
900	-71.44	166.68	-82.77	142.81	-80.53	120.32	-78.03	94.60	-72.71	78.87	-59.23	0.36	-71.33	155.67
1000	-71.44	166.68	-82.62	142.81	-80.90	120.32	-78.40	94.60	-72.56	78.87	-59.08	0.36	-71.18	155.67
1200	-71.44	166.68	-82.39	142.81	-81.45	120.32	-78.95	94.60	-72.33	78.87	-58.85	0.36	-70.95	155.67
1500	-71.44	166.68	-82.16	142.81	-82.00	120.32	-79.50	94.60	-72.10	78.87	-58.62	0.36	-70.72	155.67
2000	-71.44	166.68	-81.93	142.81	-82.55	120.32	-80.05	94.60	-71.87	78.87	-58.39	0.36	-70.49	155.67
5000	-71.44	166.68	-82.64	142.81	-83.53	120.32	-81.04	94.60	-72.59	78.87	-59.11	0.36	-70.93	155.67
10000	-71.44	166.68	-82.89	142.81	-83.86	120.32	-81.37	94.60	-72.84	78.87	-59.36	0.36	-71.12	155.67
50000	-71.44	166.68	-83.09	142.81	-84.12	120.32	-81.63	94.60	-73.04	78.87	-59.56	0.36	-71.27	155.67
Tangent	-71.44	166.68	-83.12	142.81	-84.15	120.32	-81.66	94.60	-73.06	78.87	-59.58	0.36	-71.28	155.67

ATTACHMENT 22-B PANTOGRAPH CLEARANCES TUNNELS AND UNDERPASSES

Minimum Designed Contact Wire Height

On portions of the route in a tunnel with direct fixation track, and with fixed termination simple catenary style OCS, the minimum contact wire design height shall be:

Minimum pantograph operating Height	13' 6"
Contact wire construction tolerance	½"
Contact wire sag between hangers	½"
OCS. FT system sag at 120°F, 60' span	3 ½"
Vertical direct fixation track construction and maintenance tolerances from Figure 3.1	½"
Vehicle bounce	1"
Minimum designed contact wire height	**14' 0"**

On portions of the route under a bridge, with ballasted track, and with auto-tensioned simple catenary style OCS the minimum contact wire design height shall be

Minimum pantograph operating Height	13' 6"
Contact wire construction tolerance	½"
Contact wire sag between hangers	½"
Vertical ballasted track construction and maintenance tolerances from Figure 3.1	2"
Vehicle bounce	1"
Minimum designed contact wire height	**13' 10"**

NOTE: The use of minimum values for contact wire height at a site cannot be assumed. This is due to the influences on contact wire height of other features adjacent along the route. Such features include vertical track curves and grade crossings.

Static Pantograph Height for Vehicle Dynamic Envelope Calculations

The pantograph height for determination of Vehicle Dynamic Envelope shall be calculated from the actual contact wire design height for that location, plus the following allowances.

Summed O.C.S. Allowances:

Contact wire construction tolerance	½"
Pantograph carbon wear	½"
Contact wire wear	¼"
Summed O.C.S. Allowances:	**1 ¼"**

Static Pantograph Height = C/W Ht + 1 ¼"

Determination of Clearance Envelope

The clearance envelope adjacent to LRV pantographs in tunnels and underpasses shall be determined as follows:

1. Determine Design Contact Wire Height.
2. Add 1¼ inch to allow for construction tolerances, wire wear and carbon wear to determine a Static Pantograph Height for clearance calculations purposes.
3. Determine vehicle dynamic envelope from Attachment 22-A –Vehicle Dynamic Envelope, using linear interpolation for varying design static pantograph heights if necessary.
4. For horizontal clearance envelope ordinates, add Other Wayside Factors (OWF) as described in Section 22.2.2. and
5. For vertical clearance envelope ordinates, add construction tolerances (CT) for the tunnel or bridge
6. Add Running Clearances (RC) as described in Section 22.2.3 in both horizontal and vertical directions.

No wayside structure or non-energized OCS support structure shall be located within the clearance envelope thus defined.

Clearance of Structures Built Over Overhead Contact System – Additional criteria exist for calculating minimum horizontal and vertical clearance of overhead structures, including tunnel ceilings, from the overhead contact system wires:

Wiring construction tolerance	1"
OCS Design Wire System Depth including fittings	7"
Static Electrical Clearance OCS to Structure	4"
Vertical Clearance above Designed Contact Wire Height	**12"**
Maximum contact wire lateral displacement	14.5"
Wiring stagger tolerance	1"
Static Electrical Clearance OCS to Structure	4"
Horizontal Clearance relative to superelevated centerline	**19.5"**

Additional local clearances for OCS support assemblies maybe required at intervals along the route. The locations and clearance requirements are influenced by the track profile, the horizontal track alignment, the length of the overhead structure, and the shape of the surface components of that structure, and so requires collaboration and coordination in the design of the overhead structure and the OCS.

TRIMET

CHAPTER 24

SECURITY

CHAPTER 24 – SECURITY

TriMet is committed to addressing security concerns from the start of project planning and design. TriMet's *System Security Program Plan* establishes TriMet's policy on system security. Included in the plan are specific requirements for security awareness and responsibilities governing designs of new or modified facilities. This chapter of the Design Criteria supports and expands the *System Security Program Plan*.

Additionally, FTA has published a *Security and Emergency Preparedness Planning Guide* for design of FTA-funded transit facilities. Section 24.11 includes additional information about the FTA Guide.

24.1 DESIGN GOALS

These criteria are intended to provide broad security-related recommendations for the design of stations, park-and-ride lots, bus stops, maintenance buildings and associated facilities used by TriMet. Safety and security factors are a top priority for all transit agencies throughout the U.S. when planning and designing new facilities.

TriMet is committed to building a transit system that offers safe passage for the thousands of riders who use it each day. TriMet made a conscious decision years ago to design its system as an open, freely accessible one. The seamless transition from public to private space is meant to be user-friendly, but it can complicate security management and make good design even more critical.

Thoughtful design, along with community cooperation and partnership, will make the system and surrounding neighborhoods safer. Security-related facility design and consistent maintenance helps discourage crime and enhances the perception of safety for riders.

24.2 CRIME PREVENTION THROUGH ENVIRONMENTAL DESIGN

Security elements in the design of transit facilities will be based on the concept of "crime prevention through environmental design," known as CPTED (pronounced "septed"). CPTED is widely accepted as a relatively inexpensive but effective crime deterrence strategy. Its central precept is that immediate environment of a public space can be designed in a way that affects behavior. Through management of the environment, criminal activity is discouraged, and both the incidence and fear of crime are reduced.

CPTED relies on three basic strategies:

1. Natural surveillance—placing physical features, lighting, activities and people in ways that maximize observance of activity.

2. Natural access control—using judicial placement of entrances, exits, fencing, landscaping and lighting to direct foot and auto traffic in ways that discourage crime.

3. Territorial reinforcement—using physical and symbolic boundaries and features to define the space, encourage ownership and reinforce desired activities.

The design guidelines in this criteria use CPTED principles to reinforce safety and security. Designers shall make themselves familiar with CPTED principles and practices and incorporate them into design of TriMet facilities.

24.3 GENERAL SECURITY CRITERIA

24.3.1 Visibility

- Provide maximum visibility into and out of all transit facilities from as many sides as possible.
- Provide clear, direct access to station areas, bus stops and park-and-ride lots.
- Locate facilities in active areas and design the surrounding area to maximize use and views.
- Illuminate light rail stations and major facilities at night with as much indirect lighting as possible.
- Design major facilities as distinctive "landmarks."
- Construct transit shelters and waiting areas to have clear lines of sight over parking areas and drop-off areas.
- Use glass instead of plexiglass for most enclosures as plexiglass yellows and scratches and gives an impression of lack of maintenance.

24.3.2 Lighting – Lighting is a critical security measure. Lighting design objectives including security are listed in Section 11.5.1. The most important factor in lighting is to sustain a constant, uniform level of light in each area. Not only does darkness furnish criminals with ideal cover, criminals can also hide in shadows created by weak and uneven lighting. It is also advisable to provide ample lighting for vulnerable areas such as the sides of buildings and back doors. This lighting should avoid spotlighting points, which leaves surrounding areas dark.

- Illuminate stations with indirect lighting at the pedestrian level to make faces visible and avoid creating shadows.
- Provide the overall lighting function with high-security mast lighting.

- Provide mid-level lighting at heights of 10 to 14 feet to light pedestrian access points to stations and station facilities.

- Use high mast lights (40 to 50 feet high) rather than pedestrian level lights to provide uniform lighting throughout park-and-ride facilities.

- Avoid lighting and landscape conflicts. Provide a minimum of one to two foot candles per square foot of light at the pedestrian level as recommended by the Illuminating Engineering Society of America (IES).

24.3.3 Access and ADA

- Low-floor light rail vehicles and buses provide direct, level access from the platform and promote easy access for senior citizens and people with disabilities.

- Low-floor cars eliminate the need for lift equipment on light rail platforms. Lift equipment can obstruct pedestrian movement and provide potential hiding places.

- Station platforms must be designed to be open and people-friendly, not cluttered with barriers, and accommodating of persons with disabilities while integrating with the context of the street environment. All facilities must be designed to meet the Federal Transit Administration's (FTA) Americans with Disabilities Act design guidelines.

24.3.4 Art - Art in public spaces, whether designed into architectural elements or in freestanding works, adds a humanizing link that can lessen the public's feeling of discomfort in an unfamiliar setting and encourage "ownership" of the facility.

- Artistic elements, especially freestanding artworks, should be designed with durable, vandal-resistant materials to the greatest extent possible.

- Artwork should be located where it doesn't unduly obstruct views or cast shadows.

- Artwork might be placed out of reach in some cases, where it can be viewed with less risk of damage.

- Artwork should be of a design and material consistent with its long-term appearance and function.

- Artwork should be securely attached and should be free of sharp or heavy elements that could be used to inflict bodily harm.

- Artistic elements should not require high levels of routine maintenance. Clean and undamaged surfaces contribute to a sense of personal safety.

24.4 LIGHT RAIL STATIONS

24.4.1 Locating Stations – Station locations are selected primarily on the basis of estimated

ridership, cost, environmental impacts and other technical factors. Station design for security purposes will focus on site placement of station facilities to maximize the opportunities at station locations while counteracting potential security hazards.

- Locate stations where surrounding land uses, either existing or anticipated, will maximize the potential for activity around the stations, with the most intense use within a quarter-mile walking distance from the station.
- Stations should be located to provide access from as many directions as possible.
- Stations should be located at destination points, i.e. activity center and land uses, with high potential ridership and bus transfer opportunities.
- Locate stations to encourage high visibility and promote clear lines of sight.

24.4.2 Canopy Shelters

- Create shelters that provide weather protection, but allow easy surveillance.
- Avoid square columns or columns wider than 16 inches to minimize potential hiding places.
- Create shelters with glass roofs, which make shelters appear as "lanterns" at night and do not cast long shadows. Strive for a minimum eave height of nine feet to allow easy viewing into the shelter.
- Avoid deep U-shaped windscreens, which can create a feeling of entrapment.
- Use graffiti resistant materials and coatings or use easily replaceable and cost-effective materials.

24.4.3 Platform Furniture

- Minimize the amount of platform furniture to reduce platform obstructions while providing rider comfort.
- Provide a "furniture zone" to keep access routes clear and direct.
- Provide divisions in benches to discourage sleeping and loitering.
- Provide leaning rails along with bench areas so riders waiting for transit have more than one option.
- Choose materials that are not easily carved or subject to other vandalism.
- Verify with TriMet whether emergency phones will be required.
- If bike lockers are required, locate and design lockers to preserve clear lines of sight and to allow security checks inside the lockers.

24.4.4 Ticket Vending Machines and Fare Collection

- Locate vending machines in furniture zones to keep access points clear.
- Keep vending areas well lit.
- Provide machines of the smallest dimension possible to minimize availability of hiding places.
- Locate vending machines in areas where other transit information is provided.

24.4.5 Signage and Kiosk Systems

- Signage for directions, maps, timetables, etc. needs to be clear, easily understood and placed in multiple locations to help passengers feel in control of their journey.
- Simplicity and good design also result in ease of maintenance. Long-term maintenance is important because cleanliness at stations can reduce passengers' sense of vulnerability while traveling through a public space.
- Clean and distinct facility identification signs, regulations signs and other identification techniques emphasize a sense of agency and community ownership over the facility.
- Signage should be direct and imply the owner/operator's authority over the facility and genuine intent to enforce regulations.
- Signage should be strategically placed outside of stations so that it is not necessary to enter the station to obtain system information. This helps to diminish the presence of non-riders.
- Graffiti and vandal-resistant materials should be used for all signage and kiosk systems.

24.4.6 Joint Uses

- Current planning and design efforts at light rail stations provide joint-use facilities on platforms wherever possible.
- Joint uses such as operations offices, community facilities and retail operations provide all-day presence and enhance riders' comfort knowing stations are occupied with people of authority.
- Transit oriented development planning and station area planning should focus on safety and security by locating activity areas and full-day uses within walking distance and visibility of station platforms.

24.4.7 Bicycle Lockers

- Locate lockers in well-lit, frequently visited areas, within sight of boarding platforms or bus shelters.

- Do not locate lockers on platforms, in pedestrian pathways, over utilities or vaults, against walls, or under highway structures.
- Ensure adequate access around the lockers for users and ensure that use of the locker does not interfere with bus or rail operations.
- Do not obstruct clear lines of sight for operators and security personnel.
- Do not compromise art features.
- Ensure ease of inspection and security access when placing lockers. Incident and events will require security personnel to view all contents within the lockers.
- Coordinate with TriMet's Security Department for review of bicycle locker design and placement.

24.5 PARK AND RIDE LOTS

- Provide unobstructed views and sightlines to the greatest extent possible.
- Provide clear, direct, easily understood access to and exit from each facility at stations and park-and-ride lots.
- For light rail stations, provide a minimum of two open, well-lit entrance and exit points for pedestrians to the station.
- Provide adequate shelter from the weather.
- Avoid structures, landscaping and any amenities that cast long shadows.
- Provide an expression of "neighborhood ownership" by integrating the design of the facility into the existing surroundings.
- Provide direct, well-defined access at park-and-ride facilities to shorten walking distance and ensure maximum station interface.
- Provide convenient and open vehicular circulation routes at park-and-rides to allow maximum visibility and convenient police surveillance.
- Permit neighborhoods and businesses to critique design concepts from their historical or neighborhood perspectives.
- Increase the natural surveillance of a facility by enhancing public and operator observation techniques.
- Select designs that enhance maintenance and graffiti removal.

- Eliminate and prevent blind corners and other hiding places for criminal activity.
- Concentrate people in areas where observation is possible.
- Place booths, phones and other security items close by major corridors and paths.
- Define a strong sense of territory, demarcating the "transit area" from the public rights-of-way with paving materials, structures, landscaping, signage, or other means.
- Provide a sense of arrival. Users should clearly understand when they have entered the facility.
- Provide adequate lighting.
- Avoid pedestrian tunnels and overpasses when possible. Tunnels and overpasses approved as project elements should provide the most direct route to the station, be accessible to police patrol and meet ADA requirements. Overpasses should be open to view to the maximum extent possible.

24.6 PARKING GARAGES

24.6.1 General – Security design involves selecting the right building features, materials and systems to meet established passive security and active security requirements. Passive security refers to physical design features such as lighting. Active security refers to human activities that may or may not involve specialized equipment, such as security patrols, intercoms and monitored closed-circuit television (CCTV) systems.

- Zoning ordinances and building code requirements shall be studied for possible conflict with effective design guidelines for safety and security, such as requiring landscaping to screen parking facilities, placing height limits on light poles and mandating enclosure of exit stairs.
- Elevator lobbies and stairs in open parking garages should be open to the parking areas except at roof levels where glass enclosures may be provided for weather protection.
- Where possible, elevators and stairs should be located on the perimeter to permit natural surveillance from exterior public areas via glass-back elevators and glass at stairs and elevator lobbies.
- Access control and perimeter security should always be considered in the initial design stage. Even if the potential site for the parking facility is low risk, the risk level could change in the future.
- Emergency communications such as panic buttons, telephones and CCTV should be designed for easy installation in high-risk facilities.

- Access to station platform areas should be limited to ticket holders to give riders a greater sense of security.

- Large stations should be designed with the option of added facilities for stations attendants should they become necessary.

- To discourage non-rider parking, access into large parking garages should be controlled with procedures such as ticket validation or other processes that create a minimal burden on the rider and may not require payment.

- Avoid pedestrian tunnels and overpasses connected to the facility when possible. Tunnels and overpasses approved as project elements should provide the most direct route, be accessible to police patrol and meet ADA requirements. Overpasses should be open to view to the maximum extent possible.

- Where large parking garages complement a large station, care should be given to enhance observation of the garage from the transit areas.

- A community-based security approach such as the use of dedicated station attendants or transit-funded patrols provided by local police agencies should be used for large stations.

- Bicycle parking stalls and bicycle lockers should be provided near the entrances to parking facilities. Design lockers with provision for security inspection of internal spaces.

24.6.2 Parking Garage Lighting – Lighting is a critical security feature in a parking facility. Uniformity is especially important. Passing from light to dark areas creates problems for drivers because of the eye's inability to adjust rapidly. Light should extend into the edges of parking stalls rather than just into driving aisles. Another important lighting consideration is glare. Glare reduces the contrast of an object against its background, making it difficult for the eye to perceive depth accurately. Glare can be minimized by the careful selection and positioning of fixtures. Some manufacturers of light fixtures now include built-in shields that reduce glare while providing some up-light for vertical illumination.

24.6.3 Surfaces – Light-colored surfaces increase brightness, which can enhance a sense of personal safety. In certain high-risk cases, and with TriMet approval, white paint on ceilings and beam soffits may be used to reflect light and increase lighting uniformity.

24.6.4 Natural Surveillance – Openness enhances natural surveillance. The openness of the facade should be maximized for crime prevention. Openness on four sides is preferable. Another way to enhance natural surveillance is to bring retailers or other joint uses into the area. Controlling vehicular access to a parking facility is beneficial to security. Requiring the driver to take a ticket on entry and interact with a booth attendant at exit will make a facility less attractive to criminals than one that is wide open and unattended.

24.6.5 Signs and Graphics – Careful placement of signs and graphics helps orient patrons and allows them to move quickly in and out of the parking facility, making them less vulnerable to crime. Color coding and other memory aids also help patrons quickly relocate their parked vehicle when they return to the facility. Signs showing emergency telephone numbers should

also be provided.

24.6.6 Security Personnel – The visible presence of uniformed officers is one of the best crime prevention methods and should be considered in high-risk facilities. Unscheduled patrols by officers who vary their routes throughout their shifts appear to be especially effective.

24.6.7 Surveillance Equipment

- Surveillance design and equipment shall be reviewed by TriMet to coordinate it with the Agency's overall Security Plan.
- Provisions should be made at all stations, park-and-ride lots and parking garage structures to add closed-circuit television (CCTV), regardless of whether CCTV equipment is included in the subject project. All required conduits shall be embedded within the structural members or otherwise hidden from view.
- Camera locations should be carefully planned to provide maximum visibility.
- Surveillance cameras with pan-zoom-tilt capacity or other new technology are options at certain locations. The cameras must be monitored around-the-clock by people capable of dispatching emergency personnel.

24.7 LANDSCAPING

- Use landscaping to direct riders to the station in a clear, direct manner.
- Keep landscaping to a minimum for clear visibility, easy maintenance and free movement.
- Avoid densely foliated plants in the height zones from 24 inches to 80 inches.
- Keep tree limbs trimmed to a minimum height of 80 inches.
- Avoid putting planters in direct pedestrian access routes.
- Avoid continuous hedge materials that provide potential hiding places.
- Avoid landscaping that obscures lighting.
- Use landscaping to discourage graffiti on walls and discourage access to other facilities susceptible to vandalism.
- Use landscape materials such as thorn bushes to deny access.
- Use landscape materials to provide a visual identification of the boundaries of the transit facility or park-and-ride.

- Maintain landscaping as a commitment to being a "good neighbor" to surrounding businesses and residents.

24.8 SIDEWALK AND STREET DESIGN (URBAN SETTINGS)

- Sidewalks should be separated from the street by planter strips, street trees in tree grates and/or on-street parking to provide pedestrian safety and enhance the pedestrian experience.
- Sidewalks and street design should provide the most direct route possible to and from the station or park-and-ride facility.
- A minimum of two routes into and out of the facility should be provided for pedestrians.
- Sidewalks must be at least five feet wide to allow two people to pass and to meet ADA requirements, with six-foot to eight-foot minimums being more desirable, depending on the context.
- Street lighting must be provided to allow safe, visible paths at night.
- Signage and information systems at corners are necessary to provide convenient direction.

24.9 TUNNELS

Tunnels used to carry transit operations require special considerations due to their access, ventilation, and operational characteristics.

24.9.1 Intrusion Detection – Intrusion detection shall be provided at each portal of major tunnel structures. Intrusion detection shall be linked to CCTV facilities (if provided) to allow remote monitoring of the portal area when intrusion is detected. For technical details of the intrusion detection system, refer to Section 13.12.

24.9.2 Radio System – Long tunnels shall be provided with a radio transmission system to allow uninterrupted coverage of the City of Portland's 800 MHz radio communication system. For technical details of the radio system, refer to Section 13.11.

24.9.3 Ventilation structures – Ventilation structures for tunnels shall be located and equipped to provide reasonable deterrence from unauthorized intrusion. Perimeter walls or fencing and area lighting shall be provided where possible given the real estate available and surrounding community characteristics. CCTV should be used to allow remote monitoring of the ventilation structures, especially those used for air intake.

24.10 TRIMET FACILITIES

24.10.1 General – This section provides criteria for security at TriMet's non-public operations

facilities. Examples of these facilities include Operations and Maintenance Facilities, staff buildings, operator rooms, TPSS buildings and signal buildings. At the start of design of these kinds of facilities, designers shall seek confirmation on applicability of the following criteria from TriMet's Project Manager.

24.10.2 TRACS System – At many of its facilities, TriMet uses an electronic access control system known as TRACS. This system is used on all major employee office buildings and maintenance facilities, and is being expanded to include many small buildings. The system is normally installed by a specialist contractor under separate contract to TriMet's Facilities Management Department.

In order to facilitate future installation of the TRACS system, most new and rehabilitated buildings will require provision of conduits and boxes to accommodate the system. TriMet's Project Manager will confirm whether this section is applicable to the design at hand.

When so required, the following provisions shall be made for future installation of TRACS:

1. At 6" above the top of each controlled door, install a single gang box mounted at the center of the door fed by a ¾" conduit. Inside this conduit provide two (2) 22 AWG 4-conductor wires for the REX and door contact. Also provide one (1) 18 AWG 2-conductor cable for power in this conduit to allow for future use of an electromagnetic lock at the top of the door.

2. If an electric strike is used, at the jam side of the door provide a single gang box fed with a ½" conduit from the single gang box at the top of the door. Inside this conduit include one (1) 18 AWG 2-conductor wires for power to the electric strike and reader, and one (1) 22 AWG shielded 6-conductor wire for data and signal. To accommodate a card reader and to meet ADA standards, this box must be 42" above the floor (to the center of the box). Inside the box provide a penetration to the outside fitted with a ½" conduit sleeve for mounting the card reader outside the door.

3. If a "D" lock is used, provide a single gang box at the center hinge of the door fed by a ½" conduit from the single gang box at the top of the door. Inside the conduit include one (1) 18 AWG 2-conductor wire for power.

4. Run the ¾" conduit from the gang box at the top of the door to the equipment room or other location where future head end equipment will be kept.

24.10.3 Perimeter Security Fence – At all Maintenance and Operations facilities, a perimeter security fence shall be provided. The height of the fence shall be a minimum of 6 feet. The fence shall be constructed of galvanized steel posts and rails, and galvanized steel mesh fabric ("chain link") unless otherwise directed or approved by TriMet's Project Manager.

24.10.4 Automatic Vehicular Gates – Remotely activated vehicular gates shall be provided at major vehicle access points at all operations facilities with perimeter security fence. These gates shall be operated by TriMet's TRACS system. Whenever possible, locate the gates where they can be conveniently viewed from areas of the facility that are typically manned. If this is not possible, provisions for remote monitoring with video cameras should be included.

Automatic vehicular gates shall conform to the following:

- Operation from exterior side shall be conveniently located and configured for all vehicles anticipated to use the access point (e.g. LIFT buses and private automobiles), and shall be reasonably protected from damage by vehicles.
- Exterior operation point shall include a two-way intercom connection with a feature to allow gate operation at an appropriate location inside the facility.
- Operation from the interior side shall be through loop detection embedded in paving.
- The period of operation (from fully closed to fully open or vice versa) shall take no longer than 10 seconds.
- Door-swing style gates, if feasible, shall be specified. Cantilevered spans, if used, shall not exceed 14 feet. Gate styles that lift the entire gate vertically above vehicles shall not be used.
- All motors, drive gear, and other working parts shall be:
    1. Extremely durable, and intended for high frequency, commercial, exterior applications
    2. Located on the interior of the facility
    3. Readily accessible for maintenance, including adequate working clearances on all sides
    4. Located so that maintenance and replacement will not impede access while occurring
    5. Protected from damage by vehicles
- In addition to TRACs and loop-detection operation, all gates shall have accommodations for simple manual operation, and shall have safety features included to prevent the gate from closing on vehicles or people.

24.11 FTA FINDINGS ON SECURITY

In November 2004 FTA published *Transit Security Design Considerations.* This document provides security-oriented design considerations for transit bus and rail vehicles, and for the transportation infrastructure. The full document is available on TriNET at http://trinet/ops/security/links_to_useful_security_information/securitycpted.ftaguide11.04.pdf.

TriMet's designers should familiarize themselves with the FTA Transit Security Design Considerations before design begins. These considerations shall be used as a guideline to the design of TriMet facilities. Specific security elements included in the design shall be reviewed with TriMet.

TRIMET

APPENDIX A

DRAFTING PROCEDURES

TRIMET

Capital
Projects and
Facilities
Division

DRAFTING PROCEDURES

MARCH 2005

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ATTACHMENT A – DRAFTING PROCEDURES

1.1 INTRODUCTION

This manual establishes the basic criteria for preparing engineering drawings for the Tri-County Metropolitan Transportation District of Oregon (TriMet). These outlines, conventions and procedures are to be used in developing digital design data, preparing electronic files, and drafting project drawings. The following sections make up the body of this manual:

1. Computer-Aided Design Procedures – Outlines the methodology and conventions that will be followed when creating Computer-Aided Design (CAD) files.
2. General Drafting Standards – Sets forth the general drafting standards applicable to all drawings.

1.1.1 Objective – The objective of this manual is to establish a uniform appearance for all drawings and a consistent structure for all electronic information produced. Drawings produced by the consultant will match the structure and layout of drawings produced by TriMet. Use of these procedures will ensure a more consistent final product for all contract submittals.

1.1.2 Requirements – Accurate and complete electronic files of all relevant design information and documents prepared for the project will be required by TriMet. All project drawings will be produced using AutoCAD design software. The version of AutoCAD to be used will be determined by TriMet at the beginning of the project. Civil Design Software must be pre-approved by TriMet. Any deviation from these software standards must be pre-approved by TriMet.

1.1.3 Deviations – TriMet must be notified immediately if:
- A project team member believes these criteria provide insufficient information
- There are any discrepancies in drawing criteria
- Conflicts exist between the CAD Standards and other project criteria

1.1.4 Revisions – This is a "living" document. These standards are subject to amendment as conditions and experience warrant. TriMet will control and approve all changes to these criteria and issue updates as appropriate.

1.2 COMPUTER-AIDED DESIGN (CAD) PROCEDURES

1.2.1 General

1.2.1.1 CAD Methodology – Design efforts will create numerous electronic drawing files. TriMet has classified these electronic drawing files into two types, Reference Files and Sheet Files.

1.2.1.2 Reference Files – Reference Files will contain the geometric data developed for specific design elements of an alignment segment, site plan, park-and-ride, structure or other feature. Consultants will create and maintain individual

Reference Files for each design element of their work. Reference Files will conform to the criteria specified in this Manual. Reference Files must be pre-approved by TriMet prior to importing into eChange.

1.2.1.3 Sheet Files – Sheet Files will present completed design elements in a plan or profile format. This is done by "overlaying" Reference Files to Sheet Files using AutoCAD's file referencing capabilities. Sheet Files will be plotted as needed to produce hard copy drawing sets. Sheet Files will conform to the criteria specified in this Manual.

1.2.1.4 File Control – Files prepared for the project will be owned by TriMet and will reside on TriMet's server. Consultant will submit a list of proposed Reference Files and a compilation of the sheet files that are anticipated. Each drawing will be assigned a unique number by TriMet. TriMet will prepare and maintain a database of all drawings identified.

1.2.1.5 File Access – All file access will be managed through TriMet's Drawing Management Software (eChange). Any other form of electronic file transfer must receive pre-approval from TriMet's CAD manager.

1.2.1.6 Final submittals to TriMet: See contract for submittal requirements. Unless otherwise approved, TriMet will produce all hard copies required.

1.2.1.7 Intermediate submittals to TriMet – 11" x 17" plots will be used for all intermediate submittals and will be produced by TriMet.

1.2.2 Quality Assurance/Quality Control (QA/QC) Procedures – For information concerning all of the project QA/QC procedures, including issues related to CAD, please refer to the document titled "TriMet Quality Control/Quality Assurance Manual."

1.2.3 Reference Files – Reference files will be created in AutoCAD using the drafting standards specified in Section 2 of this manual. Reference files will be discipline specific and will contain design elements only for the specific location to which they pertain.

Reference files will be used to transfer digital information for design coordination and interface between consultants and TriMet. Proper use is essential to ensure effective design coordination.

1.2.3.1 Reference File Names – Reference file names will be assigned on a project basis. These guidelines will be discussed at the first contract CAD meeting.

1.2.4 Sheet Files – TriMet will provide an AutoCAD template file (see Attachment P) to be used as the basis for ALL sheet files. Sheet Files will use AutoCAD's external file referencing (XREF) capabilities to present design information in a standard plan sheet format. Sheet Files will contain only sheet specific information (i.e. standard project border, title block information, north arrow, bar scale, notes, dimensions). All design element information will be displayed by "overlaying" the appropriate Design File as an XREF (see Section 1.2.14 for criteria specific to using XREFS). General notes, typical sections, details, elevations, and abbreviation sheets may be set up without the use of Reference Files.

An electronic Sheet File will be created for each drawing required. All sheet files will include a view called "plot" at coordinates (0,0) (34,22).

1.2.4.1 Sheet File Names – See Attachment C for sheet file naming procedures.

1.2.5 Design Data Files – Civil design data files will use the same name as design Drawing File name whenever possible.

1.2.6 CAD Procedures

1.2.6.1 Units – Engineering drawings will have units set to decimal feet, with one unit equal to one foot.

Architectural drawings, that are not site plans, will have units set to Architectural feet and inches, with one unit equal to one inch.

A scale factor of 12 times will be required when converting an engineering drawing to an architectural drawing. A scale factor of 1/12 times will be required when converting an architectural drawing to an engineering drawing.

All reference files will be created with one unit equal to one foot.

1.2.6.2 Layers – See Attachment F for layer naming procedures.

1.2.7 Text – Text on all drawings will be of the style, font type, height, and weight specified below. A modified AutoCAD font file named SMPLX.shx is the standard font file to be used for all projects. This text font file will be provided by TriMet. Multiple styles with predefined heights may be used but they must use the provided SMPLX font. The minimum text height allowed is 0.1". See Attachment E – SMPLX Font Special Characters.

Text heights different from those specified in this Manual may not be used without prior consent from TriMet.

1.2.8 Linework – Much of the information provided in an engineering drawing is conveyed using line types. Maintaining consistent standards in assigning line types is essential if drawings are to be interpreted accurately and have a professional appearance.

1.2.9 Line Types – Standard AutoCAD line types are to be used. Any other Linetype must be pre-approved by and supplied to TriMet in electronic format.

1.2.10 Line Weights – Line weights are controlled during plotting by assigning pens to layer colors. To ensure uniformity, TriMet will provide AutoCAD "color dependent plot style table" (ctb) files. Standards for line weights and layer colors are illustrated in Attachment D – Pen Assignment Table.

1.2.11 Screened Line Work – When screened backgrounds are required, the information will be plotted using the project standard screen patterns by layer. The AutoCAD layer colors designated for screened linework are outlined in Attachment D – Pen Assignment Table.

1.2.12 Hatching – Hatch patterns are used to distinguish between material types. To insure uniformity between drawings standard AutoCAD hatch patterns are to be used. If a hatch pattern is not provided in AutoCAD and is deemed necessary to complete the task required, TriMet's CAD Manager will be informed. The pattern will be added to the library and to future addenda of the Drafting Standards Manual.

1.2.13 Symbols – Standard drawing symbols will be provided by TriMet (see Attachment A). Most of these symbols are included as a part of the TriMet template file. Any consultant wanting to use a separate block library must submit a description and electronic copy of all blocks to TriMet's CAD Manager. Separate block libraries must be approved by TriMet prior to use on the project. All approved block libraries will be provided to TriMet in electronic format for review and archiving on TriMet's computer network. All blocks will be assigned to suitable layers.

1.2.14 XREFS (External References) – Design files and base map files will always be used with the reference option. Do not bind or insert design files or base maps. Design Files will be referenced in Model Space at 1:1 and origin of (0,0).

1.2.15 Pen Mapping – To ensure consistency in drawing appearance, a standard mapping of plotter pens to electronic drawing line colors has been established. Consultants will use the project standard pen mapping when producing hard copy drawings. TriMet will provide consultants with AutoCAD "color dependent plot style table (ctb)" files when contracts are awarded.

1.2.16 Plotter Configuration – TriMet will provide AutoCAD "color dependent plot style table (ctb)" files. This will ensure a consistent look to all project submittals and graphics. Any changes to this "ctb" files must first be approved by TriMet's CAD Manager.

1.3 GENERAL DRAFTING STANDARDS

1.3.1 Drafting Medium – All drafting will be done electronically using the methodology specified in this section.

1.3.2 Drawing Size and Type – Drawings will be 22 inches by 34 inches (ASA Standard Size D). The designer will select the appropriate drawing type, as specified in Section 1.4 of this Manual. Drawing type formats cannot be changed without authorization from TriMet. **Drawings will be based upon TriMet's AutoCAD template file (see Attachment P).**

1.3.3 Submittal Drawing Production – All hard copy drawing submittals will be produced in-house by TriMet CAD staff from electronic drawing files residing on TriMet's drawing server. No hard copy submittals will be accepted without TriMet approval.

1.3.4 Lettering – Lettering type, height, and weight will be as specified in this Manual, except when specific requirements are established.

1.3.4.1 Lettering Orientation – Lettering will be oriented to facilitate reading from the bottom or the right-hand edge of the drawing, but will not rotated beyond 90°. See Attachment G for lettering orientation.

1.3.4.2 Case Sensitivity – All lettering will be upper case, unless otherwise specified.

1.3.5 Line Work – Line work will be in AutoCAD format.

1.3.6 Weights and Types – Line weights and types will be standard AutoCAD types and will conform to the project standards. Line type will be by layer. Any additional line types required must be pre-approved by TriMet and be delivered in electronic format.

1.3.7 Standard Drawing Title Block – The standard title block is to be referenced in ACAD paper space at coordinate (0,0). The Title Block information is an attribute file. These data fields are edited in AutoCAD using the DDATTE command and will be completed as specified below and shown in Attachment A Standard Symbols.

1.3.7.1 Drawing Title Box – The drawing title will be completed as shown below and in Figure 1.
Line 1: Project Title – Predefined attribute by project
Line 2: Line Section or Location Identifier
Line 3: Optional
Line 4: Optional
Line 5: Optional

1.3.7.2 Drawing Scale Box – If a single scale is used on the drawing, then that scale will be entered numerically in this box, such as 1"=100', or ¼"=1'-0". If more than one scale is used on the drawing or if a part of the drawing is not drawn to scale, the entry in this box will be "AS NOTED." If a drawing is entirely not drawn to scale, the entry will be "NOT TO SCALE."

1.3.7.3 Contract Number Box – Not used unless instructed.

1.3.7.4 Drawing Number Box – The drawing number will be the six-digit filename for the electronic Sheet File that corresponds to the drawing. The format for Sheet File names is specified in Attachment C.

1.3.7.5 Revision Level Box – Not used unless instructed.

1.3.7.6 Sheet Number Box – A sheet number will be assigned to each sheet of a plan set of drawings. It is to be a sequential number beginning with 1, and starting with the Title Sheet. These numbers govern the placement of each sheet in the plan set. This number will be hand lettered by TriMet after the final plan set is assembled.

1.3.7.7 Client Signature Box – The final drawings will be signed and dated in ink, in the appropriate box by TriMet's Project Manager.

1.3.7.8 Consultant Signature Box – Upon final submittal the signature box will

be signed and dated in ink, in the appropriate box by the Consultant Project Manager.

1.3.7.9 Professional Seal Box – The professional seal box will contain an electronic seal to be hand signed upon final submittal. A preliminary stamp (provided by TriMet) will be used till the design is completed.

1.3.7.10 Signature Box – The signature box will contain the following:

- The initials of the person who performed the design work and the date design work began will be electronically incorporated on the "DESIGNED" line.
- The initials of the person who performed the major portion of the drafting work and the date drafting began will be electronically incorporated on the "DRAWN" line.
- The person who confirms that the drawing is camera ready will initial and date in ink on the "CHECKED" line and will not be the same person shown on the "DESIGNED" line.
- The person who is responsible for the overall design shown on the drawing will initial and date in ink on the "APPROVED" line.
- Initials will be of first, middle, and last names. Dates will be of the format "mm/dd/yy".

1.3.7.11 Revisions Block – A block will be created and distributed by TriMet to the consultant for insertion in this box. See Appendix A.

1.3.7.12 Consultant Logo Box – The Consultant's Logo is to be inserted or referenced in this box. Insertion is to be at 0,0. The Consultant's Logo is not to be made a part of the Title Block.

1.4 STANDARD DRAWING TYPES

There are eight basic drawing types. Their format will follow the general guidelines specified in this Manual.

1.4.1 General Sheets – These drawings consist of the Cover Sheet, Title Sheet, and Drawing Index Sheets, and the Project Control Sheets when required. All these sheets will be prepared and supplied by TriMet.

1.4.2 General Discipline Sheets – These drawings consist of the Abbreviations, Symbols, and General Notes Sheet for each discipline.

1.4.3 Plan and Data Sheets – Plan sheets use the entire drawing area for orthographic projections or data tables. Sufficient space will be left on the right hand or bottom side for notes.

1.4.4 Profile Sheets – Profile sheets use the entire drawing area for depicting vertical profiles and generally have a corresponding Plan Sheet. A standard profile grid will be shown over the entire drawing area.

1.4.5 Plan and Profile Sheets – Plan and profile sheets use the top half of the sheet for orthographic projections and the lower half for vertical profiles. A standard profile grid will be shown over the lower half.

1.4.6 Detail Sheets – Detail sheets will be divided into 3/6/12 equal spaces. Where practical, details will be developed to fit into these spaces. If necessary, the grid may be modified. Detail sheets will be filled in from left to right and top to bottom.

1.4.7 Section Sheets – Section sheets will follow the same guidelines as Detail sheets (section 2.5.1.6).

1.5 GENERAL FORMAT

1.5.1 Drawing Orientation – Drawings will be oriented with the baseline stationing progressing from left to right across the sheet. Plan views will be oriented parallel to the track or street alignment. Details will be oriented in the same way as those of the Plan or Elevation from which the Detail is taken.

Typical sections will be portrayed looking ahead on line, in the direction of increasing stationing. When more than one section is drawn on a sheet, the sections will be arranged so that the stations increase from the bottom to the top of the sheet and from left to right. Architectural sections will, whenever possible, be taken looking to the left, ahead on line, or up.

1.5.2 Dimensions – Project drawings will employ dimensional systems for specific disciplines, as noted below:

- Track, Civil, Utility, and Systems Drawings. The decimal system will be used for coordinate systems, elevations, gradients, points on horizontal and vertical alignments, survey information, inverts, and slope designations.
- Structural, Architectural, Mechanical, and Electrical Drawings. The decimal systems will be used for specific topographical elevations. The feet and inches system will be used for all other layout dimensions and details.
- For All Disciplines. All angular dimensions will be stated in degrees-minutes-seconds. (Example: 44°15'32").

The decimal system will be written in feet taken to two decimal places. Track alignment coordinates will be carried to four decimal places. If a number is less than one foot, a "0" will be placed in front of the decimal point. Where dimensions are shown in feet and inches, the feet and inches will be separated by a short dash (example: 12'-10"). A zero will be shown for the inches figure if the dimension is a round figure in feet (example: 9'-0"). If the inches figure includes a fraction of an inch, the numerator and denominator of this fraction will be shown on the same horizontal line and separated by a space (example: 2¼").

Dimensions will be lettered (0.125") parallel to and above the dimension line and will be shown to identifiable, finite points, or lines. Dimension lines will end with an arrowhead. Dimension repetition on the same drawing or part of the drawing will be avoided. If several identical features have the same dimension, this dimension will be shown on one of the

features, accompanied by the notation "(TYP)" (example: 21'-9 ¾" (TYP)).

When a dimension is not drawn to scale, the dimension will be denoted with the notation "NTS" (not to scale).

1.5.3 Scales – The basic scale used on each drawing will be noted in the Scale Box of the Title Block. A graphic scale will be shown on all sheets a scale is used. The graphic scale should be located in the lower right of the drawing to the extent possible. The North arrow should be located in the upper right corner of the drawing to the extent possible.

On drawings where various scales are used, the Scale Box of the Title Block will read "AS NOTED" and the individual scales used will be shown by notation directly below each section and detail. If an elevation, section, or detail is shown schematically and it is not intended to specify the scale, the view will be noted "NTS" under its title or, in the case of an entire drawing not drawn to scale, "NTS" will be shown in the Scale Box.

If the vertical scale is different from the horizontal scale that is used on the same drawing, both scales will be shown numerically, with each preceded by the letter "H" or "V" (Examples: H:1"=50" V:1"=10').

1.5.4 Labels – Station offsets will be labeled horizontal and parallel to the sheet in 0.125-inch letters. Leaders will be drawn underlining the station offset and pointing to the point labeled. Arrowheads will not be used for station offsets.

1.5.5 Notes – Notes applicable to the whole drawing will be shown in a numbered list beginning in the far right upper corner of the drawing in the width allocated for notes. A header of "NOTES:" (always plural) is to precede the list of numbered notes. The header is to be 0.14-inch letters with a 0.35 mm pen weight. One space will be provided between individual notes. Notes will be 0.125-inch letter height.

In charts, columns of notes are to follow guidelines described above; numbers are to be right justified with equal decimal place accuracy.

Specific construction notes will be placed directly in plan or profile view as appropriate. When space is limited in plan or profile, a numbered keynote reference may be used with a leader to the item being noted. The leader will terminate with an arrowhead indicating the object, or with a dot when an area is being referenced. Keynote references will be 0.125 inch letters placed in 0.28-inch diameter circles. The corresponding keynotes will be listed as specified above. The list of keynotes will have a header of "CONSTRUCTION NOTES."

1.5.6 Identifying Titles – See Attachment A for Standard symbols

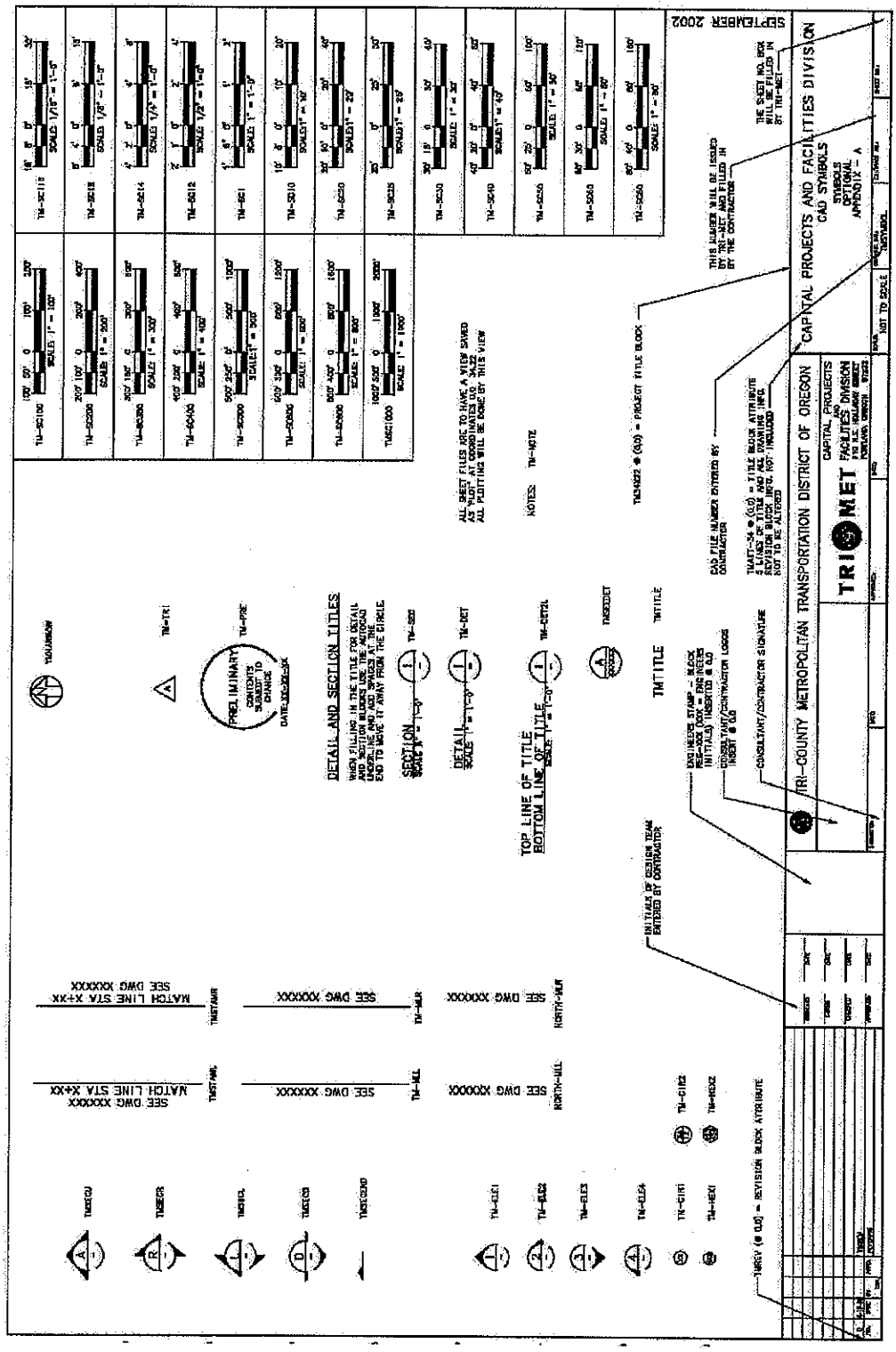
1.5.7 Identifying Reference Symbols – Detail reference symbols will show the detail number in the top half and the referenced drawing number in the lower half. When a detail is located on the sheet where the call-out is made, a dash will be shown in place of the drawing number. See Attachment A for typical detail symbols.

Section reference symbols will show the section letter in the top half and the referenced drawing number in the lower half. A section taken through a feature shown on a drawing will be identified by a line broken at its middle and extended beyond the limits of the section by

at least ½ inch. Sections should be identified in such a way that the letters progress in consecutive order of the alphabet from left to right and from top to bottom of the drawing. See Attachment A for typical section symbols.

1.5.8 Match Lines – Where a feature shown on one drawing continues on another drawing, a match line or a reference to the adjoining sheet will be provided. Match lines will be a continuous line labeled "SEE DWG XXXXXX". For drawings that show continuation of alignment, the match lines will be labeled "STA XXX+XX" as the first line of text and "SEE DWG XXXXXX" on the second line of text. Labels should be parallel to the match line, outside the limits of drawing coverage.

ATTACHMENT "A" CAD SYMBOLS



ATTACHMENT "C" CADD FILE DRAWING NAME GUIDELINES

DISCIPLINE

A	ARCHITECTURAL
C	CIVIL
E	ELECTRICAL
G	GENERAL
J	SYSTEMS
K	TRACK
L	LANDSCAPE
M	MECHANICAL
R	RIGHT-OF-WAY
S	STRUCTURAL
T	TRAFFIC
U	UTILITIES

DESCRIPTION

2-DIGITS TO DESCRIBE AREA, LOCATION, PROJECT NUMBER OR SECTION OF A PROJECT

SUB-DISCIPLINE

Sub-discipline format shall be determined by project by TriMet and the design team.

ATTACHMENT "D" **PEN ASSIGNMENT TABLE**

ACAD CODE	COLOR DESCRIPTION	LINE EXAMPLE	PEN PATTERN	PEN	HALF SIZE	FULL SIZE
01	RED			7	.007	0.01
02	YELLOW			7	.010	0.012
03	GREEN			7	.011	0.02
04	CYAN			7	.014	0.02
05	BLUE			7	.028	0.039
06	MAGENTA			7	.020	0.028
07	WHITE			7	.012	0.014
08	DARK GREY	30% SCREEN		253	.007	0.01
09	LIGHT GREY	40% SCREEN		253	.010	0.012
10	BRIGHT RED	50% SCREEN		253	.014	0.02
11	PINK	60% SCREEN		253	.014	0.028
12	DARK RED	70% SCREEN		253	.024	0.035
13	LIGHT ROSE	80% SCREEN		254	.010	0.014
14	ROSE	90% SCREEN		254	.012	0.02
15	DARK ROSE			7	.005	0.007

TRIMET CAPITAL PROJECTS AND FACILITIES DIVISION 710 N.E. HOLLADAY STREET PORTLAND, OREGON 97232			PEN ASSIGNMENT TABLE ATTACHMENT – D	
DRAWN	DESIGN	CHECKED	APPROVED:	DATE: MARCH 2005
SCALE: NONE	FILE NAME: ATTACH_D.DWG		CONTRACT NO:	SHEET NO:

ATTACHMENT "E" **SMPLX FONT SPECIAL CHARACTERS**

SPECIAL CHARACTERS FOR SMPLX FONT

½ %%160 =	½	%%D =	°
%%161 =	¼	%%P =	±
%%162 =	¾	%%C =	⌀
%%132 =	⅛	%%% =	%
%%133 =	⅜	%%128 =	±
%%134 =	⅝	%%129 =	⌀
%%135 =	⅞	%%130 =	Ω
%%136 =	1/16	%%163 =	℄
%%137 =	3/16	%%164 =	℄
%%138 =	5/16		
%%139 =	7/16		
%%140 =	9/16		
%%141 =	11/16		
%%142 =	13/16		
%%143 =	15/16		
%%144 =	1/32		
%%145 =	3/32		
%%146 =	5/32		
%%147 =	7/32		
%%148 =	9/32		
%%149 =	11/32		
%%150 =	13/32		
%%151 =	15/32		
%%152 =	17/32		
%%153 =	19/32		
%%154 =	21/32		
%%155 =	23/32		
%%156 =	25/32		
%%157 =	27/32		
%%158 =	29/32		
%%159 =	31/32		

EXAMPLES:

TYPE IN	TO GET
1%%162"	1¾"
4'-3%%160"	4'-3½"

TRIMET CAPITAL PROJECTS AND FACILITIES DIVISION 710 N.E. HOLLADAY STREET PORTLAND, OREGON 97232			SMPLX FONT SPECIAL CHARACTERS	
DRAWN	DESIGN	CHECKED	APPROVED:	DATE:
SCALE:	FILE NAME: APPEND_E		CONTRACT NO:	SHEET NO:

ATTACHMENT "F" LAYERS

Each consultant shall use the following format for layer names. Each consultant shall submit a layer list for TriMet's approval. If the consultant wishes to use a different layering system a written layer list and definition of each layer must be submitted to TriMet for approval.

DISCIPLINE	STATUS		DESCRIPTION		
C	X	-	TRACK		
J	P	-	POLES		
A	X	-	WALL		
L	P	-	FENCE		
S	X	-	RWALL		

DISCIPLINE DESIGNATIONS

A	Architectural
C	Civil
E	Electrical
G	General
J	Systems Engineering
K	Trackwork
L	Landscaping
M	Mechanical
R	Right-of-Way
S	Structural
T	Traffic
U	Utilities
W	Wetland Mitigation

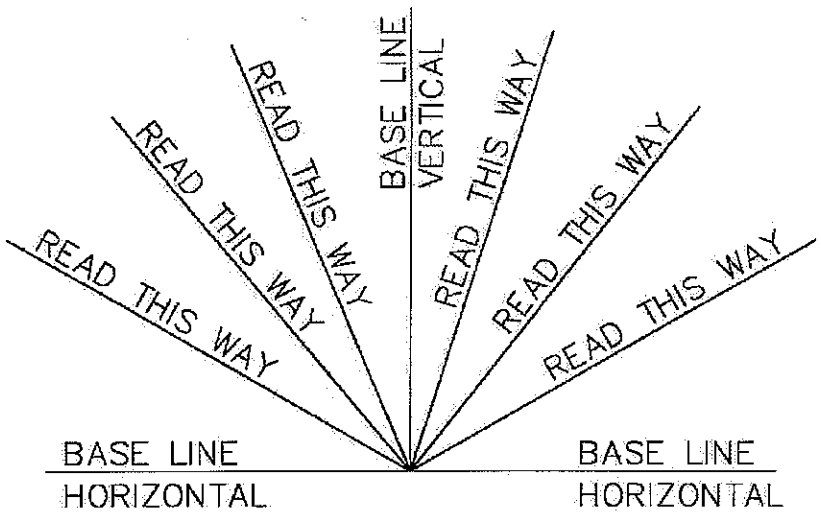
STATUS

X = Existing
P = Proposed
G = General

DESCRIPTION

4-8 characters, descriptive features on layers

ATTACHMENT "G" **LETTERING ORIENTATION**



TRIMET CAPITAL PROJECTS AND FACILITIES DIVISION 710 N.E. HOLLADAY STREET PORTLAND, OREGON 97232			LETTERING ORIENTATION	
DRAWN	DESIGN	CHECKED	APPROVED:	DATE:
SCALE: NONE	FILE NAME: APPEND_G		CONTRACT NO:	SHEET NO:

ATTACHMENT "I" REFERENCE FILE NAMES

Each consultant shall use the following format for reference file names. Each consultant shall submit a reference file list for TriMet's approval. If the consultant wishes to use a different reference file naming system, a written reference file list and definition of each reference file must be submitted to TriMet for approval.

PROJECT NUMBER OR LINE SECTION		DESCRIPTION
10A	-	TRACK
15	-	POLES
16	-	WALL
19	-	FENCE
10C	-	RET. WALL

PROJECT NUMER OR LINE SECTION
The project number or line section will be assigned by TriMet

DESCRIPTION
4-6 characters, descriptive features in reference files

ATTACHMENT "M" TRIMET PROJECTS GENERAL CAD PROCEDURES

1. PROJECT TITLE BLOCK – DO NOT IMPORT
   - **TriMet provided AutoCAD template file (see Attachment P)**
   - Not to be altered in any way
   - Do not import
   - First Title Block Line = Project Name
   - Second Title Block Line = XXXXX

2. CONSULTANT LOGO
   - Insert as a block at 0,0

3. CONSULTANT STAMP
   - Insert as a block at 0,0
   - File name to be REG-XXX (XXX = Engineer's initials)

4. MODEL SPACE WINDOW
   - Create layer "mview"
   - Color = 3
   - Turn on/off do not freeze

5. PROJECT FONT
   - There is to be only one font used on the project
   - Project Font = SMPLX.SHX (Provided with standard symbols)

6. PLOT WINDOW
   - Every sheet file will have a view called "plot"
   - View "plot" to be at paper space coordinates (0,0) (34,22)

7. PROJECT DIMENSIONING
   - All dims will use filled arrows
   - All dimension lines and arrows will be color 1 (red)
   - All dimension text will be color 2 (yellow)
   - Dimension text to be centered above the line (horizontal dimensions)
   - Dimension text to be centered/horizontal (vertical dimensions)
   - Do not underline leader text

8. GENERAL NOTES
   - Do not use colors higher than color 15 (They plot in color)
   - Layer "0" to be color 7
   - Do not change the pre-set windows for plan sets
   - Do not fill in sheet number on title block attribute
   - Limit use of text on reference files to the very minimum
   - Reference files are to be scaled at 1-to-1 not at 1-to-12

ATTACHMENT "N" ECHANGE GUIDELINES

The following items are given as guidelines to a more efficient use of the TriMet Document Management System (eChange).

1. Drawing security is controlled by group access. You can only edit drawings imported by your group.
2. Everyone is a member of the General User Group (General Users cannot edit drawings in (eChange).
3. Every user will be placed in an editor group by the eChange Administrator. As a member of this group you can edit, check-in and checkout drawings.
4. We strongly recommend your company assigning one or two "Gate Keepers" to control the flow of drawings in and out of eChange.
5. The term "Pens-up" is defined as the date the Consultant must have all drawings for a given submittal checked back into eChange.
6. When "checking out" files over the Internet, be sure to download the file even though the "check out box" says the file is checked out.
7. Files must be checked-in and out one at a time.
8. Only the eChange Administrator can delete a file, change a title or a drawing description.
9. The faster your Internet connection (T1, DSL, modem) the faster you can check in or check out drawings.

ATTACHMENT "O" PROCEDURES FOR AS-BUILT DRAWINGS AND SPECIFICATIONS

1. During course of construction, revisions often are required to final design documents issued for construction. Ultimately, these revisions are incorporated into the as-built drawings and specifications that TriMet retains for record.

2. Our current program is to as-built drawings and specifications as work progresses. This serves several purposes:

   a. It provides current documents to field personnel who are responsible for resolving issues and constructing the project.

   b. It allows other interested parties to remain informed regarding revisions.

   c. It captures information while those most knowledgeable about the project are still involved.

   d. It avoids the often overwhelming and inefficient task of post-construction as-builting.

3. Buck Lorts is responsible for the production of as-built documents. The assigned lead person on each project or portion of a project is responsible for delivering as-built information to Buck for incorporation into the final design documents.

4. When a change or revision to issued for construction documents becomes necessary, the assigned lead person must determine:

   a. How to identify the change or revision:

      i. PC – potential change (i.e., contract price change anticipated, leading to CO)

      ii. CLR – clarification (i.e., no change in price anticipated)

      iii. MR – (i.e., minor revision to pay item)

      iv. FO – field order (i.e., directed field change, leading to CO)

      v. RFI – request for information (i.e., technical question asked and answered)

   b. Whether TriMet CAD Department, or a consultant, makes the change in CAD:

      i. If TriMet performs the CAD work, the assigned lead marks up hard copies of all affected documents and delivers them to TriMet CAD Department. TriMet CAD Department will check out the documents from eChange, make the changes, print revised documents for lead person review and approval, print final corrected documents and deliver them to the lead person for distribution. (Only TriMet eChange administrators, Buck Lorts and John McBride, can check out and

change consultant CAD files.)

ii. If a consultant performs the CAD work, the consultant checks out the documents (sheets) and XREFS from eChange, makes the changes, checks the revised documents (sheets) and XREFS back to eChange, and sends TriMet CAD Department an email identifying which documents have been revised/checked in along with their identifying tracking document (PC, CLAR, MR, FO, or RFI number). TriMet CAD Department then reviews the documents for correct change identification (clouds, deltas, stars, title block info, etc.), prints the final corrected documents, and sends them to the lead person for final checking and distribution.

c. Whether a stamped, sealed document is required:

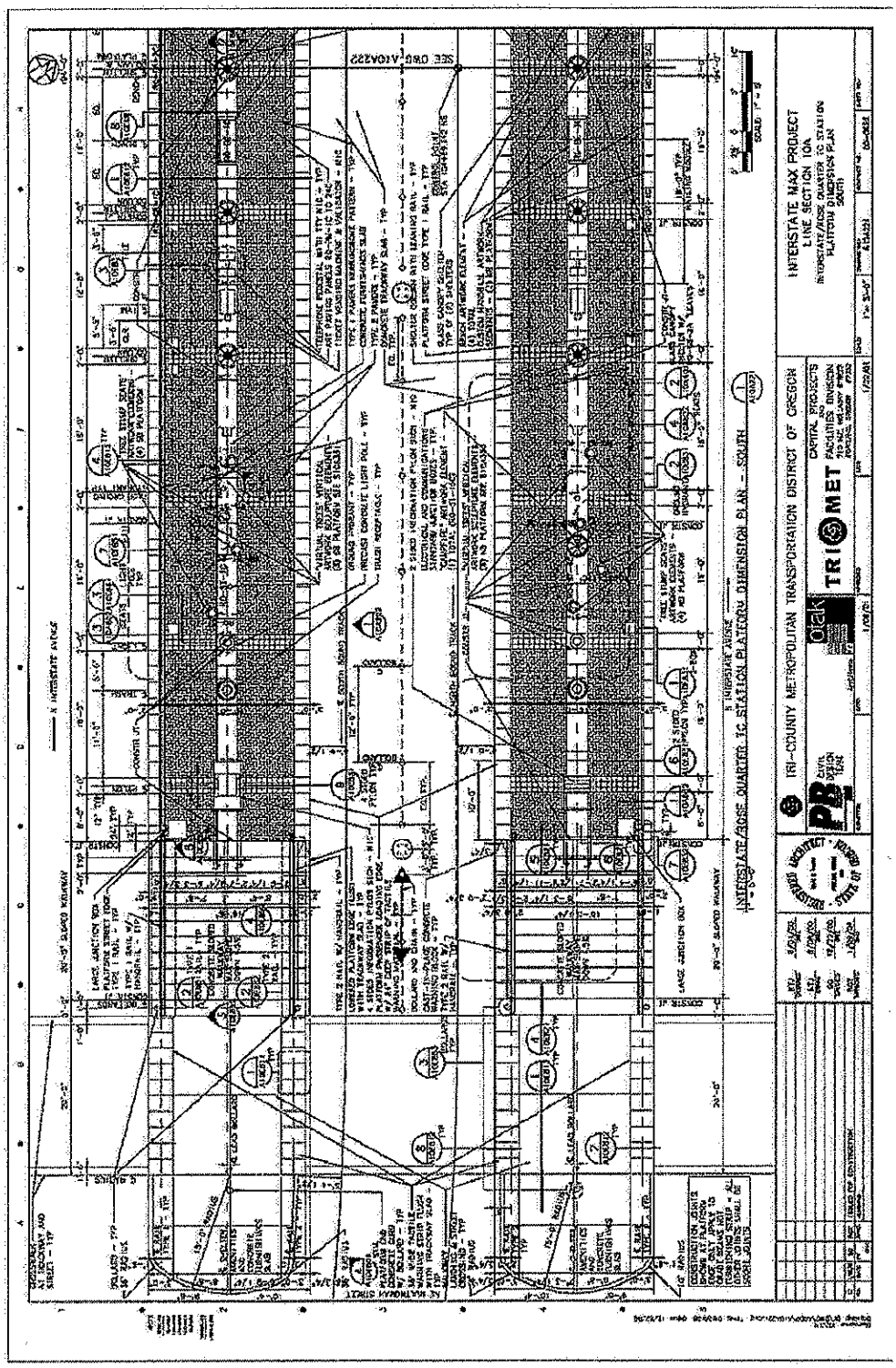
i. The assigned lead, with concurrence from the Design Development manager or Systems Engineering manager, or Director of Project Implementation, shall determine whether a change or revision requires stamped, sealed documents.

ii. If required, the lead person shall ensure that a signed, sealed document by an appropriate person is received and issued.

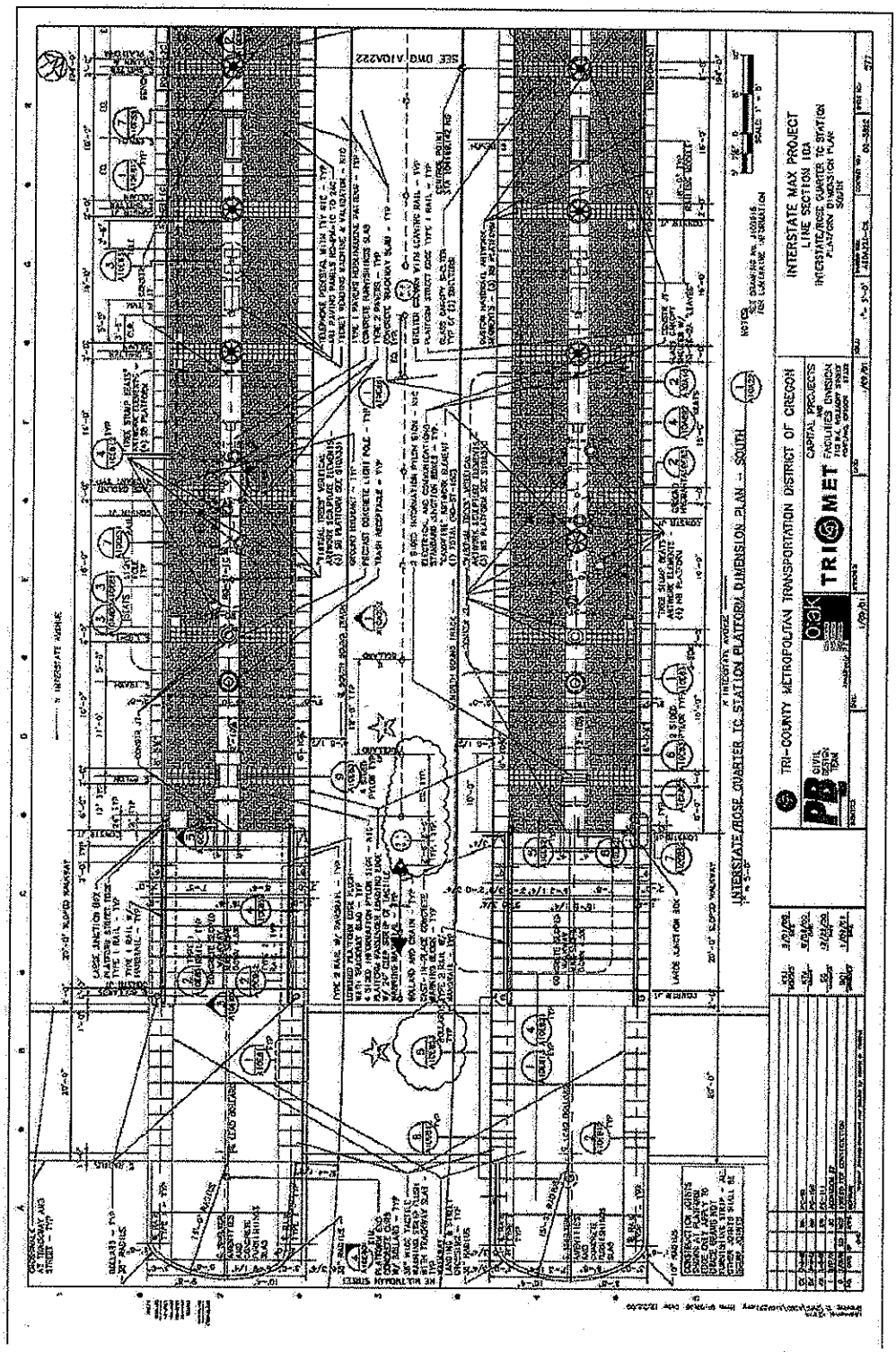
iii. Revisions or changes may be made to signed, sealed documents provided that either the seal is removed from the revised document or the person who originally signed and sealed the original document is informed of any and all revisions to it and agrees to sign and seal the revised document. In all cases, revisions or changes shall be identified, noted and tracked on the document in accordance with TriMet procedures.

5. Samples of a revised drawing with the seal removed, and the original sealed drawing are attached for your information.

Sample original sealed drawing



Sample revised drawing with the seal removed



ATTACHMENT "P" – TRIMET STANDARD TEMPLATE

THIS TEMPLATE TO BE USED FOR ALL TRIMET PROJECT DRAWINGS