2012 GREEN BOOK SECTION 306

305-2.4 Framing. Mudsills shall be firmly and evenly bedded on solid material. Sills and caps shall have a full, even bearing on the pedestals, posts, or piles and shall be secured in place as indicated on the Plans.

Bents shall be accurately aligned before the bracing is placed. Bracing shall be fastened at the ends and at each intersection by bolts. Bracing shall be of such length as will provide a minimum distance of 8 inches (200mm) between the outside bolt and the end of the brace. Treated posts or piles shall not be cut to accommodate the bracing. Treated filler blocks shall be used if necessary to fill any space that may occur between the bracing and the member of the bent.

In placing joists, the best edge shall be placed down. The elevation of the tops of adjacent joists shall not vary more than 1/8 inch (3mm). Outside joists shall have butt joints, Interior joists shall be lapped and shall extend the full width of the cap to obtain full bearing. Bridging between joists shall be solid and fastened to the joists near the top of the block and on each side of the bottom of the block. Bridging shall be accurately cut to fit closely between the joists.

Trusses, when completed, shall show no irregularity of line. Chords shall be straight and true from end to end in horizontal projection, and in vertical projection shall show a smooth curve through panel points conforming to the correct camber. Uneven and rough cuts at the points of bearing will be cause for rejection of the piece containing the defect.

Laminated bridge floors shall be constructed as shown on the Plans. The planks shall be laid with the best edge down.

Spiking of deck planking in roadway areas of bridges and similar structures shall be accomplished by the means of an air hammer equipped with a suitable driving head so designed and constructed as to ensure that the spikes are driven to sufficient depth to draw the planking tightly to the joints without damaging or abrading the surface of the plank.

305-2.5 Painting. The railing of timber bridges, including the posts, the entire outer edge of bridge decks, except treated surfaces, and any other surfaces indicated on the Plans to be painted, shall be painted as prescribed in 210-1.5 and 310.

The surface of wooden guard rails above the ground shall be painted as prescribed in 210-1.5 and 310.

The lumber shall be cut to fit and the entire surface shall be given the specified prime coat. The remaining coats shall be applied after the structure has been erected.

305-2.6 Measurement and Payment. Timber structures will be paid for as provided in the Bid. Where board measure (thousand cubic meters) is used as the basis of payment, the quantity to be paid for will be determined from actual (nominal) widths and thicknesses and the actual lengths of the pieces in the finished structure, except that in the case of laminated timber flooring, the number of laminations to be paid for shall be the required number of the size specified after dressing and the length of each lamination shall be considered as the full width or length of the floor.

The Contract Unit Price per board measure (thousand cubic meters), per linear foot (meter) of structure, or the lump sum, shall include full compensation for furnishing all nails, hardware, paint, and wood preservative.

SECTION 306 - UNDERGROUND CONDUIT CONSTRUCTION

306-1 OPEN TRENCH OPERATIONS.

306-1.1 Trench Excavation.

306-1.1.1 General. For the purpose of shoring or bracing, a trench is defined as an excavation in which the depth is greater than the width of the bottom of the excavation.

Excavations for appurtenant structures, such as but not limited to manholes, transition structures, junction structures, vaults, valve boxes, catch basins, thrust blocks, and boring pits shall, for the purpose of shoring and bracing, be deemed to be in the category of trench excavation.

Excavation shall include the removal of all water and materials of any nature which interfere with the construction work. Removal of groundwater to a level below the structure subgrade will be necessary only when required by the Plans or Special Provisions.

Excavation for conduits shall be by open trench unless otherwise specified or shown on the Plans. However, should the Contractor elect to tunnel or jack any portion not so specified, he shall first obtain approval from the Engineer. Payment for such work will be made as though the specified methods of construction had been used.

306-1.1.2 Maximum Length of Open Trench. Except by permission of the Engineer, the maximum length of open trench where prefabricated pipe is used shall be 500 feet (150m) or the distance necessary to accommodate the amount of pipe installed in a single day, whichever is the greater. The distance is the collective length at any location, including open excavation, pipe laying and appurtenant construction and backfill which has not been temporarily resurfaced.

Except by permission of the Engineer, the maximum length of open trench in any one location where concrete structures are cast in place will be that which is necessary to permit uninterrupted progress. Construction shall be pursued as follows: excavation, setting of reinforcing steel, placing of floor slab, walls, and cover slab or arch. Each shall follow the other without any one operation preceding the next nearest operation by more than 200 feet (60m).

Failure by the Contractor to comply with the limitations specified herein may result in an order to halt the work until such time as compliance has been achieved.

306-1.1.3 Maximum and Minimum Width of Trench. For pipe (except corrugated steel pipe), the minimum and maximum width of trench permitted shall be as indicated on the Plans or Standard Plans.

For corrugated steel pipe, the trench shall be at least 16 inches (400mm) wider than the diameter of the pipe to be installed.

If the maximum trench width is exceeded, the Contractor shall provide additional bedding, another type of bedding, or a higher strength of pipe, as shown on Plans or approved by the Engineer, at no additional cost to the Agency.

Additional payments or deductions from the Contract Unit Price per trench excavation for conduits will be based upon a calculated volume. The width used in calculating the volume of excavation for prefabricated conduit will be the maximum width of trench shown on the Plan and measured at the top of the pipe. In case of sewers or storm drains formed and cast in place, such volume will be based upon the outside width of the structure being constructed plus 3 feet (0.9m).

Additional payment or deductions from Contract Price for trench resurfacing will be based upon an area determined by the maximum width of trench as specified herein.

306-1.1.4 Access to Trenches. Safe and suitable ladders which project 2 feet (0.6m) above the top of the trench shall be provided for all trenches over 4 feet (1.2m) in depth. One ladder shall be provided for each 50 feet (15m) of open trench, or fraction thereof, and be so located that workers in the trench need not move more than 25 feet (7.5m) to a ladder.

306-1.1.5 Removal and Replacement of Surface Improvements. Bituminous pavement, concrete pavement, curbs, sidewalks, or driveways removed in connection with construction shall be removed in accordance with 300-1.3 and reconstructed in accordance with 302 or 303-5.

306-1.1.6 Bracing Excavations. The manner of bracing excavations shall be as set forth in the rules, orders, and regulations of the Division of Occupational Safety and Health of the State of California.

Prior to commencing the excavation of a trench 5 feet (1.5m) in depth or greater and into which a person will be required to descend, the Contractor shall first obtain a permit to do so from the Division of Occupational Safety and Health pursuant to 7-10.4.1.

Should the bracing system utilize steel H-beams or piles or other similar vertical supports, driving of said vertical supports will not be permitted except for the last 4 feet (1.2m). The vertical supports shall be placed in holes drilled to a depth of 4 feet (1.2m) above the proposed bottom of pile, except where this procedure is impracticable. The vertical support may then be driven to the required depth, not to exceed 4 feet (1.2m). During the drilling and driving operations, the Contractor shall take care to avoid damage to utilities.

At locations where the drilling of such holes is impracticable because of the existence of rocks, running sand, or other similar conditions, and provided said impracticability is demonstrated to the satisfaction of the Engineer by actual drilling operations by the Contractor, the Engineer may, upon request of the Contractor, approve the use of means other than drilling for the purpose of placing the vertical support. Such other means, however, must be of a nature which will accomplish, as nearly as possible, the purpose of the drilling, namely, the prevention of damage to existing surface or subsurface improvements, both public and private. All costs for this work shall be included in the prices bid for the items involved.

If sheeting is used to support the excavated trench, the sheeting shall be removed by the Contractor, and no such sheeting will be permitted to remain in the trench. When field conditions, the type of sheeting, or methods of construction used by the Contractor are such as to make the removal of sheeting impracticable, the Engineer may permit portions of the sheeting to be cut off to a specified depth and remain in the trench.

306-1.2 Installation of Pipe.

306-1.2.1 Bedding.

306-1.2.1.1 General. Bedding material and placement shall conform to this subsection except as otherwise specified in 306-1.2.1.2 or 306-1.2.1.3. The bedding zone shall be defined as the area containing the material specified that is supporting, surrounding, and extending to 1 foot (0.3m) above the top of pipe. Where it becomes necessary to remove boulders or other interfering objects at subgrade for bedding, any void below such subgrade shall be filled with the bedding material designated on the Plans. Where concrete is specified to cover the pipe, the top of the concrete shall be considered as the top of the bedding.

If soft, spongy, unstable, or other unsuitable material is encountered upon which the bedding material or pipe is to be placed, this material shall be removed to a depth ordered by the Engineer and replaced with bedding material suitably densified. Additional bedding so ordered, over the amount required by the Plans or Special Provisions, will be paid for as provided in the Bid. If the necessity for such additional bedding material has been caused by an act or failure to act on the part of the Contractor or is required for the control of groundwater, the Contractor shall bear the expense of the additional excavation and bedding.

Bedding material shall first be placed on a firm and unyielding subgrade so that the pipe is supported for the full length of the barrel. There shall be 4 inches (100mm) minimum of bedding below the pipe barrel and 1 inch (25mm) minimum clearance below a projecting bell for sewer, storm drain and water pipe. There shall be a minimum side clearance of 6 inches (150mm) on each side of the pipe barrel. For pipes and cables not requiring bedding by their owners, the trench width shall be appropriate to obtain

the required compaction around the installation by mechanical equipment, except where cement slurry or CLSM is used. The material in the bedding zone shall be placed, and densified either by jetting or by mechanical compaction. When jetting is used, the lifts shall not exceed 4 feet (1.2m). Mechanical compaction shall be per 306-1.3.2.

When densifying the bedding material by jetting, the trench wall shall have a minimum sand equivalent of 15. The jet pipe shall meet the requirements of 306-1.3.3 and be of sufficient length to reach within 2 feet (0.6m) of the bottom of the pipe. Jetting shall provide enough water to thoroughly saturate and densify, without voids, the bedding material around the pipe. The jet pipe shall be inserted at intervals of 3 feet (1m) maximum, contiguous along each side of the pipe. Neither flooding, nor free standing water will be permitted. Unless the sheeting or shoring is to be cut off and left in place, densification of bedding for pipe shall be accomplished after the sheeting or shoring has been removed form the bedding zone, and prior to the placement of backfill.

Except where otherwise specified, bedding material shall be sand, gravel, crushed aggregate, or native free-draining granular material having a sand equivalent of not less than 30 or having a coefficient of permeability greater than 1-1/2 inches/hour (35mm per hour), or other material approved by the Engineer.

Concrete used for bedding shall be as specified in 201-1. Concrete shall be cured for the indicated time period prior to backfilling.

In cases where native free-draining granular material is suitable for use as bedding, the trench may be excavated to a point above the invert grade and the trench bottom hand shaped so that the bottom segment of the pipe is firmly supported on undisturbed material.

Unless otherwise specified, special pipe bedding will not be required for steel or iron water pipe, and the trench bottom need not be shaped to the outside diameter of the pipe. However, the trench bottom shall provide firm and uniform bearing.

306-1.2.1.2 Bedding for Narrow Trenches. Narrow trenches are defined as 10 inches (250mm) or less in width. Bedding for narrow trenches shall be placed as specified in 306-1.2.1.1 except as modified herein.

Bedding for narrow trenches meeting the requirements of this subsection shall be specified by the owner of the installation. When bedding is specified by the owner, it shall be placed on firm and unyielding subgrade so as to support the pipe or cable for its full length. Bedding shall not be jetted unless specified by the owner of the installation.

When the Contractor is permitted to place the pipe or cable without bedding, it shall be placed on firm and unyielding subgrade.

These excavations shall be backfilled as specified per 306-1.3.4. The Contractor shall take all necessary precautions to prevent the pipe or substructure from floating when placing trench backfill slurry or CLSM.

306-1.2.1.3 Bedding for Plastic Pipe and Fittings. Plastic pipe and fittings, including but not limited to:

Pipe	Subsection
ABS Solid Wall Pipe	207-15
ABS or PVC Composite Pipe	207-16
PVC Solid Wall Pipe	207-17
Annular High-Density Polyethylene Pipe with Smooth Interior, Corrugated Exterior, with Bell-and-Spigot Joints (Type S)	207-18
PE Solid Wall Pipe	207-19
Centrifugally Cast Fiberglass Reinforced Plastic Mortar Pipe	207-20

shall be bedded as shown on the Plans and specified in the Special Provisions.

No internal or external bracing of the pipe shall be allowed during or after pipe placement, bedding or backfill.

The bedding zone shall begin 4 inches (100mm) below the pipe or bell, whichever is lower, and shall extend to a minimum of 12 inches (300mm) above the pipe or bell, whichever is higher. The bedding zone limits shall extend on each side of the pipe or bell shall be in accordance with Table 306-1.2.1.3 (A).

TABLE 306-1.2.1.3 (A)

Nominal Pipe Size inches (mm)	Side Clearance inches (mm)	
	Min.	Max.
Up to and including 15 (375)	8 (200)	12 (300)
Over 15 (375) to and including 30 (750)	12 (300)	18 (450)
Over 30 (750)	Per the Plans	

Bedding materials shall be placed and densified to the requirements shown on the Plans or specified in the Special Provisions. For ABS and PVC composite pipe, the bedding material shall conform to 306-1.2.1.1 (A). For all other pipe and fittings, the bedding material shall be crushed rock conforming to 200-1.2 and Table 306-1.2.1.3 (B) unless otherwise specified in the Special Provisions or shown on the Plans. No minimum relative compaction requirement shall apply to crushed rock. The crushed rock shall be placed by slicing, shovel-spading, or shovel rodding to insure complete filling of the haunch areas below the pipe.

TABLE 306-1.2.1.3 (B)

Nominal Pipe Size inches (mm)	Maximum Rock Gradation
Up to and Including 15 inches (375mm)	1/2 inch (12mm)
Over 15 Inches (375mm)	3/4 inch (19mm)

Bedding for fittings shall be portland cement concrete, Class 330-C-23(560-C-3250), conforming to 201-1.1.2.

306-1.2.2 Pipe Laying. Pipe will be inspected in the field before and after laying. If any cause for rejection is discovered in a pipe after it has been laid, it shall be subject to rejection. Any corrective work shall be approved by the Engineer and shall be at no cost to the Agency.

When connections are to be made to any existing pipe, conduit, or other appurtenances, the actual elevation or position of which cannot be determined without excavation, the Contractor shall excavate for, and expose, the existing improvement before laying any pipe or conduit. The Engineer shall be given the opportunity to inspect the existing pipe or conduit before connection is made. Any adjustments in line or grade which may be necessary to accomplish the intent of the Plans will be made, and the Contractor will be paid for any additional work resulting from such change in line or grade in the manner provided in 3-2.

Pipe shall be laid up-grade with the socket or collar ends of the pipe up-grade unless otherwise authorized by the Engineer.

Corrugated metal pipe shall be laid with external laps of the circumferential seams toward the inlet end. Corrugated pipe shall be shipped and handled in such a manner as to prevent damage to protective coatings.

When specified, circular corrugated steel pipe shall be elongated in the shop or in the field before backfilling. The pipe shall be vertically elongated from a true circle to provide an increase in the diameter of approximately 5 percent for the full length.

Installation of slotted corrugated steel pipe shall not be started until after paving of the traffic lanes adjacent to the pipe has been completed at the locations where the pipe is to be placed. The slot shall be covered with roofing paper or other approved covering during backfilling operations to prevent infiltration of material into the pipe.

Pipe shall be laid to Plan line and grade, with uniform bearing under the full length of the barrel of the pipe. Suitable excavation shall be made to receive the socket or collar, which shall not bear upon the subgrade or bedding. Any pipe which is not in true alignment or shows any undue settlement after laying shall be taken up and re-laid at the Contractor's expense.

Pipe sections shall be laid and jointed in such a manner that the offset of the inside of the pipe at any joint will be held to a minimum at the invert. The maximum offset at the invert of pipe shall be 1 percent of the inside diameter of the pipe or 3/8 inch (10mm), whichever is smaller.

In joining socket-and-spigot pipe, the spigot of each pipe shall be so seated in the socket of the adjacent pipe as to give a minimum of 3/8 inch (10mm) annular space all around the pipe in the socket. Unavailable offsets shall be distributed around the circumference of the pipe in such a manner that the minimum offset occurs at the invert.

When pipe is laid in a sheeted trench, all sheeting against which concrete cradle is to be placed shall be faced with at least one thickness of building paper and the sheeting shall be withdrawn without displacing or damaging the cradle, except as otherwise provided in 306-1.1.6.

After the joints have been made, the pipe shall not be disturbed in any manner.

At the close of work each day, or whenever the work ceases for any reason, the end of the pipe shall be securely closed unless otherwise permitted by the Engineer.

306-1.2.3 Field Jointing of Clay Pipe. Unless otherwise indicated on the Plans, any of the following joints may be used for sewers constructed of clay pipe:

a) **Type "D" Joints (Rubber-Sleeve Coupling with Shear Ring for Plain-End Clay Pipe).** Pipe joints shall be made with the couplings described in 208-2.2. Unless otherwise specified, pipe shall be delivered to the jobsite with the rubber sleeve and shear ring installed on one end of the pipe or fitting. Before installing compression bands, the surface of the rubber sleeve shall be thoroughly wetted with a silicone base lubricant. This lubricant shall not be injurious to the sleeve, stainless steel bands, or plastic shear ring. Joints installed on to pipe in the plant shall have compression bands torqued to 70 inch-pounds (8 N·m), minimum. When the joint is installed in the field, the plain end of the pipe to be joined shall be inserted into the sleeve and the compression bands torqued to 70 inch-pounds (8 N·m), minimum, and shall provide uniform tension. Type "D" Joints may be used on pipe on curves in accordance with Item c) below.

b) **Type "G" Joints (Polyurethane Compression).** Type "G" joints shall be made with pipe prepared as specified in 208-2.3.

   Prior to jointing, the matting surfaces shall be clean, and lubricated with a lubricant recommended by the pipe supplier. The pipe shall be joined spigot into socket and when jointing is completed shall be within the following joint space tolerance:

TABLE 306-1.2.3 (A)

Pipe Size inches (mm)	Joint Space Inches (mm)
15 - 18 (375 - 450)	5/8 (16)
21 - 42 (525 - 1050)	7/8 (22)

This joint space shall not be increased because of deflected joints on curve. Straight pipe with Type "G" joints is permitted for pipelines on curves in accordance with Item c) below.

c) **Straight Nonbeveled Pipe On Curves.** Straight nonbeveled pipe with Type "D" or "G" joints is permitted for pipelines on curves, provided the radius of curvature is not less than that shown in the following table. For radius of curvature less than that shown, beveled pipe or shorter lengths shall be provided.

TABLE 306-1.2.3 (B)

D Pipe Size inches (mm)	For Pipe Length ft (m)	Min. Radius of Curvature ft (m)	Max. Deflection Per Joint Degrees	Max. Deflection Per Length inches (mm)
6 to 12 (150 to 300)	5 (1.5)	120 (37)	2.4	2-1/2 (63)
	5-1/2 (1.7)	132 (40)	2.4	2-3/4 (70)
	6 (1.8)	144 (44)	2.4	3 (76)
15 to 24 (375 to 600)	5 (1.5)	160 (49)	1.8	1-7/8 (47)
	5-1/2 (1.7)	176 (54)	1.8	2-1/16 (52)
	6 (1.8)	192 (59)	1.8	2-1/4 (57)
	7-1/2 (2.3)	240 (73)	1.8	2-13/16 (71)
27 to 36 (675 to 900)	5 (1.5)	240 (73)	1.2	1-1/4 (31)
	5-1/2 (1.7)	264 (80)	1.2	1-3/8 (34)
	6 (1.8)	288 (88)	1.2	1-1/2 (38)
	7-1/2 (2.3)	360 (110)	1.2	1-7/8 (47)
39 to 42 (975 to 1050)	5 (1.5)	320 (97)	0.9	15/16 (23)
	5-1/2 (1.7)	352 (107)	0.9	1-1/16 (27)
	6 (1.8)	384 (117)	0.9	1-1/8 (28)

For pipe lengths not included above, use the following:

TABLE 306-1.2.3 (C)

D Pipe Size inches (mm)	Maximum Allowable Deflection Δd inches per ft (mm per m) of pipe	Equation for Minimum Radius of Curvature (L = Pipe Length)
6 to 12 (150 to 300)	1/2 (42)	r = 24L
15 to 24 (375 to 600)	3/8 (31)	r = 32L
27 to 36 (675 to 900)	1/4 (21)	r = 48L
39 to 42 (975 to 1050)	3/16 (16)	r = 64L

306-1.2.4 Installation, Field Jointing, and Inspection of Reinforced Concrete Pipe.

a) **General.** Circular concrete pipe with elliptical reinforcement shall be laid with the minor axis of the reinforcement cage in the vertical position. The minor axis shall be marked by the manufacturer with a 4 inch (100mm) high "T". Normally lay pipe with socket end up hill starting at the bottom of the line. Plastic lined reinforced concrete pipe shall be jointed and otherwise treated in accordance with this subsection and the applicable requirements of 311-1.

b) **Tongue-and-Groove (T&G) Self-Centering Joints.** All joints shall be cleaned with a wire brush and wetted before mortaring. All mortar shall conform to the applicable provisions of 201-5.1 for Class C mortar.

No mortaring of outside joints will be required except where concrete pipe is used on curves, unless otherwise specified.

Pipes used on curves shall have one or both ends beveled, or shall be pulled to provide a smooth curve. Pipes used on curves shall have one or both ends beveled, or shall be pulled to provide a smooth curve. If the extreme ends of the pipe do not overlap and the resulting clear space between the extreme ends does not exceed 1 inch (25mm) the space shall be filled with Class C mortar for the full thickness of the pipe wall. If the clear space between the extreme ends of the pipes is more than 1 inch (25mm) but less than 3 inches (75mm), a concrete cover is required for the joint using Class 520-C-2500 (310-C-17) concrete to a minimum depth of 6 inches (150mm) for a width of 15 inches (380mm) centered about the joint. Such concrete cover shall be placed from the bottom of the pipe to a point where the extreme ends of the pipe overlap. Sandbags or dirt sacks will be acceptable side forms. The inside of the joint shall be mortared as above. If the clear space between the extreme ends of the pipe is 3 inches (75mm) or greater but less than 6 inches (150mm) a concrete collar is required. If the clear space is 6 inches (150mm) or greater, a transition structure is required.

When pipe is under 24 inches (600mm) in diameter, the joints shall be made by filling the outer joint space with mortar.

When the pipe is 24 inches (600mm) or greater in diameter, the entire interior annular space of the joint shall be filled to its full depth to ensure a strong, level, and tight joint. The mortar shall be forced tightly into the joint, completing the joint with a level, smooth, troweled finish. The joint area shall then be wiped clean of excess mortar. The jointing procedure shall be as follows:

1) When the entire trench is to be jetted or flooded, no joints shall be mortared before the next two joints in advance are laid. However, the mortaring of joints shall be completed as specified herein before jetting is started.

2) When the entire trench is to be compacted mechanically, no interior joints shall be mortared until the compaction has been completed. The joint shall then be completed as specified herein.

3) Where the lower portion of the trench is to be jetted and the remainder mechanically compacted, the joints shall be mortared in two operations. Before jetting is started, the inside joints shall be filled to within approximately 1 inch (25mm) of the inside surface, the mortar being pressed into place to make a firm and tight joint.

After jetting and compaction have both been completed, the inside joints shall be cleaned and completed as specified herein.

4) For gravity sewer pipe, the top half of the outside joint shall be filled with mortar by means of troweling or wiping prior to placement of backfill, and the inside joints shall be completed as specified herein.

In all cases, the entire depth of the finished inside joint shall be filled with mortar in such a manner as to ensure a strong, watertight joint.

c) **Collar Joints.** Pipe with collar joints shall be laid with the collar end up-grade. The pipes shall be tightly butted together and uniform caulking space left between the pipe and the collar. When the entering pipe has been placed and checked for line and grade, the body of the pipe shall be backfilled with earth on both sides to hold the pipe firmly in place. The caulking space shall then be completely filled with stiff mortar tamped firmly in small increments by means of a caulking tool and hammer.

d) **Gasket-Type Joints for Reinforced Concrete Pipe.** The ends of the pipe shall be so formed that, when the pipes are laid together and joined, they shall make a continuous and uniform line of pipe with a smooth and regular surface.

Joints shall be watertight and flexible. Each joint shall contain a gasket per 208-3 or other material approved by the Engineer, which shall be the sole element responsible for water tightness of the joint. This gasket shall be a circular or profile-type cross section unless otherwise approved by the Engineer. The length and cross-sectional dimension of the gasket, the annular space provided for the gasket, and all other joint details shall be such as to produce a watertight joint. The slope of the longitudinal gasket contact surfaces of the joint with respect to the longitudinal axis of the pipe shall not exceed 2 degrees.

Under ordinary laying conditions, the work shall be scheduled so that the socket end of the pipe faces in the direction of laying.

For O-ring type gaskets, prior to placing the spigot into the socket of the pipe previously laid, the spigot groove, the gasket, and the first 2 inches (50mm) of the inside surface of the socket shall be thoroughly cleaned, then lubricated with a soft vegetable soap compound.

The gasket after lubrication shall be uniformly stretched when placing it in the spigot groove so that the gasket is distributed evenly around the circumference.

For pipe in which the inside joints are to be pointed, suitable spacers shall be placed against the inside shoulder of the socket to provide the proper space between abutting ends of the pipe.

For profile type gaskets, follow the requirements of the manufacturer for lubrication and assembly to provide a watertight joint.

Where steel joint rings are used, a suitable cloth, plastic, or paper band shall be placed around the outside of the pipe and centered over the joint to prevent dirt from entering the joint recess.

The joint band shall be bound to the pipe by the use of steel box strapping or by an equivalent method, and shall completely and snugly encase the outside joint except for an opening near the top where grout is to be poured into the joint recess. Grout shall be poured and allowed to set before densification of bedding and backfill materials by jetting or flooding methods. In any case, joints shall be grouted before backfill is placed over the top of the pipe. With the jointing band properly secured, the joint recess shall be moistened with water and then filled with Class "C" mortar. The mortar grout shall completely fill the outside annular space between the ends of the pipe and around the complete circumference. After the recess has been filled, the jointing band shall be replaced over the opening left for pouring and the mortar allowed to set. After the bedding and backfill have been densified, the inside joint recess shall first be moistened, then filled with stiff Class "C" mortar. The finished joint shall be smooth and flush with the adjacent pipe surfaces.

After the joint is assembled, a thin metal feeler gage shall be inserted between the socket and the spigot and the position of the gasket checked around the complete circumference of the pipe. If the gasket is not in the proper position, the pipe shall be withdrawn, the gasket checked to see that it is not cut or damaged, the pipe relayed, and the gasket position again checked.

e) **Field Inspection of Reinforced Concrete Pipe.** Installed pipe shall be inspected after completion of the backfill operation for:

1. Joint offset tolerances per 306-1.2.2.
2. Joints installed per this subsection.
3. Compliance with 207-2.8 or 207-3.2 for the respective pipe material except as modified below.

Unless otherwise specified, installed and backfilled pipe shall not exhibit cracks with widths in excess of those shown in Table 207-2.9.2 (A).

306-1.2.5 Field Jointing of Nonreinforced Concrete Pipe.

a) **Tongue-and-Groove Joints.** The groove end of pipe shall be buttered with a stiff mixture of Class "C" mortar prior to joining pipe. The pipe joint shall then be carefully wiped on the inside.

b) **Socket-and-Spigot Mortar Joints.** In making the joints, the entire annular space shall be completely and compactly filled with Class "C" mortar.

Mortar placed in the joint to assist in the assembling and centering of the pipe shall not be considered as filling that portion of the joint in which it is placed. The mortar shall be beveled on a 1-to-1 slope from the outer edge of the socket, and the interior of the pipe cleaned of surplus mortar or other foreign material.

When approved by the Engineer, a narrow gasket of oakum or lead may be caulked into each joint in wet trenches, after which the mortar shall be placed therein.

Interior joints in pipe shall be neatly wiped on the inside.

c) **Socket-and-Spigot Gasket Joints.** The outside of the spigot and the inside of the socket of the pipe shall be thoroughly cleaned prior to laying. The gasket and the socket interior shall be lubricated with a soft vegetable soap compound before the pipes are joined.

306-1.2.6 Field Jointing of Iron Pipe.

a) **General.** The type of joint to be used will be indicated on the Plans or in the Specifications. If not designated, the type of joint may be any of those listed below:

b) **Cement Joints.** A gasket of untarred jute or oakum twisted into a rope of about the same diameter as the joint space and thoroughly saturated with neat cement grout shall be well driven against the base of the socket. After placing this gasket, caulking cement shall be pushed into the socket with a steel caulking tool until the interior of the socket is completely filled and then it shall be thoroughly tamped with a caulking tool.

The joint shall then be beveled off from the outer edge of the socket to the sides of the pipe, special care being taken to obtain good work on the lower part of the joint.

The joints shall be protected from the sun immediately after they are caulked.

c) **Lead Joints.** A gasket of twisted or braided jute or oakum shall be driven tightly into the socket so that the lead, after having been poured and caulked, shall have a depth of at least 2 inches (50mm) in the socket. The socket shall be free from dirt, grease, and water, and the runner shall be firmly held in place before the lead is poured. The melting pot shall be kept near the joint to be poured and each joint shall be made at one pouring. Dross and slag shall not be allowed to accumulate in the melting pot ladles. After the joints have cooled sufficiently, they shall be properly caulked by hand or mechanical methods so as to secure a tight joint.

d) **Flanged Joints.** Flanged joints shall be firmly and fully bolted with machine bolts of proper size. Approved gaskets shall be used at all flanged joints.

e) **Mechanical Joints.** The outside of the spigot and the inside of the socket shall be thoroughly cleaned of foreign matter. The gland and gasket shall then be slipped on to the spigot end of the pipe. The gasket shall be pressed evenly into the socket only after the spigot is seated in the socket. The gland shall be brought up evenly by tightening alternately the nuts spaced 180 degrees apart.

f) **Slip-On Joint.** The gasket and gasket seal inside the socket shall be wiped clean before the gasket is inserted. A thin film of soft vegetable soap compound shall be applied to the gasket and the outside of the spigot end of the pipe. The spigot shall then be positioned inside the socket and shoved home. Lubricant other than that furnished with the pipe shall not be used unless approved by the Engineer.

306-1.2.7 Field Jointing of Corrugated Metal Pipe. Where metal pipe and/or couplings and metal pipe and/or couplings with metallic coatings are joined with dissimilar metals, the contact points shall be coated with asphalt mastic per 207-11.5.2. Pipe sections shall be laid in the trench with a maximum spacing between sections of 1-1/2 inches (38mm). Annular corrugated pipe shall be laid in the trench with outside laps or circumferential joints upgrade. The pipe coupling corrugations or projections shall properly engage the pipe sections before bolts are tightened. Care shall be taken to ensure that dirt or other particles do not get between the outside of pipe and the pipe coupling.

Aluminum pipe and aluminized steel pipe shall not be in contact with reinforcing steel or structural steel members. Aluminum pipe and aluminized steel pipe shall be coated with asphalt mastic coating per 207-11.5.2 where concrete or slurry backfill is required or where the pipe is to be embedded in concrete.

Paved inverts shall be placed and centered on the bottom of the trench. Any damage to the protective lining and coating shall be repaired prior to the backfilling around the pipe.

Watertight joints, when required by the Plans or the Special Provisions, shall conform to 207-11.2.2.

306-1.2.8 (Deleted).

306-1.2.9 Field Jointing of Solvent-Welded ABS and PVC Pipe. Solvent-welded jointing of ABS and PVC pipe shall be in accordance with the approved manufacturer's printed instructions which shall be furnished to the Engineer. Solvent cement shall be in accordance with 207-15.1 for ABS pipe and 207-17.3.3 for PVC pipe.

The spigot end shall be inserted to the proper depth of the socket as indicated by the home mark.

306-1.2.10 Jointing of Gasket-Type ABS, CHDPE and PVC Pipe. Jointing shall conform to the manufacturer's specifications which shall be submitted to the Engineer per 2-5.3. Gaskets shall conform to 208-4.

The spigot end shall be inserted to the proper depth of the socket as indicated by the "home mark." The home mark shall be shown as a circumferential line or by the words "home mark" on the outside of the pipe. The home mark shall be clearly and permanently indicated on the spigot end of the pipe at the factory.

306-1.2.11 Jointing of Injection-Sealed PVC Pipe. Jointing shall conform to the manufacturer's specifications which shall be submitted to the Engineer per 2-5.3.

The spigot end shall be inserted to the full depth of the socket as indicated by the "home mark" and driven into the locking taper as recommended by the manufacturer.

The ports in the socket end shall be positioned to allow observance of flow of the adhesive compound from the exhaust port. The adhesive compound shall be injected until air is no longer observed to bubble from the exhaust port. Escape of adhesive compound beyond the retainer ring shall be cause for rejection of the joint.

306-1.2.12 Maximum Allowable Deflection for Plastic Pipe and Fittings.

306-1.2.12.1 General. Pipe and fittings shall be tested to ensure that vertical deflections and measured diameter do not exceed the maximum allowable deflection. The maximum allowable deflection shall be:

a) Three percent of the maximum average ID for ABS or PVC Composite Pipe and fittings.

b) For pipe and fittings other than ABS or PVC Composite, the following percentage of the maximum average ID shall conform to Table 306-1.2.12.1 (A):

TABLE 306-1.2.12.1 (A)[2,3]

Nominal Pipe Size		Percentage Deflection Allowed[1]
Inches	Millimeters	
Up to and including 12	Up to and including 300	5.0
Over 12-to and including 30	Over 300 -to and including 750	4.0
Over 30-to and including 60	Over 750 -to and including 1500	3.0
Over 60-to and including 90	Over 1500-to and including 2250	2.5
Over 90-to and including 120	Over 2250-to and including 3000	2.0
Over 120	Over 3000	1.5

1. 30 days after Installation.
2. Deflections of up to 6.5 percent of the in-field measured diameter are acceptable for storm drain applications.
3. Deflection tests shall not be performed sooner than 30 days after completion of placement and compaction of backfill. The pipe and fittings shall be cleaned and inspected for offsets and obstructions prior to testing.

For solid wall flexible pipe and fittings, the maximum average ID shall be equal to the average OD minus 2 minimum wall thicknesses in accordance with the applicable ASTM(s). Manufacturing and other tolerances shall not be considered when determining maximum allowable deflections.

For CHDPE pipe and fittings, the ID for each lot (as defined in 207-18.5.1) shall be calculated by averaging the diameter at 8 equally spaced points around the circumference of a section of unloaded pipe. For storm drain applications, the mandrel size shall be 93.5 percent of the average ID calculated at the Work site. The Contractor shall be responsible for measuring, recording and providing the ID's to the Engineer prior to installation.

306-1.2.12.2 ID's 24 inches (600mm) or Smaller. A mandrel shall be pulled through the pipe by hand to ensure the maximum allowable deflection has not been exceeded. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

Any over-deflected pipe shall be uncovered and, if not damaged, reinstalled. Damaged pipe shall not be reinstalled, but shall be removed from the Work site. Any pipe subjected to any method or process other than removal, which attempts, even successfully, to reduce or cure any over deflection, shall be uncovered, removed from the worksite, and replaced with new pipe. The mandrel shall:

a) Be a rigid, nonadjustable, odd-numbered-leg (9 legs minimum) mandrel having an effective length not less than its nominal diameter.

b) Have a minimum diameter at any point along the full length conforming to Table 306-1.2.12.2 (A).

c) Be fabricated from steel and be fitted with pulling rings at each end.

d) Be stamped or engraved on a segment other than the runner, with the pipe material specification, nominal size, and mandrel OD (e.g. PVC D3034-200mm-187.10mm; ABS Composite D2680-250mm-243.43mm; PVC D3034-8"-7.366"; ABS Composite D2680-10"-9.584").

TABLE 306-1.2.12.2 (A)

Pipe Material	Nominal Size		Minimum Mandrel Diameter[1]	
	Inches	mm	Inches	mm
PVC-ASTM D3034 (SDR 26)	6	150	5.503	139.78
	8	200	7.366	187.10
	10	250	9.207	233.86
	12	300	10.961	278.41
	15	375	13.559	344.40
PVC-ASTM D3034 (SDR 35)	6	150	5.619	142.72
	8	200	7.524	191.11
	10	250	9.405	238.89
	12	300	11.191	284.25
	15	375	13.849	351.76
PVC-ASTM F679 (T-1 Wall)	18	450	16.924	429.87
	21	525	19.952	506.78
	24	600	22.446	570.13
	27	675	25.297	642.54
	30	750	28.502	723.95
ABS or PVC Composite Pipe ASTM D2680	6	150	5.636	143.15
	8	200	7.663	194.64
	10	250	9.584	243.43
	12	300	11.475	291.47
	15	375	14.356	364.64
CCFRPM ASTM D3262, 46 psi (318KPa)	12	300	11.820	300.23
	18	450	17.729	450.32
	20	500	19.661	499.39
	24	600	23.527	597.59
	30	750	29.229	742.42
	36	900	35.403	899.24

1. Metric mandrel diameters are direct conversions of mandrel diameters in U.S. Standard Measures. If the above types of pipe are available and specified by the appropriate ASTM in metric dimensions, as the primary measure, the Engineer will determine the appropriate mandrel diameter which conforms to this subsection.

Prior to use, the mandrel shall be certified by the Engineer or by another entity approved by the Engineer. Use of an uncertified mandrel or a mandrel altered or modified after certification will invalidate the test.

If the mandrel fails to pass through the pipe, the pipe will be deemed to be over-deflected.

306-1.2.12.3 ID's Greater Than 24 inches (600mm) to Less Than or Equal to 36 inches (900mm). Deflections shall be determined by a method submitted to the Engineer per 2-5.3. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

306-1.2.12.4 ID's Greater Than 36 inches (900mm). Deflections shall be determined by using a 1 inch (25mm) diameter, nonadjustable metal bar; a minimum-radius rigid template; or by a method approved by the Engineer. Fittings shall be visually inspected to ensure the maximum allowable deflection has not been exceeded.

306-1.2.12.5 Acceptance. Any over-deflected pipe shall be uncovered and, if not damaged, reinstalled. Damaged pipe shall not be reinstalled, but shall be removed from the Work site. Any pipe subjected to any method or process other than removal, which attempts, even successfully, to reduce or cure any over-deflection, shall be uncovered, removed from the Work site, and replaced with new pipe.

306-1.2.13 Installation of Plastic Pipe and Fittings. Plastic pipe and fittings shall be placed as shown on the Plans and specified in the Specifications. Plastic pipe bedding shall be bedded conformance with 306-1.2.1.3.

Connections of pipe and fittings to a manhole shall be watertight. The use of manhole water stops shall be approved by the Engineer. Water stops shall be installed in conformance with the manufacturer's recommendations. The manufacturer's recommendations shall be submitted to the Engineer per 2-5.3. Junctions connecting pipe or fitting to a pipe shall utilize a "wye" fitting. "Tee" connections will not be permitted. Pipe may be used on curves only if deflection fittings or couplings are used, or if solid wall pipe is bent without any application of heat. If deflection fittings or couplings are proposed for use on curves, the proposed alignment and method of joining shall be submitted to the Engineer per 2-5.3. Solid wall pipe proposed for use on curves shall be bent per the manufacturer's recommendations. The manufacturer's recommendations shall be submitted to the Engineer per 2-5.3. The minimum centerline radius to be achieved by bending solid wall pipe shall be based on the pipe diameter, dimension ratio (ratio of the OD to the minimum wall thickness) and the manufacturer's recommendations.

306-1.3 Backfill and Densification.

306-1.3.1 General. Backfill shall be placed as follows except as modified in 306-1.3.4. Backfill shall be considered as starting at the top of the bedding zone. For concrete encasement the backfill shall be considered as starting at the top of the concrete encasement.

Backfill or fill shall start at the subgrade for cast-in-place structures such as, but not limited to, manholes, transition structures, junction structures, vaults, valve boxes, and reinforced concrete box conduits

Backfill, except that within State Highway, shall be placed as specified in 306-1.3.2 and 306-1.3.3. Compaction requirements shall be in accordance with 306-1.3.5.

When the depth of cover of the top pipe or cable is less than 30 inches (760mm), the top 24 inches (600mm) of backfill, measured from the surface, shall be compacted to 90 percent relative compaction.

Except where the pipe must remain exposed for force main leakage test and subject to the provisions herein, the Contractor shall proceed with backfilling operations as soon as possible. Care shall be exercised so that the pipe will not be damaged or displaced. If the pipe is supported by concrete bedding that does not cover the pipe, the remainder of any bedding material shall be placed to 1 foot (0.3m) over the top of the pipe. The backfill above the concrete bedding shall not be placed nor sheeting pulled until concrete bedding has been cured per 201-1.

The Contractor may place fill or backfill against or over the top of any cast-in-place structure in accordance with Table 306-1.3.1 (A), unless otherwise specified or approved by the Engineer.

TABLE 306-1.3.1 (A)

Operation	Location	
	Against Sides of Structures (Days)	Over Top of Structure (Days)
Placement of Loose Backfill	5	21
Densification of Backfill	7	28[1]

1. Or 100 percent of the specified compressive strength.

Rocks greater than 6 inches (150mm) in any dimension will not be permitted in backfill placed between 1 foot (0.3m) above the top of any pipe or box and 1 foot (0.3m) below pavement subgrade.

When the trench is wider than 3 feet (0.9m), rocks not exceeding 12 inches (300mm) in greatest dimension, which originate from the trench, will be permitted in the backfill from 1 foot (0.3m) above the top of any pipe or box to 5 feet (1.5m) below the finished surface.

Rocks greater than 2-1/2 inches (60mm) in any dimension will not be permitted in backfill placed within 1 foot (0.3m) of pavement subgrade.

Where rocks are included in the backfill, they shall be mixed with suitable excavated materials to eliminate voids.

Subject to the provisions specified herein, the material obtained from project excavations may be used as backfill provided that all organic material, rubbish, debris, and other objectionable materials are first removed. However, broken portland cement concrete and bituminous-type pavement obtained form the project excavations will be permitted in the backfill subject to the same limitations as rocks.

Where it becomes necessary to excavate beyond the limits of normal excavation lines in order to remove boulders or other interfering objects, the voids remaining after the removal of the boulders shall be backfilled with suitable material and densified as approved by the Engineer.

The removal of all boulders or other interfering objects and the backfilling of voids left by such removals shall be at the expense of the Contractor and no direct payment for the cost of such work will be made. The cost of such work shall be included in the prices in the Bid for the various items of work.

Voids left by the removal of sheeting, piles and similar sheeting supports shall be immediately backfilled with clean sand which shall be jetted or vibrated into place to ensure dense and complete filling of the voids.

Densification shall proceed as soon as possible.

If the Engineer determines that it is not practical to attain the required compaction by mechanical methods, or jetting, such as in areas around utilities, vaults, or other structures, trench backfill slurry per Table 201-1.1.2 (A) will be required.

306-1.3.2 Mechanically Compacted Backfill. Backfill shall be mechanically compacted by means of tamping, sheepsfoot, pneumatic tire, or vibrating rollers, or other mechanical tampers. All such equipment shall be of size and type approved by the Engineer. Impact-type pavement breakers (stompers) shall not be permitted over or adjacent to pipe, duct, or cable, unless permitted by the Engineer.

Permission to use specific compaction equipment shall not relieve the contractor from responsibility to ensure that the use of such equipment will not result in damage to adjacent ground, existing improvements, or improvements installed under the Contract. The Contractor shall make its own determination in this regard.

Mechanically compacted backfill shall be placed in horizontal layers of thickness compatible to the material being placed and the type of equipment being used. Each layer shall be evenly spread, moistened (or dried, if necessary), and then tamped or rolled until the specified relative compaction has been attained.

Unless otherwise approved by the Engineer, material for mechanically compacted backfill shall be placed in lifts which, prior to compaction, shall not exceed the thickness specified below for the various types of equipment:

a) Impact, free fall, or "stomping" equipment- maximum lift thickness of 24 inches (0.6m)

b) Vibratory equipment, including vibratory plates on backhoe dipsticks, vibratory smooth-wheel rollers, and vibratory pneumatic-tired rollers - maximum lift thickness of 18 inches (0.5m).

c) Rolling equipment, including sheepsfoot (both vibratory and nonvibratory), grid, smooth-wheel (nonvibratory), grid, smooth wheel (nonvibratory), and segmented wheels - maximum lift thickness of 8 inches (0.2m).

d) Hand-directed mechanical compactors such as vibratory plates or tamper - maximum lift thickness of 4 inches (100mm).

306-1.3.3 Jetted Backfill. Backfill to be densified by water shall be jetted. Jetting will be permitted only if the soils of the trench walls have a minimum sand equivalent of 15. Jetting shall be accomplished by the use of a jet pipe to which a hose is attached, carrying a continuous supply of water under pressure.

Backfill shall be jetted in accordance with the following requirements:

a) The jet pipe shall consist of a minimum 1-1/2-inch (38mm) diameter pipe to which a minimum 2-inch (50mm) diameter hose is attached at the upper end. The jet shall be of sufficient length to project to within 2 feet (0.6m) of the bottom of the lift being densified.

b) The Contractor shall jet to within 2 feet (0.6m) of the bottom of the lift and apply water in a manner, quantity and at a rate sufficient to thoroughly saturate the thickness of the lift being densified. The jet pipe shall not be moved until the backfill has collapsed and the water has been forced to the surface.

c) The lift of backfill shall not exceed that which can be readily densified by jetting, but in no case shall the undensified lift exceed 15 feet (4.5m).

d) Suitable backfill material to be jetted shall have a sand equivalent of 15 or greater.

e) Where the nature of the material excavated from the trench is generally unsuitable for densification with water, the Contractor may, at no cost to the Agency, import from an approved source suitable material for jetting or densify the excavated material by other methods as approved by the Engineer. The backfill shall be allowed to thoroughly drain until the surface of the backfill is in a firm and unyielding condition prior to commencement of any subsequent improvements. The Engineer may require the Contractor, at the Contractor's expense, to dig a sump and provide a pump to remove any accumulated water.

f) The Contractor shall make its own determination that jetting will not result in damage to adjacent structures or facilities. Any resulting damage shall be repaired at the Contractor's expense.

g) The Contractor shall have available a continuous supply of water at a minimum pressure of 40 psi (275 kPa) gage. If a water truck is used to supply water, it shall have a pump capable of supplying water at 40 psi (275 kPa) gage and shall have the capacity to jet the trench without refill.

h) After jetting trench backfill, the Contractor shall prepare the top of the backfill to comply with 306-1.3.5 and to provide a firm and unyielding subgrade conforming to 301-1. Jetting maybe supplemented with mechanical methods.

306-1.3.4 Backfilling Narrow Trenches. Narrow trenches are defined as 10 inches (250mm) or less in width. Backfill for narrow trenches shall be placed as specified in 306-1.3.1 except as modified herein. Narrow trenches shall be backfilled by the use of trench backfill slurry per 201-1 or CLSM per 201-6, unless otherwise approved by the Engineer.

When narrow trenches are backfilled using trench backfill slurry or CLSM, the Contractor may place the material in a single lift using vibrators for consolidation. The Contractor shall take all necessary precautions to prevent the pipe or substructure from floating or becoming displaced. The top of the trench backfill slurry or CLSM shall be placed flush with top of the pavement when steel plates are not placed over narrow trenches. The trench backfill slurry or CLSM shall be cut back to a minimum of 1 inch (25mm) but no greater than 8 inches (200mm) below the existing pavement prior to placing permanent paving. For trenches 6 inches (150mm) or less in width, the compacted thickness of asphalt concrete shall be 3 inches (75mm).

Backfill to be mechanically compacted in narrow trenches shall be placed per 306-1.3.1 and 306-1.3.2, except as modified herein. Backfill shall not have any rocks greater in any dimension, than 1/4 the width of the trench. Mechanically compacted backfill shall meet the relative compaction requirements of 306-1.3.6. In place density for narrow trenches shall be determined in accordance with ASTM D2937 or by a method approved by Engineer.

306-1.3.5 Jetted Bedding and Backfill Compaction Requirements. Except as specified otherwise, trench bedding and backfill densified thru jetting shall be densified to the following minimum relative compaction:

a) 85 percent relative compaction:
   1) From the bottom of the trench to the beginning of the upper 3 feet (0.9m), measured from the pavement surface (or finish grade where there is no pavement) within native material or unengineered embankments.
   2) Outside the traveled way, shoulders, and under sidewalks, in the upper 3 feet (0.9m), measured from the pavement surface (or finish grade where there is no pavement).
   3) Under sidewalks.

b) 90 percent relative compaction:
   1) In the upper 3 feet (0.9m), measured from the pavement surface (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, and other paved areas (or areas to receive pavement).
   2) Within engineered embankments.
   3) Where lateral support is required for existing or proposed structures.
   4) 95 percent relative compaction where required by 301-1.3.

306-1.3.6 Mechanical Compaction Requirements. Except as specified otherwise, mechanically compacted trench backfill shall be densified to the following minimum relative compaction:

a) 85 percent relative compaction:
   1) In the bedding zone.
   2) Outside the traveled way and other paved areas (or areas to receive pavement).
   3) Under Sidewalks.

b) 90 percent relative compaction:
   1) In the upper 3 feet (0.9m) measured from the pavement surface (or finish grade where there is no pavement), within the existing or future traveled way, shoulders, and other paved areas (or areas to receive pavement).
   2) Within engineered embankments.
   3) Where lateral support is required for existing or proposed structures.

c) 95 percent Relative Compaction where required by 301-1.3.

306-1.3.7 Imported Backfill. If the Contractor elects to import material from a source outside the project limits for use as backfill, said materials shall be clean soil, free from organic material, trash, debris, rubbish, broken portland cement concrete, bituminous materials, or other objectionable substances.

Whenever the Contractor elects to use imported material for backfill, it shall deliver, not less than 10 days prior to intended use, a sample of the material to the Engineer. The sample shall have a minimum dry weight of 100 pounds (45 kg) and shall be clearly identified as to source, including street address and community of origin. The Engineer will determine the suitability, the minimum relative compaction to be attained, and the placement method.

Should the imported material not be substantially the same as the approved sample, it shall not be used for backfill and shall be removed from the Work site at the Contractor's expense.

The densification method for imported material authorized by the Engineer will be dependent upon its composition, the composition of the in-place soil at the point of placement, and the relative compaction to be obtained.

306-1.3.8 Transported Backfill. The Contractor may transport or back-haul material to be used as backfill material from any portion or line of the Work to any other portion or line of the Work. Such transported material shall be clean soil, free from organic material, trash, debris, rubbish, or other objectionable substances except that broken portland cement concrete or bituminous type paving as specified in 306-1.3.1 may be included.

306-1.4 Testing Pipelines.

306-1.4.1 General. All leakage tests and all post-installation closed circuit television (CCTV) inspections shall be completed and approved prior to placing of permanent resurfacing.

When leakage or infiltration exceeds the amount allowed by the Specifications, the Contractor at its expense shall locate the leaks and make the necessary repairs or replacements in accordance with the Specifications to reduce the leakage or infiltration to the specified limits. Any individually detectable leaks shall be repaired, regardless of the results of the tests. Leakage tests shall be made on completed pipelines as follows:

a) Storm Drains - Not required unless called for on the Plans or in the Special Provisions.

b) Gravity Sanitary Sewers 24 inches (600mm) or less in diameter where difference in elevation between inverts of adjacent manholes is 10 feet (3m) or less - Water exfiltration test or water infiltration test as directed. The Engineer may allow substitution of an air pressure test for the water exfiltration test.

c) Gravity Sanitary Sewers 24 inches (600mm) or less in diameter where difference in elevation between inverts of adjacent manholes is greater than 10 feet (3m) - Air pressure test or water infiltration test as directed.

d) Gravity Sanitary Sewers 24 inches (600mm) or greater in diameter - Air pressure test or water infiltration test as directed.

e) Gravity Sanitary Sewers which are in service and a bypass system is not available - the Contractor shall perform post-installation CCTV inspection per 500-1.1.5 and payment shall be per 500-1.1.9.

f) Pressure Sanitary Sewers (force mains) - Water pressure test at 120 percent of maximum operating pressure.

g) Water Pipelines - Water pressure test: Pipe specified by pressure classification, 50 psi (350 kPa) over pressure classification. Other type of pipe, 120 percent of maximum operating pressure.

306-1.4.2 Water Exfiltration Test. Each section of sewer shall be tested between successive manholes by closing the lower end of the sewer to be tested and the inlet sewer of the upper manhole with stoppers. The pipe and manhole shall be filled with water to a point 4 feet (1.2m) above the invert of the sewer at the center of the upper manhole; or if groundwater is present, 4 feet (1.2m) above the average adjacent groundwater level.

The allowable leakage will be computed by the formulae:

$E_{US} = 0.0001\ LD\ \sqrt{H}$ for mortared joints.

($E_{SI} = 0.00009\ LD\ \sqrt{H}$ for mortared joints)

$E_{US} = 0.00002\ LD\ \sqrt{H}$ for all other joints.

($E_{SI} = 0.000018\ LD\ \sqrt{H}$ for all other joints.)

Where:

L = length of sewer and house connections tested, in feet (meters).

E_{US} (E_{SI}) = the allowable leakage in gallons (liters) per minute of sewer tested.

D = the internal diameter of the pipe in inches (millimeters).

H = is the difference in elevation feet (meters) between the water surface in the upper manhole and the invert of the pipe at the lower manhole; or if groundwater is present above the invert of the pipe in the lower manhole, the difference in elevation between the water surface in the upper manhole and the groundwater at the lower manhole.

The Contractor shall, at its expense, furnish all water, materials and labor for making the required test. All tests shall be made in the presence of the Engineer.

306-1.4.3 Water Infiltration Test. If, in the opinion of the Engineer, excessive groundwater is encountered in the construction of a section of the sewer, the exfiltration test for leakage shall not be used.

The end of the sewer at the upper structure shall be closed sufficiently to prevent the entrance of water, and pumping of groundwater shall be discontinued for at least 3 days, after which the section shall be tested for infiltration.

The infiltration into each individual reach of sewer between adjoining manholes shall not exceed that allowed by the formula in 306-1.4.2 where H is the difference in the elevation in feet (meters) between the groundwater surface and the invert of the sewer at the downstream manhole.

Unless otherwise specified, infiltration will be measured by the Engineer using measuring devices furnished by the Agency.

306-1.4.4 Air Pressure Test. The Contractor shall, at its expense, furnish all materials, equipment, and labor for making an air test. Air test equipment shall be approved by the Engineer unless otherwise provided on the Plans or in the Special Provisions.

The Contractor may conduct an initial air test of the sewer mainline after densification of the backfill, but prior to installation of the house connection sewers. Such tests will be considered to be for the Contractor's convenience and need not be performed in the presence of the Engineer.

Each section of sewer shall be tested between successive manholes by plugging and bracing all openings in the sewer mainline and the upper ends of all house connection sewers. Prior to any air pressure testing, all pipe plugs shall be checked with a soap solution to detect any air leakage. If any leaks are found, the air pressure shall be released, the leaks eliminated, and the test procedure started over again. The Contractor has the option of wetting the interior of the pipe prior to the test.

The final leakage test of the sewer mainline and branching house connection sewers, shall be conducted in the presence of the Engineer in the following manner:

Air shall be introduced into the pipeline until 3.0 psi (20 kPa) gage pressure has been reached, at which time the flow of air shall be reduced and the internal air pressure shall be maintained between 2.5 and 3.5 psi (17 kPa and 24 kPa) gage pressure for at least 2 minutes to allow the air temperature to come to equilibrium with the temperature of the pipe walls. Pressure in the pipeline shall be constantly monitored by a gage and hose arrangement separate from hose used to introduce air into the line. Pressure in the pipeline shall not be allowed to exceed 5 psi (34 kPa) gage pressure.

After the temperature has stabilized and no air leaks at the plugs have been found, the air pressure shall be permitted to drop and, when the internal pressure has reached 2.5 psi (17 kPa) gage pressure, a stopwatch or sweep-second-hand watch shall be used to determine the time lapse required for the air pressure to drop to 1.5 psi (10 kPa) gage pressure.

If the time lapse (in seconds) required for the air pressure to decrease from 2.5 to 1.5 psi (17kPa to 10kPa) gage pressure exceeds that shown in Table 306-1.4.4 (A), the pipe shall be presumed to be within acceptance limits for leakage.

If the time lapse is less than that shown in the table, the Contractor shall make the necessary corrections to reduce the leakage to acceptance limits.

TABLE 306-1.4.4 (A)

Time in Seconds for Pressure to Drop from 2.5 to 1.5 psi (17kPa to 10 kPa) Gage Pressure

Main Line		4 inch (100mm) House Connection					Main Line		6 inch (150mm) House Connection				
Nominal Diameter inches (mm)	Length ft (m)	House Connection Length					Nominal Diameter inches (mm)	Length ft (m)	House Connection Length				
		0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)			0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)
8 (200)	0 (0)	0	20	40	50	70	8 (200)	0 (0)	0	40	80	100	100
	50 (15)	40	50	70	90	80		50 (15)	40	70	110	110	110
	100 (30)	70	90	100	100	90		100 (30)	70	110	120	110	110
	150 (45)	110	120	110	100	100		150 (45)	110	120	120	120	110
	200 (60)	140	120	110	110	100		200 (60)	140	130	120	120	120
	300 (90)	140	130	120	110	110		300 (90)	140	130	120	120	120
	400 (120)	140	130	120	120	110		400 (120)	140	130	130	120	120
250 (10)	15 (50)	50	70	90	100	90	250 (10)	15 (50)	50	90	120	120	110
	30 (100)	110	130	120	110	110		30 (100)	110	140	130	130	120
	60 (200)	170	150	140	130	120		60 (200)	170	150	140	140	130
	90 (300)	170	160	150	140	130		90 (300)	170	160	150	140	140
	120 (400)	170	160	150	150	140		120 (400)	170	160	150	150	140
300 (12)	15 (50)	80	100	110	110	110	300 (12)	15 (50)	80	120	140	130	120
	30 (100)	160	170	150	140	130		30 (100)	160	170	150	140	140
	60 (200)	200	180	170	160	150		60 (200)	200	180	170	160	150
	90 (300)	200	190	180	170	160		90 (300)	200	190	180	170	160
	120 (400)	200	190	180	180	170		120 (400)	200	190	180	180	170

TABLE 306-1.4.4 (A) *(Continued)*

Main Line		4 inch (100mm) House Connection					Main Line		6 inch (150mm) House Connection				
Nominal Diameter inches (mm)	Length ft (m)	House Connection Length					Nominal Diameter inches (mm)	Length ft (m)	House Connection Length				
		0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)			0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)
375 (15)	15 (50)	120	140	160	140	130	375 (15)	15 (50)	120	160	160	150	140
	30 (100)	250	220	190	170	160		30 (100)	250	210	190	170	160
	60 (200)	260	230	220	200	190		60 (200)	260	230	210	200	190
	90 (300)	260	240	230	220	210		90 (300)	260	240	220	210	200
	120 (400)	260	240	230	220	220		120 (400)	260	240	230	220	210
450 (18)	15 (50)	180	200	190	170	150	450 (18)	15 (50)	180	220	190	170	160
	30 (100)	310	260	230	210	190		30 (100)	310	260	220	200	190
	60 (200)	310	280	260	250	230		60 (200)	310	280	260	240	220
	90 (300)	310	290	280	260	250		90 (300)	310	290	270	260	240
	120 (400)	310	290	280	270	260		120 (400)	310	290	280	270	260
525 (21)	15 (50)	240	260	230	200	180	525 (21)	15 (50)	240	260	220	200	180
	30 (100)	360	310	280	250	230		30 (100)	360	300	260	240	200
	60 (200)	360	330	310	290	280		60 (200)	360	330	300	280	260
	90 (300)	360	340	320	310	300		90 (300)	360	330	320	300	290
	120 (400)	360	340	330	320	310		120 (400)	360	340	330	310	300
600 (24)	15 (50)	320	320	270	240	210	600 (24)	15 (50)	320	310	260	220	200
	30 (100)	410	360	320	290	270		30 (100)	410	350	310	280	260
	60 (200)	410	380	360	340	320		60 (200)	410	370	350	320	310
	90 (300)	410	390	370	360	350		90 (300)	410	380	360	350	330
	120 (400)	410	390	380	370	360		120 (400)	410	390	370	360	350
675 (27)	15 (50)	400	370	310	280	250	675 (27)	15 (50)	400	350	290	260	230
	30 (100)	460	410	370	340	310		30 (100)	460	390	350	320	290
	60 (200)	460	430	410	390	370		60 (200)	460	420	390	370	350
	90 (300)	460	440	420	410	390		90 (300)	460	430	410	390	380
	120 (400)	460	450	430	420	410		120 (400)	460	440	420	410	390
750 (30)	15 (50)	490	420	360	310	280	750 (30)	15 (50)	480	490	330	290	260
	30 (100)	510	460	420	380	360		30 (100)	510	440	390	360	330
	60 (200)	510	480	460	440	420		60 (200)	510	470	440	420	390
	90 (300)	510	490	470	460	440		90 (300)	510	480	460	440	420
	120 (400)	510	500	480	470	460		120 (400)	510	490	470	460	440
825 (33)	15 (50)	560	460	400	350	320	825 (33)	15 (50)	560	440	370	320	290
	30 (100)	560	510	460	430	400		30 (100)	560	490	440	400	370
	60 (200)	560	530	510	490	460		60 (200)	560	520	490	460	440
	90 (300)	560	540	520	510	490		90 (300)	560	530	510	490	470
	120 (400)	560	550	530	520	510		120 (400)	560	540	520	510	490
900 (36)	15 (50)	610	510	440	390	360	900 (36)	15 (50)	610	480	410	360	320
	30 (100)	610	560	510	480	440		30 (100)	610	540	480	440	410
	60 (200)	610	580	560	530	510		60 (200)	610	570	540	510	480
	90 (300)	610	600	580	560	540		90 (300)	610	590	560	540	520
	120 (400)	610	600	580	570	560		120 (400)	610	590	570	560	540

TABLE 306-1.4.4 (A) *(Continued)*

Main Line		4 inch (100mm) House Connection					Main Line		6 Inch (150mm) House Connection				
Nominal Diameter inches (mm)	Length ft (m)	House Connection Length					Nominal Diameter Inches (mm)	Length ft (m)	House Connection Length				
		0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)			0 ft (0m)	100 ft (30m)	200 ft (60m)	300 ft (90m)	400 ft (120m)
975 (39)	15 (50)	660	560	490	440	390	975 (39)	15 (50)	660	530	450	390	350
	30 (100)	660	610	560	520	490		30 (100)	660	590	530	480	450
	60 (200)	660	630	610	580	560		60 (200)	660	620	590	560	530
	90 (300)	660	640	620	610	590		90 (300)	660	640	610	590	570
	120 (400)	660	650	630	620	610		120 (400)	660	640	620	610	590
1050 (42)	15 (50)	710	610	540	480	430	1050 (42)	15 (50)	710	580	490	430	390
	30 (100)	710	660	610	570	540		30 (100)	710	640	580	530	490
	60 (200)	710	680	660	630	610		60 (200)	710	670	640	610	580
	90 (300)	710	690	680	660	640		90 (300)	710	690	660	640	620
	120 (400)	710	700	680	670	660		120 (400)	710	690	670	650	640

306-1.4.5 Water Pressure Test. Preparatory to testing, the section of the pipeline to be tested shall be filled with water and placed under a slight pressure for at least 48 hours. The pipeline shall then be brought up to the test pressure specified and maintained on the section under test for a period of not less than 4 hours.

Accurate means shall be provided for measuring the quantity of water required to maintain full pressure on the line for the test period, which volume shall not exceed:

For U.S. Standard Measures:

$$L_{US} = \frac{CND\sqrt{P}}{1{,}850}$$

For SI Units:

$$L_{SI} = \frac{CND\sqrt{P}}{32{,}600}$$

Where:

L_{US} (L_{SI}) = Maximum allowable leakage in gallons (liters) per hour for section of pipeline tested.
N = Number of joints in length tested.
D = Diameter of pipe in inches (mm).
P = Test pressure in psi (kPa).
C = 1.0 for reinforced concrete pressure pipe with rubber joints, cylinder type.
C = 3.0 for reinforced concrete pressure pipe with rubber joints, non-cylinder type.
C = 0.50 for cast iron pipe with mechanical or rubber gasket joints.
C = 1.0 for other type of cast iron joints (caulked and other types of pipe.)

No leakage is allowed for welded steel pipe with welded joints.

306-1.4.6 Leakage Test for Corrugated Metal Pipelines. After the pipe has been laid and assembled, and when required, the pipeline shall be filled with water to a hydrostatic pressure head of 10 feet (3m) above the point in the line to be tested.

A hydrostatic test shall be conducted for a period of not less than 24 hours, during which time an accurate measure of the water required to maintain the test pressure shall be made. Any leakage

developed by the test shall not exceed 0.60 gallon per inch (90mL per mm) of inside diameter per 100 feet (30m) of pipe per hour. Any leakage in excess of this amount shall be stopped in a manner satisfactory to the Engineer, and the test repeated until the total leakage does not exceed the amount specified. All obvious leaks shall be stopped in a manner satisfactory to the Engineer, whether or not the leakage from the line exceeds that permitted herein.

306-1.5 Trench Resurfacing.

306-1.5.1 Temporary Resurfacing. Unless permanent pavement is placed immediately, temporary bituminous resurfacing 2 inches (50mm) thick shall be placed and maintained at locations determined by the Engineer wherever excavation is made through pavement, sidewalk or driveways. In sidewalk areas the temporary bituminous resurfacing shall be at least 1 inch (25mm) thick; in all other areas it shall be at least 2 inches (50mm) thick. At major intersections and other critical locations, a greater thickness may be ordered. Temporary resurfacing shall be placed as soon as the condition of the backfill is suitable to receive it and shall remain in place until the condition of the backfill is suitable for permanent resurfacing.

The bituminous mixture used for temporary trench resurfacing shall conform to Class D2 asphalt concrete mixture in 203-6.4.3; and bitumen conforming to grade SC-800 liquid asphalt in the Slow Curing Product table, 203-2.4.

The mixture may be furnished from stockpiles or directly from the plant and may be laid cold, at the option of the Contractor. Prior to placing temporary resurfacing, the Contractor shall level and compact the backfill on which the surfacing is to be placed. The grade of the backfill on which the resurfacing is to be placed shall be such as to provide the full thickness of temporary resurfacing specified. The temporary resurfacing shall be placed, rolled, maintained, and removed and disposed of by the Contractor.

On improvements being constructed under contract with the Agency, the Proposal will contain a Bid item for an estimated number of tons (tonnes) of temporary bituminous resurfacing materials. The Contract Unit Price per ton (tonne) shall include full compensation for furnishing, placing, maintaining, removing, and disposing of such temporary resurfacing materials.

Payment will be limited to that quantity of material ordered placed by the Engineer and shall include material used to maintain the temporary resurfacing until the permanent resurfacing is placed. Material which is placed by the Contractor for its convenience shall be at no cost to the Agency.

306-1.5.2 Permanent Resurfacing. Unless otherwise shown on the Plans, Permit or in the Special Provisions, all surface improvements damaged or removed as a result of the Contractor's operations shall be reconstructed by the Contractor to the same dimensions, except for the pavement thickness, and with the same type of materials used in the original work. Trench and excavation resurfacing shall be 1 inch (25mm) greater in thickness than existing pavement.

Subgrade for trench resurfacing shall conform to 301 and the pavement reconstruction shall comply with the applicable provisions of 302. Asphalt concrete pavement shall also comply with 306-1.5.3. Aggregate base, when encountered within the structural section area, shall be compacted to a minimum density of 95 percent and compacted in lifts per 301-2.2. The thickness of aggregate base shall be equal to that existing adjacent to the excavation.

306-1.5.3 Placement of Permanent Repair Hot Mixed Asphalt Concrete. The asphalt concrete shall be placed in compacted lifts per Table 306-1.5.3.

TABLE 306-1.5.3

Compaction Equipment	Maximum Compacted Thickness inches (mm)
Vibratory Plate	1-1/2 (38)
Pneumatic Plate	2 (50)
Vibratory Rammers	2 (50)
Steel Wheel Roller*	2-1/2 (63)
Vibratory Roller*	3 (75)
Pneumatic Tired Rollers	Not Permitted

* Rollers must fit entirely within the trench.

After placement of the backfill and/or aggregate base, the sides of the excavation shall be cleaned prior to the application of an asphalt tack coat. The tack coat may be an emulsified asphalt conforming to 203-3 or a paving asphalt conforming to 203-1. This tack coat when cured or cooled shall be of sufficient thickness to uniformly cover all vertical surfaces of the existing asphalt concrete. An extra heavy application of the tack to the vertical edges will not be cause for rejection. Excess tack on the horizontal surface of the aggregate base or subgrade shall be spread uniformly over the surface and may require the application of a blotting sand to prevent bleed through. Areas that are not sufficiently coated shall have the tack reapplied. Care must be exercised by the Contractor to insure that the tack coat is not damaged during the placement of the asphalt concrete.

306-1.5.4 Base Course for Asphalt Concrete Placement The base course shall be a B or C gradation and shall be placed by either a spreader box, paving machine or "shoe" attachment.

For trenches less than 3 feet (1m) wide and individual excavations or bore holes having an area of less than 50 square feet ($5m^2$), the base course pavement shall be placed in such a manner as to obtain the specified density and smoothness.

The compacted surface shall not deviate from the planned base course elevation by more than 1/4 inch (6mm).

306-1.5.5 Finish Course for Asphalt Concrete Placement. The finish course shall be a C or D gradation. For trenches 8 feet (2.5m) or greater in width, the final lift of asphalt concrete shall be placed with a paving machine or a full width spreader box. When the total tonnage required for the final lift of asphalt concrete on the Work is greater than 110 tons (100 tonnes), a paving machine shall be used.

For trench widths 3 feet (1m) or greater and less than 8 feet (2.5m), the final lift shall be placed with a narrow paving machine or a spreader box when the total tonnage required for the final lift of asphalt concrete on the Work is greater than 17 tons (15 tonnes).

For trenches less than 3 feet (1m) wide and individual excavations or bore holes having an area of less than 50 ft^2 ($5m^2$), the final lift shall be placed in such a manner as to obtain the specified density and smoothness.

306-1.5.6 Density and Smoothness. For trench width 3 feet (1m) or greater, the Contractor shall compact all lifts with a self propelled steel wheeled roller meeting the PLI (N/mm) requirement specified in 302-5.6.

For trench widths less than 3 feet (1m) wide, the Contractor shall compact all lifts by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The PLI (N/mm) requirements of 302-5.6 shall not apply except for the final lift. The final lift shall be compacted using a steel wheel roller meeting the N/mm (PLI) requirements of 302-5.6.

For individual excavations or bore holes having an area of less than 50 square feet ($5m^2$), the Contractor shall compact all lifts by steel wheel rollers, vibratory plates, or rammers of such width to fit within the sides of the excavation. The PLI (N/mm) requirements of 302-5.6 shall not apply.

Pneumatic tire rollers or truck tires shall not be allowed on any of the lifts.

Trenches of any width backfilled with CLSM or trench backfill slurry will not require aggregate base. Asphalt concrete shall be replaced to the full depth of existing asphalt concrete plus 1 inch (25mm), except for trenches specified in 306-1.3.4.

For trench widths 3 feet (1m) or greater, the compaction temperatures of the asphalt concrete mat shall be per 302-5.6. For trench width less than 3 feet (1m), the compaction of the asphalt concrete mat shall be initiated before the material cools to less than 200°F (94°C).

The minimum compaction after rolling shall be 95 percent of the density obtained in accordance with the methods specified in 302-5.6.2. When the density is determined by a core sample, it shall be based on a full depth sample, as specified in 302-5.6.2.

The final pavement surface for trenches wider than 3 feet (1m) and parallel to the centerline of the street shall meet the smoothness requirements of 302-5.6.2. Trenches less than 3 feet (1m) wide, individual excavations or bore holes having an area less than 50 ft^2 ($5m^2$), and trenches of any width not parallel to the centerline of the street shall match the smoothness of the existing pavement, except final pavement surface tolerances are minus 0 to plus 1/8 inch (3mm) based on the existing pavement on either side of the excavation. Final pavement below the existing surface is not acceptable.

Finish courses with deviations exceeding the above requirements shall be removed and replaced. Such pavement shall be removed to a minimum depth of 1-1/2 inches (38mm) for the full width of the trench. The minimum length of removal along the trench shall extend for 4 feet (1.2m) beyond the ends of the deviations, but in no case exceed the limit of the original excavation.

306-1.5.7 Concrete Resurfacing. Replacement of PCC pavement for trench or individual excavations or bore holes shall be 1 inch (25mm) greater in thickness than existing the pavement. The existing concrete pavement shall be saw cut per 300-1.3. The concrete shall conform to and be placed per 302-6.

306-1.6 Basis of Payment for Open Trench Installations. Pipe and conduit shall be measured along the longitudinal axis between the ends as laid and shall include the actual pipe in place and shall not include the inside dimensions of structures. House connection sewers shall be measured from the center of the main sewer to the upper end of the house connection sewer. Catch basin connections shall be measured from the inside face of the catch basin to the inside face of conduit or structure to which connection is being made. Chimney pipe shall be measured vertically from the upper end of the chimney to the invert of the sewer.

The Contract Unit Price per linear foot (meter) for pipe and conduit in place shall be considered full compensation for all wyes, tees, bends, monolithic catch basin connections, and specials shown on the Plans; the removal of interfering portions of existing sewers, storm drains, and improvements; the closing or removing of abandoned conduit and structures; the excavations of the trench; the control of ground and surface waters; the preparation of subgrade; placing and joining pipe; backfilling the trench; permanent resurfacing; and all other work (excluding temporary resurfacing) necessary to install the pipe or conduit, complete in place.

Payment for structures such as manholes, junction structures, lamp holes, and catch basins shall be made at the price in the Bid for each structure and shall be full payment for each structure complete in place, including excavation, backfill, constructing inverts, furnishing and installing castings, restoration of the street surface, and all other work, excluding temporary resurfacing, necessary to complete the Work.

306-1.7 Precast Reinforced Concrete Box (PRCB).

306-1.7.1 General. These specifications cover the construction of single-cell PRCB sections intended to be used for the conveyance of storm water. PRCB sections shall conform to 216.

306-1.7.2 Repairs. PRCB sections damaged due to imperfections in fabrication or handling shall be repaired by a method approved by the Engineer.

306-1.7.3 Subgrade. Subgrade material shall be densified to 90 percent relative compaction. Unsuitable subgrade material shall be removed to the depth shown on the Plans or determined by the Engineer and replaced with leveling bed material. Voids below subgrade shall be filled with leveling bed material prior to densification.

306-1.7.4 Leveling Bed Material. Leveling bed material shall conform to 216-2.4 and be densified to 90 percent relative compaction.

306-1.7.5 Installation. PRCB sections shall be laid up-grade with the groove ends up-grade unless otherwise approved by the Engineer. Connections shall be constructed as shown on the Plans.

At the close of work each day, or whenever the work ceases for any reason, each end shall be securely closed as approved by the Engineer.

306-1.7.5.1 Tongue-and-Groove Joints. Tongue and groove joints shall be constructed in accordance with 306-1.2.4 (b) modified as follows:

a) Only one end shall be beveled for PRCB sections placed on curves.

b) Concrete used to fill clear spaces more than 1 inch (25mm) and less than 3 inches (75mm) shall be 560-C-3250 (330-C-23) or Class C mortar conforming to 201-5 unless otherwise specified in the Special Provisions.

Preformed flexible joint sealant conforming to ASTM C990 or AASHTO M198 may be used. Preformed flexible joint sealant shall be installed in accordance with the manufacturer's specifications on the tongue and groove, in order to fill the joint annular space on the inside of the PRCB section. Flexible plastic gaskets shall not be used on PRCB pulled to provide a curve.

Preformed flexible joint sealant bands conforming to ASTM C877 may be used, in conjunction with mastic or mortar, when installed in accordance with the manufacturer's specifications.

306-1.7.5.2 Structure Backfill. Structure backfill shall conform to 300-3.5.1. Structure backfill material shall be placed 12 inches (300mm) from the top and 24 inches (600mm) from each side.

306-1.7.6 Measurement. PRCB will be measured for payment along the longitudinal axis between the ends laid for each size. The length shall include the actual length of the PRCB in place but it shall not include the inside dimensions of structures.

306-1.7.7 Payment. Payment shall conform to 306-1.6. Payment for additional leveling bed material shall conform to 3-3 unless otherwise specified in the Special Provisions.

306-2 JACKING OPERATIONS.

306-2.1 General. Before starting excavation, the Contractor shall, in accordance with 2-5.3, submit Working Drawings of jacking pit bracing, casing (or conduit), and jacking head proposed to be used.

Unless otherwise specified, the methods and equipment used in jacking casing or conduit shall be optional with the Contractor, provided that the proposed method is approved by the Engineer. Such approval, however, shall in no way relieve the Contractor of the responsibility for making a satisfactory installation meeting the criteria set forth herein. Only workers experienced in jacking operations shall be used in performing the work.

The leading section of conduit shall be equipped with a jacking head securely anchored thereto to prevent any wobble or variation in alignment during the jacking operation.

The driving ends of the conduit shall be properly protected against spalling and other damage, and intermediate joints shall be similarly protected by the installation of sufficient bearing shims to properly

distribute the jacking stresses. Any section of conduit showing signs of failure shall be removed and replaced with a new section of precast conduit, or with a cast-in-place section, which is adequate to carry the loads imposed upon it.

Excavation shall not be made in excess of the outer dimensions of the conduit being jacked unless approved by the Engineer. Every effort shall be made to avoid any loss of earth outside the jacking head. Excavated material shall be removed from the conduit as excavation progresses, and no accumulation of such material within the conduit will be permitted.

Once the jacking operation has commenced, it shall be continued uninterrupted around the clock until the conduit has been jacked between the specified limits. This requirement may be modified if the Contractor submits to the Engineer for prior approval methods and details that shall prevent the "freezing" of the conduit and ensure that the heading is stable at all times.

Upon completion of the jacking operations, all voids around the outside face of the conduit shall be filled by grouting.

Grouting equipment and material shall be on the Work site before jacking operations and drilling of grout holes are completed in order that grouting around the jacked conduit may be started immediately after the jacking operations have finished.

Should appreciable loss of ground occur during the jacking operation, the voids shall be backpacked promptly to the extent practicable with soil-cement consisting of a slightly moistened mixture of 1 part cement to 5 parts granular material. Where the soil is not suitable for this purpose, the Contractor shall import suitable material at its expense. The soil-cement shall be thoroughly mixed and rammed into place as soon as possible after the loss of ground.

306-2.2 Jacking Reinforced Concrete Pipe. When pipe is specified to be jacked into place, the design of such pipe is based upon the superimposed loads and not upon the loads which may be placed upon the pipe as a result of the jacking operations. Any increase in pipe strength in order to withstand jacking loads shall be the responsibility of the Contractor.

Where pipe 60 inches (1500mm) or greater in nominal inside diameter is to be jacked for a distance greater than 32 feet (10m), a pilot tunnel shall be constructed first to ensure accuracy of grade and alignment. The dimension and support of the pilot tunnel will be optional with the Contractor subject to the approval of the Engineer. Such approval shall in no way relieve the Contractor of the responsibility for damage of any nature which might occur as a result of the method used.

Supports for pilot tunnels shall be removed as jacking progresses.

Unless the Contractor submits an alternate proposal to the Engineer for approval, the following method shall be used for supporting and guiding the pipe:

After the pilot tunnel has been constructed, a concrete cradle shall be placed true to line and grade and conforming to the outside radius of the pipe. The cradle shall be of such dimensions as to adequately and uniformly support the pipe under the lower 60-degree sector measured on the outside of the pipe. The curved surface shall be formed or accurately screeded to the proper dimensions. It shall be reinforced with not less than 0.3 percent of longitudinal steel and not less than 0.5 percent of transverse steel with respect to the cross-sectional area of the cradle. The transverse steel shall be bent on a radius equal to the radius of the outside of the pipe plus 2 inches (50mm) and shall extend to within 1 inch (25mm) of the edge of the cradle.

In lieu of the concrete cradle specified above, the Contractor may, subject to the approval of details by the Engineer, set steel rails in the concrete base slab to true line and grade.

The Contractor shall place grout holes, pipe, and fittings in the pipe invert on centers not greater than 5 feet (1.5m) and shall perform such pressure grouting as is necessary to fill voids and to secure uniform bearing between the cradle and the pipe. The grout shall be neat cement grout. Grouting pressures shall be as determined in the field by the Engineer.

All costs involved in the performance of the work of constructing pilot tunnels and cradles shall be included in the price in the Bid for jacking pipe.

306-2.3 Jacking Steel Casing. Unless otherwise specified on the Plans, the size and wall thickness of the casing to be jacked to accommodate the contract pipeline shall be at the Contractor's option, except that the casing thickness shall be not less than 3/8 inch (9.5mm), and the Contractor shall be fully responsible for the sufficiency of the casing provided.

The joints of sections of casing to be jacked shall be welded with a continuous circumferential weld. It shall be the Contractor's responsibility to provide stress transfer across the joints which is capable of resisting the jacking forces involved.

All clay pipe installed in a jacked casing shall have mechanical compression joints. The pipe shall be braced or filled to prevent shifting or flotation during backfilling operations.

Backfill shall be gunite sand, gunite concrete, or pressure concrete, except where specified otherwise in the Plans or in the Specifications. Pressure concrete shall not be placed until the mix design, placement method, and equipment have been approved by the Engineer.

If the pressure concrete mix cannot be readily pumped or placed by the placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

Gunite sand backfill shall conform to 306-3.7. Where gunite sand backfill is used, the pipe shall be laid on a concrete subbase or on gravel bedding where shown on the Plans or approved by the Engineer.

Where gunite concrete or pressure concrete backfill is to be used, the pipe shall be laid on a subbase of pipe bedding concrete as specified in 201-1 at least 5 inches (125mm) thick at the centerline.

The pipe barrels shall rest upon concrete support blocks with the pipe sockets clearing the concrete subbase by at least 1/2 inch (13mm).

In addition to submitting details of the jacking pit bracing, casing, and jacking head required in 306-2, the Contractor shall submit to the Engineer for approval details of the following in advance of the proposed jacking operation: concrete support blocks, bracing to prevent pipe shifting or flotation, and pressure concrete mix design, placement method, and equipment.

306-2.4 Jacking Corrugated Steel Pipe. Corrugated steel pipe to be jacked in place between the limits shown on the Plans shall conform to provisions of these specifications and the following: The thickness of the pipe designated in the Contract item will be the minimum thickness permitted. Any heavier thickness of pipe or other facilities required to withstand jacking pressure shall be determined and furnished by the Contractor at its expense.

Corrugated pipe lengths may be joined by field riveting. Variation from theoretical alignment and grade at the time of completion of placing shall not exceed 1 inch per 100 feet (8mm per 10m).

The diameter of the excavated hole shall not be more than 0.1 foot (30mm) greater than the outside diameter of the pipe. Sluicing or jetting with water will not be permitted. When material tends to cave in from outside these limits, a shield shall be used ahead of the first section of pipe or the face of the excavation shall not extend beyond the end of the pipe greater than 1-1/2 feet (0.5m), unless permitted by the Engineer.

306-2.5 Tolerances. Concrete conduit shall be jacked true to line and grade and the Contractor shall modify the jacking operation to correct any deviation. Unless otherwise shown on the Plans or in

the Specifications, when a pilot tunnel is required to be constructed in connection with jacking reinforced concrete pipe or box sections, the Contractor will be permitted a tolerance from exact grade or alignment of 1 inch per 100 feet (8mm per 10m).

306-2.6 Payment. The Contract Unit Price per foot (meter) of jacked conduit shall include full compensation for excavation; constructing, supporting, and removing pilot tunnels; constructing reinforced concrete cradles where required; providing grout holes, grout, and grouting where necessary; and doing whatever else is appurtenant to jacking conduit within the limits shown on the Plans and as specified herein.

Except when a Bid item is provided for jacked casing, the cost of furnishing and jacking casing in place shall be included in the Contract Unit Price per linear foot (meter) for that portion of the pipeline or conduit to be installed within the casing.

When a section of reinforced concrete pipe conduit is specified to be constructed by jacking methods, the specified limits for jacking may be increased by the Contractor with the approval of the Engineer. Such increased limits may require an increase in the strength of the pipe to be jacked. When reinforced concrete pipe conduit is specified to be constructed by open trench method, the Contractor may construct said conduit by jacking methods, with the approval of the Engineer. Such methods may require an increase in strength of the pipe.

When a change in construction method or an increase in jacking limits as specified herein is requested by the Contractor and authorized by the Engineer, payment for the work will be based on the Contract Unit Prices as though the specified method had been used.

306-3 TUNNELING OPERATIONS.

306-3.1 General. Required pipe tunnel locations and lengths are shown on the Plans. However, tunnels may be constructed at the Contractor's option in lieu of trench construction. The Contractor shall, in accordance with 2-5.3, submit a proposed plan of tunnel operation which shall include working drawings showing details of the following:

a) Tunnel shaft bracing and dimensions.

b) Tunnel supports (see 306-3.4).

c) Method of backpacking tunnel supports.

d) Method of transporting pipe in tunnel.

e) Bracing to prevent pipe shifting and flotation.

f) Pressure concrete mix design, placement method and equipment.

Isolated tunnels or undercrossings less than 20 feet (6m) in length shall be adequately supported, subject to inspection and approval by the Engineer in the field. Submission of Working Drawings in accordance with 2-5.3 will not be required for this case.

All provisions regarding backpacking and backfilling contained in 306-3.6 and 306-3.7 shall apply to such tunnels, except that if the roof of any such tunnel, or portion thereof, is sloped upward toward the ends of the tunnel for the full width of the excavation at an angle of 45 degrees or greater with the horizontal, the backfill within the sloped portion of the tunnel may be made with material removed from the excavation and densified by flooding or jetting, or mechanically compacted to a minimum relative density of 85 percent.

If the supporting base of any substructure is disturbed or any sewer or storm drain is exposed or partially exposed, it shall be supported with a concrete wall.

306-3.2 Excavations. Access shafts or portals shall be located where shown on the Plans or designated in the Special Provisions. Where no such locations are given, the Contractor shall have the option of determining such locations subject to approval by the Engineer. In general, access shafts or portals will not be permitted within street intersections.

The Contractor shall excavate all materials encountered in the tunnel within the width and height necessary to install tunnel supports, place pipe, make joints, properly place backfill to fill all void space around the pipe and do whatever else is necessary to complete the pipe installation in the tunnel.

Clearances shown on the tunnel details on the Plans are minimum and no encroachment within the dimensions shown will be permitted. The spring line clearances shown shall be increased by 3 inches (75mm) for any tunnel to be constructed on a curve with a centerline radius of less than 300 feet (90m).

All drilling and blasting shall be performed in such a manner to avoid undue shattering or loosening of material. The Contractor shall remove all material which is likely to fall or appears dangerous to workers or the Work. The fact that such removal may enlarge the excavation beyond the required limits shall not relieve the Contractor from the necessity of performing such work, and the Contractor shall not be entitled to any additional compensation by reason of such tunnel enlargement.

Loose material in the invert shall be removed to a reasonably clean rock surface or undisturbed foundation prior to placing pipe bedding and installing pipe. Deep depressions may be filled with suitable material approved by the Engineer. The work of removing loosened invert material and filling the resulting depressions or enlargement of the tunnel from overshooting or overexcavating shall be considered a part of tunnel excavation and no additional compensation will be allowed therefore.

306-3.3 Dewatering. All water encountered in constructing the tunnel shall be disposed of by the Contractor in such manner as will not damage public or private property or create a nuisance or health menace. The Contractor shall furnish, install, and operate pumps, pipes, appliances, and equipment of sufficient capacity to keep all tunnel excavations and accesses free from water until the tunnel is backfilled, unless otherwise authorized by the Engineer. The Contractor shall provide all means or facilities necessary to conduct water to the pumps. Water, if odorless and stable, may be discharged into an existing storm drain, channel, or street gutter in a manner approved by the Engineer. When required by the Engineer, a means shall be provided for desilting the water before discharging it.

306-3.4 Tunnel Supports. Unless otherwise shown on the Plans, the materials used for tunnel supports may be timber, metal, concrete, or a combination thereof at the option of the Contractor. Steel liner plates, if used, shall be provided with grout connections sufficient in number to permit backpacking by means of grout, should such action prove necessary. All tunnel supports shall conform to the requirements set forth in the Tunnel Safety Orders of the State of California. The Contractor shall, in accordance with 2-5.3, submit Working Drawings of tunnel supports proposed to be used. Such drawings shall include full details of the proposed tunnel supports (including connections), longitudinal and transverse bracing and foot blocks, the proposed method of pipe installations, the proposed method of backpacking tunnel supports, and other pertinent details.

The tops of foot blocks shall be installed below the pipe barrel a distance of 1/16 the pipe diameter or a minimum of 4 inches (100mm), whichever is greater. Transverse timber struts, spreaders, and footings will be permitted only where necessary to support horizontal thrust from the tunnel sides. Timber bracing, where necessary, may be left in place provided it lies entirely below the bottom of the pipe the distance specified herein for foot blocks and does not occupy more than 15 percent of the bottom area of the tunnel.

Vertical and horizontal clearance dimensions between pipe sockets and the inside face of continuous tunnel supports, lagging, splining, or steel liner plates as specified herein or as shown on the Plans, will

be considered minimum dimensions. The clearance dimensions between pipe sockets and such intermittent timber and steel members as timber sets or steel rib sets are also minimum dimensions and no encroachment within the dimensions specified will be permitted. It shall be the responsibility of the Contractor to increase tunnel dimensions where necessary in order to provide adequate room for workers and equipment and such space shall be at no increase in cost to the Agency.

Unless otherwise specified or shown on the Plans, the minimum clearances shall be as follows:

For tunnels to be backfilled with pressure concrete, the minimum side clearance at the spring line of pipe sockets to continuous steel or timber shall be 12 inches (300mm), and to intermittent sets or ribs shall be 10 inches (250mm). The minimum overhead clearance from pipe sockets to nearest inside face of any steel or timber member shall be 10 inches (250mm).

For tunnels to be backfilled with gunite concrete or gunite sand, the minimum side clearance at the springline of pipe sockets shall be as for pressure concrete backfill specified above, but the minimum overhead clearance shall be increased to 18 inches (450mm).

The minimum side and top clearances prescribed herein shall be increased by 3 inches (75mm) for pipe without projecting sockets or collars and shall apply to the barrel of the pipe.

The minimum side and top clearances prescribed herein shall be increased by 3 inches (75mm) for pipe without projecting sockets or collars and shall apply to the barrel of the pipe.

No exterior work will be required on the following types of joints:

a) Socket and spigot pipe with rubber gasket or mechanical compression joints.

b) Pipe 24 inches (600mm) or larger in internal diameter.

c) Steel-ring-and-gasket-type reinforced concrete pipe for sewers, if the tunnel backfill and bedding under the pipe are concrete; or where the tunnel backfill is concrete and the bedding material under the pipe is granular and the Contractor beds the pipe for 4 inches (100mm) on each side of the joint in fresh mortar at least 3 inches (75mm) thick and extending 2 inches (50mm) above the top of the granular bedding material.

The Contractor will be required to do such reconstruction of tunnel supports at its expense as may be necessary to meet the foregoing requirements. The Agency may make minor revisions in the horizontal tunnel alignment where possible in sections at least 50 feet (15m) long to minimize the extent of such reconstruction. Similar changes in vertical alignment will generally not be approved.

All timber collar braces and, to the extent practicable, timber supports, lagging and blocking shall be removed prior to backfilling tunnels, except where such removals would be hazardous to persons or the structure. Material to remain in place shall be cleaned of adhering tunnel muck or other material not suitable for backfill.

306-3.5 Subgrade and Bedding. Pipe shall be placed and bedded as shown on the Plans or Working Drawings specifying the methods of laying and bedding pipe in trenches.

If an invert slab is required or otherwise placed separately, it shall be 5 inches (125mm) minimum thickness, the full width of the tunnel, and the concrete shall be tunnel backfill concrete as specified in 201-1. Concrete shall not be placed until placement method and equipment have been approved. The slab, when placed separately, shall be cured for at least 5 days prior to the application of heavy loading.

Payment for rock or other base material required to the extent shown on the Plans or Working Drawings for pipe bedding in trenches, shall be considered as included in the Contract Unit Price for pipe.

All rock required to fill voids caused by overexcavation or to maintain the tunnel bottom to support construction equipment and tunnel supporting members, or to control water throughout the period of tunnel excavation, shall be furnished and placed by the Contractor and the cost thereof shall be included in the Contract Unit Price for pipe complete in place and no additional compensation will be made therefore.

When ordered by the Engineer, rock, in addition to that required by the Plans for bedding, shall be placed by the Contractor and payment therefore will be made as provided in 3-2.

306-3.6 Backpacking Tunnel Supports. Voids behind all temporary or permanent tunnel support systems, including overbreak, cave-ins, and chimneys, shall be backpacked as specified herein. Backpacking shall be placed progressively as soon as practicable after placement of tunnel supports. When ordered by the Engineer, the Contractor shall place backpacking immediately. The non-backpacked length of tunnel shall be held to the minimum practicable for the method of backpacking utilized by the Contractor.

Tunnels in rock supported by timber lagging, steel liner plate, or bolted steel plate tunnel lining shall be backpacked either with pressure grout or soil-cement except that tunnel spoil may be used to the mid-height of the tunnel. When voids 1 cubic foot ($0.03m^3$) in size or larger exist behind lagging or sheeting in tunnels so supported in soil, the Contractor shall backpack behind such supports with either pressure grout or tunnel spoil when ordered by the Engineer.

Tunnels in rock or soil and supported by timber or steel sets with partial timber or metal lagging may be backpacked to the mid-height of the tunnel with tunnel spoil.

All spaces not filled with such backpacking shall be filled at the time of, and with material selected for, tunnel backfilling around the pipe.

Tunnel spoil used for backpacking shall be selected from the better spoil material available, and shall contain sufficient fines to fill all voids. Such material shall be rammed into place. Soft or wet clay may be used only if satisfactory compaction can be obtained. Otherwise the Contractor will be required to import granular material for backpacking at no additional cost to the Agency.

Soil-cement for backpacking lagged or fully lined tunnels shall consist of a slightly moistened mixture of 1 part cement to 5 parts of granular material selected from the tunnel spoil when such material is suitable. Otherwise, granular material shall be imported at the Contractor's expense. The soil-cement shall be thoroughly mixed and rammed into place immediately following placement of tunnel supports. The placement interval shall not exceed three rings of liner plate or the distance between tunnel sets. Mechanically or pneumatically operated tampers shall be used to ram the soil-cement into place unless another placing method is approved by the Engineer.

306-3.7 Tunnel Backfill. Pipe laying operations in tunnels shall not precede tunnel backfill by more than 150 feet (45m) without the approval of the Engineer. Longer reaches may be approved if tunnel clearances are increased from the minimums shown in order to obtain additional working space around the pipe.

The space between the tunnel supports and the pipe shall be completely backfilled with the materials and methods specified herein. The backfill material shall be forced or packed into all the crevices and around all timber sets or steel ribs from the tunnel invert to its crown. The Contractor shall provide whatever wedging or bracing is needed to ensure against pipe movement during placement of backfill.

Backfill for tunnels in rock shall be limited to pressure concrete or gunite concrete.

The approval of the use of gunite concrete for backfill is contingent upon the prior backpacking of tunnel supports with acceptable materials other than gunite concrete.

Unless the Plans for tunnels to be constructed in soil require the use of pressure concrete or gunite concrete for backfill, the Contractor may use gunite sand for backfill.

Gunite sand shall be placed with a pneumatic gun in accordance with the requirements for placing gunite concrete except that no portland cement need be added. The Contractor may add up to 100 pounds of cement per cubic yard (60 kg of cement per cubic meter) to improve placement stability at its option and expense. In either case, water sufficient to saturate the material and ensure proper packing and minimize rebound shall be added to the mixture. The nozzleperson shall operate in the immediate vicinity of the backfill face to ensure compaction and complete filling of voids.

The Contractor shall submit to the Engineer for approval, at least 30 days prior to backfill operations, a proposed mix design and method of placing concrete, including placing equipment. No pressure concrete backfill shall be placed until mix design, placement method, and equipment have been approved. If the approved mix cannot be readily pumped or placed by the Contractor's placing equipment, additional water may be added, provided the water-cement ratio of the approved mix design is not exceeded.

The pressure concrete shall be placed by methods capable of forcing it into crevices and filling all void spaces in the tunnel. Unless otherwise provided on the Plans, the concrete backfill shall be placed under pressure by means of a "slick" line and pneumatic or positive displacement pumps.

The combined length of the slick line and delivery line shall not exceed the recommendation of the manufacturer of the concrete pump or, if no manufacturer's performance data is available, 150 feet (45m). The discharge end of the slick line shall be rigid conduit with a minimum length of 10 feet (3m). It shall be kept buried in at least 5 feet (1.5m) of fresh concrete during concrete placement. Concrete shall be pumped continuously during withdrawal of the slick line to eliminate voids.

306-3.8 Pressure Grouting of Voids. Where the Engineer has reasonable doubt that the tunnel void spaces are completely filled, the Contractor shall pressure grout such locations as ordered through grout pipes to be installed either from the ground surface or from within the conduit. At least two grout holes will be required at each location to permit escape of air. The location of surface grout pipes may be adjusted as may be required, dependent upon traffic requirements on overhead streets.

Grout for filling voids shall be low pressure grout (less than 10 psi (70 kPa)). Neat cement grout shall be used except that large voids shall be filled with pressure concrete or grout containing sand.

Grout shall be placed by means of pumps of positive displacement or pneumatic type and capable of placing grout at pressures up to 100 psi (700 kPa) unless otherwise approved by the Engineer. Grout shall be placed at pressures which are requisite for the conditions encountered, and will ordinarily be less than 10 psi (70 kPa) except in cases where large cave-ins or other adverse conditions may require higher pressures.

Regardless of the materials or methods of backfilling or filling voids used, the Engineer shall reserve the right to require filling of void spaces known to remain by additional grouting. Such work will be deemed to have resulted from the Contractor's operations and shall be done at its expense.

306-3.9 Payment. Unless the Special Provisions or the Bid provide for Contract Unit Prices for individual work items included in tunnel work, the lump sum or Contract Unit Price per linear foot (meter) for tunnel as set forth in the Bid shall include full compensation for dewatering, backpacking, maintaining tunnel supports, placing tunnel backfill, low pressure grouting, providing access shafts of portals including excavation, backfill and replacement of surface or other improvements, furnishing and installing pipe, and doing whatever else is appurtenant to tunnel construction within the limits shown on the Plans or in the Special Provisions. Unless otherwise specified, payment for tunnel excavation shall include the excavating of any type of material encountered. High-pressure grouting required by the Engineer, and not resulting from an act or failure to act on the part of the Contractor, will be paid for as extra work as provided in 3-2.

For pipe laid through tunnel access shafts, payment shall be made as provided in 306-1.6.

306-4 CAST-IN-PLACE NONREINFORCED CONCRETE PIPE (CIPCP).

306-4.1 General. These specifications are for cast-in-place nonreinforced concrete pipe intended to be used for gravity and low head drains and irrigation systems.

a) Trench construction shall conform to 306-1.1.2, and

b) Where soils encountered are not capable of standing unsupported from the bottom of trench to the top of the pipe without sloughing and where soils are saturated or contain water quantities or other conditions harmful to the concrete, the Contractor shall install an alternate pipe as directed by the Engineer. The substitution of alternate pipe shall be at no additional expense to the Agency.

306-4.2 Materials. Concrete, unless otherwise specified, shall conform to 201-1, Class 560-C-3250 (Class 330-C-23), except that:

a) The slump shall be 1 inch (25mm) minimum and 3 inches (75mm) maximum and measured only after all water has been added. No water shall be added after the slump test material has been sampled, and

b) Concrete shall not be placed when temperature of the concrete exceeds 90°F (32°C) or is less than 50°F (10°C). The soil adjacent to the trench shall be at a temperature above freezing, and

c) Batch proportions shall be designed by the Contractor and submitted to the Engineer for written approval 7 days in advance of any work.

306-4.3 Excavation. Trenches shall be excavated to ensure the pipe is constructed on the alignment and to the grades shown on the Plans. The subgrade shall be fine graded to the tolerances specified in 306-4.6.5. No concrete shall be placed unless the trench is within the specified grade and alignment tolerances.

306-4.3.1 Trench Width. Except for curves and structures, the trench shall not exceed the width of the pipe OD plus 2 inches (50mm) for a height of 1 foot (0.3m) above the top of the pipe. The bottom of the trench shall be shaped to serve as the outside form of the pipe. The trench shall provide full, firm, and uniform support over the bottom 210 degrees of the pipe, which is referred to as the "trench form". See Plans for curves and structures.

306-4.3.2 Isolated Rock. Where isolated rock is encountered within the trench form, it shall be removed. If the rock is too large to be removed by hand, all portions of the rock within 6 inches (150mm) of the lower 90 degrees of the trench form shall be removed. The void shall be refilled with the monolithically placed concrete, if approved by the Engineer, prior to construction of the pipe placed or backfilled with soil compacted to a minimum relative compaction of 90 percent.

306-4.3.3 Extensive Rock. Where extensive rock is encountered, the bottom 90 degrees of soil and rock shall be overexcavated to a depth of 6 inches (150mm) below the trench form and 12 inches (300mm) on the remaining portions of the trench forms. The void shall be refilled with the class of concrete used for the CIPCP or with soil compacted to a minimum relative compaction of 90 percent when approved by the Engineer.

306-4.3.4 Soil Moisture. At the time of concrete placement, all soils to be in contact with cast-in-place pipe shall be moistened, but shall not contain standing, seeping, or flowing water. Provisions shall be made to dewater the trench so that flowing or standing water is eliminated. The Contractor may, at its sole cost, place a layer of 1 inch (25mm) maximum size rock 6 inches (150mm) thick below the trench invert to assist in water control.

306-4.4 Placement.

306-4.4.1 General. Concrete placement shall be in accordance with 303-1.8 except as provided herein. The flowline grade and alignment of the finished pipe shall conform to the tolerances stated in 306-4.6.5.

306-4.4.2 Concrete Forms. The concrete shall be placed around the full circumference of the pipe in one operation by means of fixed forms and traveling forms. The internal fixed forms shall be of sufficient strength to withstand the vibrating or tamping of concrete. Inflatable internal forms shall not be used. The internal fixed forms shall be of sufficient strength to prevent deformation during construction of the placed concrete. The concrete shall be vibrated, tamped, or worked with suitable devices until the concrete has been consolidated and completely fills the forms.

306-4.4.3 Pipe Junction. Where junction structures are to be constructed, the pipe shall be continuous through the structure locations. The pipe shall be cut away to the specified opening prior to the final set of concrete. Alternate methods may be used as approved in writing by the Engineer.

306-4.4.4 Construction Stoppage. When placement is stopped for a period of time that initial set is likely to occur or 20 minutes, whichever is less, a construction joint shall be made by sloping the end of the pipe at approximately 45 degrees and inserting 24 inches (600mm) long No. 3 (No. 10M) dowels 12 inches (300mm) into the center of the pipe wall at approximately 18 inches (450mm) intervals around the pipe circumference. The total exposed face shall be left in a roughened condition.

Before placing operations may resume, the concrete placed at the construction stoppage joint shall attain sufficient strength to permit an excavation to be made on each side of the joint to form a concrete collar. This collar shall be centered on the joint and have a minimum thickness of one and one-half times the pipe wall thickness and a length of 24 inches (600mm). The joint shall be cleaned of laitance, foreign, and loose materials before resuming concrete placement.

Before placing operations may resume, the concrete placed at the construction stoppage joint shall attain sufficient strength to permit an excavation to be made on each side of the joint to form a concrete collar. This collar shall be centered on the joint and have a minimum thickness of one and one-half times the pipe wall thickness and a length of 600mm (24 inches). The joint shall be cleaned of laitance, foreign, and loose materials before resuming concrete placement.

306-4.4.5 Form Removal. Internal fixed forms shall remain in place until the concrete is self-supporting, after which they may be loosened but shall not be removed for at least 6 hours after placement. As soon as practical thereafter, the forms shall be removed to facilitate inspection and prompt repair. At times of low temperature or other adverse conditions the forms may be kept in place for longer periods of time.

306-4.4.6 Finishing. The interior of the pipe shall be at least as smooth as a steel trowel finish except for the form lap ridges permitted in 306-4.6.4.

306-4.4.7 Curing. Immediately after concrete placement, the exposed top portion of the pipe shall be cured by placing a polyethylene film at least 0.0015 inch (0.038mm) thick so as to completely cover the top surface. All openings in the pipe shall be covered with 0.0015 inch (0.038mm) polyethylene and securely fastened for at least 7 days immediately after placement. At locations where work on the pipe is required, and only during the period that such work is actually in progress, shall necessary openings be uncovered.

306-4.4.8 Repairing. After the internal fixed forms have been removed, the inside of the pipe shall be inspected by the Engineer. All rock pockets, blisters, voids, or similar defects not extending through the wall and less than 2 square feet ($0.18m^2$) in area, shall be repaired immediately by removing the defective concrete and replacing it with properly bonded and cured mortar or other patching material approved by the Engineer.

All rock pockets, blisters, voids, or other defects greater than 2 square feet ($0.18m^2$) or which extend through the pipe wall shall be repaired by removing the entire pipe for 1 foot (300mm) on each side beyond the limits of the defect.

Cracks shall not be repaired until the entire backfill is in place. However, the Contractor may remove and replace cracked pipe prior to placement of the entire backfill.

Subsequent to placement of the entire backfill, the Contractor shall notify the Engineer when the pipe is ready for reinspection. Cracks less than 0.01 inch (0.255mm) in width or cracks greater than 0.01 inch (0.255mm) but less than 12 inches (300mm) long shall be painted with a cement paste. Longitudinal cracks exceeding 0.01 inch (0.255mm) in width and 12 inches (300mm) in length must be repaired by epoxy pressure grouting provided the total length of cracks for any reach is less than 25 percent. If the total length of cracks exceeds 25 percent, the entire reach shall be removed and replaced. A reach is any length between two structures.

Circumferential cracks exceeding 0.01 inch (0.255mm) in width and 12 inches (300mm) in length shall be repaired by removing at least 1 inch (25mm) of concrete in width for a depth of at least 1/2 the wall thickness. After cleaning this area, it shall be filled with properly bonded and cured mortar.

Alternate repair methods shall be submitted in writing not less than 7 days prior to use for approval by the Engineer. Any repairs performed shall ensure the specified structural strength is not compromised and by techniques which have been approved by the Engineer.

306-4.4.9 Rejection. Pipe will be rejected for any of the following reasons:

a) Longitudinal cracks exceeding 0.01 inch (0.255mm) in width and 12 inches (300mm) or greater in length unless repaired per 306-4.4.8. If longitudinal cracks occur intermittently in 25 percent or more of a reach of pipe, the pipe shall not be repaired and shall be removed and replaced.

b) Circumferential cracks exceeding 0.01 inch (0.255mm) in width and 12 inches (300mm) or greater in length unless repaired per 306-4.4.8.

c) Longitudinal cracks exceeding 1/1000 the internal diameter or a maximum 1/16 inch (1.5mm) in width.

d) Rock pockets, honeycombing, blisters, voids, or other defects that extend through the pipe wall.

e) A wall thickness less than the minimum as listed in 306-4.6.3.

f) A diameter that does not meet the requirements of 306-4.6.2.

g) Application of any wash coat of cement, grout, or other material prior to reinspection after the entire backfill has been placed.

h) Air bubble voids (bugholes) on the interior surface of the pipe exceeding 1/4 inch (6mm) in depth unless pointed with mortar or other approved material.

i) Unpaired offsets or indentations, including transverse and longitudinal form offsets exceeding those allowed in 306-4.6.4.

j) Deviation or departure from true grade or alignment exceeding that allowed in 306-4.6.5.

k) Concrete used that has a slump of less than 1 inch (25mm) or more than 3 inches (75mm) per 306-4.2. Concrete that has had water added after slump and/or cylinder samples have been taken or that does not meet the proportioning requirements of 201-1.

l) Concrete that has core strengths less than that required per 306-4.2.

m) The pipe does not pass the load test per 306-4.7.4.

n) The pipe has been damaged in any manner including but not limited to placing or compacting the backfill.

o) Concrete that was placed when the concrete temperature exceeded 90°F (32°C) or was less than 50°F (10°C), or when the soil adjacent to the trench was below freezing.

p) The trench does not provide full, firm, and uniform support over the bottom 210 degrees of the pipe or the trench width exceeds the OD per 306-4.6.3 by more than 2 inches (50mm), except when meeting the requirements of 306-4.3.1, 4.3.2, and 4.3.3.

q) The interior of the pipe is not at least as smooth as a steel trowel finish except for the form lap ridges.

306-4.5 Backfill. Backfill for cast-in-place pipe shall be considered as starting at the top of the trench form and shall conform to 306-1.3. The method of backfilling shall be subject to the approval of the Engineer. The equipment used in placing the backfill shall not cause damage to the pipe or cause loads to be placed on the pipe which are in excess of design loads.

Backfilling will not be permitted over cast-in-place concrete pipe until the concrete attains the strength specified. The Contractor may place backfill prior to 28 days upon written approval by the Engineer provided the required 28-day strength has been attained and verified by a laboratory.

306-4.6 Dimensions and Tolerances.

306-4.6.1 General. The minimum nominal size of cast-in-place pipe shall be 24-inch (600mm) ID.

306-4.6.2 Diameter. The internal diameter of the pipe at any point shall not be less than 99 percent nor more than 105 percent of the nominal diameter, and the average of any four measurements of the internal diameter made at 45-degree intervals shall not be less than the nominal diameter.

306-4.6.3 Wall Thickness. The wall thickness at any point shall not be less than specified on the Plans and in no case less than in the following table. Any length which fails to meet the thickness requirements will be rejected. The grade and alignment shall be controlled so that the wall thickness of the pipe is symmetrical.

TABLE 306-4.6.3 (A)

Internal Diameter inches (mm)	Minimum Wall Thickness inches (mm)
24 and 30 (600 and 750)	3 (76)
36 (900)	3-1/2 (89)
42 (1050)	4 (102)
48 (1200)	5 (127)
54 (1350)	5-1/2 (140)
60 (1500)	6 (153)
66 (1650)	6-1/2 (165)
72 (1800)	7 (178)
78 (1950)	7-1/2 (191)
84 (2100)	8 (203)
90 (2250)	8-1/2 (216)
96 (2400)	9 (229)
108 (2700)	10 (254)
120 (3000)	12 (305)
132 (3300)	14 (356)
144 (3600)	15 (381)

For any ID not indicated above, the minimum wall thickness shall be equal to the next size larger pipe. Wall thickness will be determined in accordance with 306-4.7.4, or when applicable, with 306-4.7.1.

306-4.6.4 Offsets and Indentations. Any offset or indentation, including transverse and longitudinal form offsets and construction stoppage joints, shall not exceed 1/4 inch (6mm) for pipe with specified ID of 42 inches (1050mm) or less, and 3/8 inch (10mm) for pipe with specified ID over 42 inches (1050mm) and less than 72 inches (1800mm), and 1/2 inch (13mm) for all pipe diameters equal to or greater than 72 inches (1800mm).

Reaches having offsets or indentations in excess of these limits shall be repaired as approved by the Engineer.

306-4.6.5 Grade and Alignment. Departure from and return to established grade shall not exceed 3/8 inch per foot (10mm/m) and maximum departure shall not exceed 1.0 inch (25mm). Maximum departure from established alignment shall not exceed 2 inches (50mm) on tangents and 4 inches

(100mm) on curves. Departure from and return to established alignment shall not exceed 1/4 inch per foot (20mm/m). A laser grade control shall be used for all trenches.

If the departure exceeds the maximum allowed, the work shall be stopped and the necessary adjustments made. The affected portions of the conduit exceeding the above departure shall be removed and replaced at the proper grade and alignment.

306-4.7 Test Requirements.

306-4.7.1 Sequence of Sampling and Testing. Sampling and testing shall be performed in the sequence described herein. Tests for portland cement concrete will be taken during concrete placing operations in accordance with 201-1.1.4. If the concrete cylinders do not meet the required 28-day strength, cores shall be obtained from the completed pipe. Cores shall be used to determine thickness and compressive strength. Strength test results shall be verified by a laboratory approved by the Engineer. If the strength of these cores fails to meet the design requirements, the pipe will be rejected.

The Engineer will determine the number and location of the samples and tests. The location shall be identified by station, and where applicable, the angle from vertical measured clockwise facing up-station.

306-4.7.2 Thickness. The Engineer will determine the wall thickness of the pipe as follows:

a) The thickness at the invert and crown of the pipe will be measured by probing at approximately 25 foot (7.5m) intervals during placement of the concrete. The probe shall be forced through the concrete to make firm contact with the form at the crown and shall be held in a position normal to the surface when the measurement is taken. The invert shall be inspected by removing a small portion and measuring the thickness. The probe shall be 3/8 inch (9.5mm) round bar, at least 2 inches (50mm) longer than the wall thickness to be measured, rounded on one end with a tee handle on the other.

b) Thickness at the invert and springline will be measured through holes drilled by the Contractor. The holes shall be at least 3/4 inch (19mm) in diameter and shall be drilled after the removal of the forms and within 72 hours of concrete placement.

Three holes shall be drilled every 50 feet (15m) at the invert and both springlines and shall be located as determined by the Engineer. The Engineer may require additional holes on curves to determine the extent of thin sections.

After measurement, the Contractor shall fill all holes using Class C mortar per 201-5. All costs of probing, drilling, removing, and repairing shall be borne by the Contractor.

306-4.7.3 Concrete Cores. Cores, where required, shall be obtained from pipe and tested in accordance ASTM C42. The cores shall have a length-to-diameter ratio of not less than one. The diameter of cores shall be at least three times the maximum size of the aggregate used in the concrete, except where the wall thickness if such that the length-to-diameter will be less than one, in which case the core diameter may be reduced to two and one-half times the maximum aggregate size used.

There shall be at least four cores taken for each 200 linear feet (60 linear meters), or fraction thereof, of pipe. Cores shall be taken at the following points at stations selected by the Engineer: one through the crown, one through the invert, and two in the lower half of the pipe 45 degrees from the vertical. The Engineer may require additional cores at any location. The Contractor shall patch all core holes in such a manner that the patch will be permanent, will not leak, and will have a smooth finish flush with the interior surface of the conduit. All costs of coring, testing, and patching core holes shall be borne by the Contractor.

306-4.7.4 Load Bearing. Load bearing tests shall be required for every 1,000 feet (300m) of pipe having the same size and wall thickness, with a minimum of one per size and two per project. The test locations will be specified by the Engineer. The test shall be performed in the presence of the Engineer, and the Contractor shall be responsible for all costs and risks involved. Failure of the test section will be cause for rejection of the conduit represented by the test.

The method and apparatus requirements for load bearing tests are as follows:

a) The test shall be performed with only the trench form providing bottom support. If the pipe has been constructed so that more than 210 degrees is in contact with the natural soil, the trench wall shall be re-excavated to provide 210 degrees of trench form without altering the existing bedded condition of the trench form.

b) The test length shall be at least 4 feet (1.2m) and not more than 5 feet (1.5m). At the option of the Contractor, the test section may be isolated from the completed pipe.

c) The test load shall be applied by use of a "sand box," consisting of a frame and bearing plate, in such a manner that sand carefully placed in the sand box forms a bearing symmetrically about the centerline and over the entire length of the test section. The width of the bedding shall be 0.7 times the specified ID of the pipe. The minimum thickness of the sand shall be 0.25 times the specified ID.

d) The frame and bearing plate shall be sufficiently rigid so that they will distribute the load uniformly and will not deform under the loaded condition. The interior surfaces of the frame shall be smooth. The lower surface of the bearing plate shall be a true plane. Cloth or plastic film shall be attached to the inside of the frame along the lower edges to prevent the loss of sand through the gap between the pipe and the frame. This type of apparatus is described in ACI Specification 346.

e) The frame shall be properly located on the pipe test section and filled with sand. The sand shall be clean and graded so that it will pass a No. 4 (4.75mm) sieve. The sand shall be struck off level and covered with the bearing plate. During the test, the bearing plate shall not contact the frame.

f) The load shall be applied symmetrically on the bearing plate until the total required has been attained. The pipe shall remain loaded until the interior of the pipe has been inspected by the Engineer and results have been observed and recorded.

g) The applied load, in pounds (newtons), shall equal the test load multiplied by the length of the test section, in feet (meters). The test load shall be calculated as follows:

U.S. Standard Measures:

$$\text{Test Load} = (127.5H + 1.5LL + 5.56T)\ OD + 34.0(ID)^2$$

SI Units:

$$\text{Test Load} = (20030H + 1.5LL + 10.48T)\ OD + 5340\ (ID)^2$$

Where:

ID = Specified inside diameter of the pipe in feet (meters).

T = Specified wall thickness of the pipe in inches (millimeters).

OD = ID + 2T/12 = Outside diameter of pipe in feet.

(SI Units: OD = ID + 2T/1000 = Outside diameter of pipe in meters.)

H = Depth of cover on pipe in feet (meters).

LL = Live load on pipe in pounds per square foot (kPa).

TABLE 306-4.7.4 (A)

Depth of Cover ft (m)	Live Load (LL) lbs/ft^2 (kPa)
3 (0.9)	489 (23.4)
4 (1.2)	314 (15.0)
5 (1.5)	234 (11.2)
6 (1.8)	182 (8.71)
7 (2.0)	145 (6.94)
8 (2.4)	119 (5.70)
9 (2.7)	120 (5.75)
10 (3.0)	90 (4.31)
Over 10 (3.0)	N/A

h) The total test load shall be supported by the test section without the development of any additional cracking.

i) After the satisfactory completion of the test, the Contractor shall repair the pipe, resulting from isolating the test section, in a manner satisfactory to the Engineer.

In lieu of using a "sand box" as described above, the Contractor may conduct a wheel load test on a 4-foot (1.2m) section of pipe when approved in writing by the Engineer. The load applied shall be determined by the equation in item 7 above applied to a section of pipe. The total test load shall be supported by the test section without the development of any additional cracking.

306-4.8 Payment. The Contract Unit Price per linear foot for CIPCP shall include full compensation for doing all work involved in constructing the pipeline, including excavation, backfill, testing, repair, and replacement as specified or as directed by the Engineer.

306-5 ABANDONMENT OF CONDUITS AND STRUCTURES. When sanitary sewer or storm drain conduits have been or are to be abandoned and are found to interfere with construction, the interfering portion shall be removed and the remaining open portion securely sealed. Where the greater internal dimension of the conduit is 4 feet (1.2m) or less, the seal shall consist of a wall of concrete not less than 6 inches (150mm) thick or a 8 inch (200mm) wall of brick and mortar. For larger openings, details of the seal will be shown on the Plans. In the case of catch basin connector pipes, the inlet opening to the mainline pipe shall also be sealed.

When a sanitary sewer or storm drain is to be abandoned within specified limits, all structures and appurtenances within said limits shall also be abandoned.

When catch basins or manholes are to be abandoned, the upper portion shall be removed to a depth of at least 1 foot (0.3m) below street subgrade and the conduits connecting to the structure shall be sealed as provided herein. The bottom of such structures shall be perforated or broken to prevent the entrapment of water.

Structures designated on the plans to be removed shall be removed to the full depth of the structure, including its foundation. Voids resulting from abandoned or removed structures shall be filled with suitable material compacted to a relative compaction of 90 percent.

Cover sets, gratings, and other steel components (except reinforcing bars) of removed or abandoned structures shall be salvaged. The Contractor shall contact the owners and, if required, shall deliver to and load such material in the owner's truck at the Work site. Otherwise, such material shall become the property of the Contractor and shall be disposed of by it away from the Work site.

306-6 REMODELING EXISTING SEWER FACILITIES. Where the Plans indicate construction involving existing sewer facilities, the Contractor shall provide temporary seals, enclosures, forced ventilation, or other devices as may be necessary to prevent odor nuisance during construction. Sewers shall be open to the atmosphere only for a reasonable time necessary for construction.

All existing sewer facilities shall be considered potential permit-required confined spaces in accordance with 7-10.4.4. Hazards to which workers may be exposed, include, but are not limited to engulfment, hydrogen sulfide gas, explosive/flammable gases, and/or oxygen deficiency. When required, the Contractor shall implement a permit space program in accordance with 7-10.4.4.

Where a manhole bottom is to be remodeled on an existing sewer, the portion to be remodeled shall be removed to a minimum depth of 3 inches (75mm) to permit construction of new channels and shelves. Sewage in new and remodeled manholes shall be controlled across the manhole in such a manner that sewage does not flow over concrete channels until they have cured for 24 hours. The controls shall prevent backup of sewage upstream from the manhole unless otherwise approved by the Engineer.

Where required by the Plans or Special Provisions, the Contractor shall submit Working Drawings for control operations in accordance with 2-5.3.

306-7 CURB DRAINS. Drains shall be constructed beneath the sidewalk to connect building drains to curb outlets and to serve low areas on adjacent property as shown on the Plans or as directed by the Engineer.

The drain shall be a 3-inch (75mm) diameter pipe for a 6-inch (150mm) curb face, and a 4-inch (100mm) diameter pipe for an 8-inch (200mm) curb face or greater. The invert of the drain shall be located 1/2 inch (13mm) above the gutter flowline. The drain pipe shall have a minimum 2-inch (50mm) clearance from top of curb and be laid on a straight grade with a minimum slope of 3/8 inch per foot (30mm/m) and terminate 1 inch (25mm) back of the curb face.

Curb drains may be constructed using pipe materials specified in 207 or other pipe materials approved by the Engineer. The pipe shall be suitably joined in accordance with the manufacturer's standard jointing system.

306-8 MICROTUNNELING.

306-8.1 General.

306-8.1.1 Description. Microtunneling is an unmanned entry method that uses a remotely operated microtunnel boring machine (MTBM) to install pipes underground with minimal surface disruption. Microtunneling continuously installs pipe behind a remotely controlled, steerable, laser-guided, full-face controlled, articulated MTBM. The pipe to be installed is connected to and follows the MTBM.

The length of drive which is possible to achieve is dependent upon the jacking force, pipe material, and pipe size.

The jacking force required is a function of many variables including the soil conditions, depth of the pipeline, annular space between the pipe and the soil, lubrication of the pipe, water table location, overburden loads, installation time, pipe material, out-of-roundness, diameter, and strength.

306-8.1.2 Minimum Soil Cover. The minimum depth of cover to the top of the installed pipe using this process shall be one and one-half to three times the outside diameter of the pipe being installed, or 6 feet (2m), whichever is greater depending on the soil conditions. With prior approval of the Engineer, the minimum depth of cover may be reduced.

306-8.1.3 Surface Description. Unless otherwise noted in the Contract Documents, settlement of heave at the ground surface during and after construction shall not exceed 1/2 inch (13mm) or unless specified in the Contract Documents as measured along the centerline of the conduit being installed. Zero settlement or heave may be required when specified in the Contract Documents or required by applicable permits.

306-8.1.4 Definitions.

Annular Space - The void created between the outside diameter of pipe being installed and extreme outer limits created by MTBM bore process.

Earth Pressure Balance - MTBM pressure applied to the cutting face equals the pressure of earth against the cutting face.

Full Face Control - Complete mechanical support of the excavated face at all times.

Lubricant- A substance applied between the pipe and soil to minimize friction and to fill the annular space.

Microtunneling Boring Machine (MTBM) - A remotely controlled, steerable, laser guided microtunnel boring machine consisting of an articulated boring machine shield and a rotating cutting head.

Pipe String - The succession of joined individual pipes being used to advance the excavation equipment.

Shaft or Pit - A vertical excavation to insert or receive microtunneling equipment and pipe.

Slurry - Water mixture, which may contain additives, that is used to transport spoils and counterbalance any ground water pressure.

306-8.1.5 Submittals. The Contractor shall submit the following items for review and approval by the Engineer in accordance with 2-5.3. Approval of the submittal by the Engineer shall be obtained prior to ordering pipe materials and/or start of the microtunneling operations.

a) Manufacturers' data sheets and specifications describing in detail the microtunneling system to be used.

b) Description of similar projects with references on which the proposed system had been successfully used by contractor/operator.

c) Description of method to remove and dispose of spoil.

d) Maximum anticipated jacking loads and supporting calculations.

e) Description of methods to control and dispose of groundwater, spoil, temporary shoring, and other materials encountered in the maintenance and construction of pits and shafts.

f) Shaft dimensions, locations, surface construction profile, depth, method of excavation, shoring, bracing, and thrust block design.

g) Pipe design data and specifications.

h) A description of the grade and alignment control system.

i) Intermediate jacking station locations and design.

j) Description of lubrication and/or grouting system.

k) Layout plans and descriptions of operational sequence.

l) A detailed plan for monitoring ground surface movement (settlement or heave) due to the microtunneling operation. The plan shall address the method and frequency of survey measurement. At minimum, the plan shall measure the ground movement of all structures, roadways, parking lots, and any other areas of concern within 25 feet (8m) on both sides of all microtunneling pipelines at a maximum spacing of 100 feet (30m) along the pipeline route, or as required by the Engineer.

m) Contingency plans for approval for the following potential conditions: damage to pipeline structural integrity and repair; loss and return to line and grade; and loss of ground.

n) Procedures to meet all applicable OSHA requirements. These procedures shall be submitted for a record purpose only and will not be subject to approval by the Engineer. At a minimum, the Contractor shall provide the following:

1) Protection against soil instability and ground-water inflow.
2) Safety for shaft access and exit, including ladders, stairs, walkways, and hoists.
3) Protection against mechanical and hydraulic equipment operations, and for lifting and hoisting equipment and material.
4) Ventilation and lighting.
5) Monitoring for hazardous gases.
6) Protection against flooding and means for emergency evacuation.
7) Protection of shaft, including traffic barriers, accidental or unauthorized entry, and falling objects.
8) Emergency protection equipment.
9) Safety supervising responsibilities.

o) Annular space grouting plan if required by the Contract Documents.

306-8.1.6 Subsurface Conditions.

a) **Microtunneling Specified by the Agency.** The Agency will make accessible to the Contractor all available subsurface information, if any, which is listed in 2-7 and 306-8.1.6 c). All subsurface investigations deemed necessary by the Contractor to complete the work shall be included at no additional cost to the Agency. Copies of all reports and information obtained by the Contractor shall be provided to the Agency.

b) **Microtunneling Requested by the Contractor.** When microtunneling is proposed by the Contractor as an alternative to the specified methods of conduit installation, the Contractor shall obtain and provide the Agency with the copies of the information and reports listed in 2-7 and 306-8.1.6 c) at no additional cost to the Agency. Microtunneling operations must be approved by the Agency prior to commencement of work.

c) **Subsurface Data.** The following subsurface information will affect equipment selection and the progress and practicality of microtunneling. The actual test data required will vary depending upon the scope of the Work and soil conditions encountered and may include but not be limited to the following:

Particle-size analysis ASTM D422

Soil Classification ASTM D2487

Plastic limit ASTM D4318

Liquid limits ASTM D4318

Plasticity index ASTM D4318

Expansion index ASTM D4829

Density ASTM D1556, D2037, D5195, D4564.

Water (Moisture) content ASTM D4959, D2216, D5220, D3017, D4643, D4944.

Shear strength:
Direct ASTM D3080
Triaxial, C.U. ASTM D4767
Unconfined compressive strength ASTM D2166
Permeability ASTM D2434
Apparent or unconfined soil cohesion.
Standard penetration test (SPT) ASTM D1586.
Water table depth
Nature of fill material
Nature of pollutants
Rock type and color
Fracture index
Rock quality designation (RQD)
Core recovery, TCR.

All reasonable attempts will be made to collect subsurface test samples within 20 feet (6m) horizontally of the centerline of the proposed conduit location. Subsurface test samples are to be collected to a minimum depth of one pipe diameter below conduit invert. The test samples should typically be collected at 200-foot (60m) intervals or at manhole locations.

306-8.1.7 Site Cleanup. Unless otherwise specified, all existing surface improvements damaged or removed as a result of microtunneling operations shall be restored to their original condition.

306-8.2 Major Components of a Microtunneling System.

306-8.2.1 MTBM. The MTBM selected shall be capable of installing the pipe while being compatible with the anticipated soil and geotechnical conditions. The MTBM cutter face shall at all times be capable of supporting the full excavated area without the use of ground stabilization and have the capability of measuring the earth pressure at the face and setting a calculated earth balancing pressure. The maximum radial annular space shall not exceed 1 inch (25mm), unless otherwise specified in the Contract Documents.

The MTBM shall be capable of controlling shield rotation by means of a bi-directional drive on the cutter head or by use of mechanical fins or grippers. The MTBM shall be mechanically articulated to enable remotely controlled steering of the shield. The MTBM shall control groundwater during excavation without the use of external dewatering equipment. The measuring and balancing of earth and groundwater pressure shall be achieved by use of a slurry or cased auger system. The system shall be capable of incremental adjustments to maintain face stability for the soil conditions encountered.

306-8.2.2 Jacking Equipment. The main jacks shall be mounted in a jacking frame and located in the jacking shaft The MTBM shall be moved forward by the jacks advancing a successive string of connected pipes toward a receiving shaft

A pipe lubrication system may be used to lower the friction developed on the surface of the pipe during jacking with approval of the Engineer. An approved lubricant, typically betonite or polymers, may be injected at the rear of the MTBM or through lubrication ports. The pipe lubrication system pressure shall be continuously monitored, recorded, and controlled to prevent pipe buckling and/or ground heave.

A thrust block is required to transfer jacking loads into the soil. The thrust block shall be perpendicular to the proposed pipe alignment. The thrust block shall be designed to support the maximum jacking pressure

developed by the main jacking system. Special care shall be taken when securing the pipe guide rails and/or jacking frame in the jacking shaft to ensure correctness of the alignment, grade, and stability of the pipe. If a concrete thrust block or treated soil zone is utilized to transfer jacking loads into the soil, the MTBM shall not be jacked until the concrete or other materials have attained the required strength.

When intermediate jacking stations are utilized, the maximum jacking force shall not exceed the maximum allowable jacking load of the pipe.

306-8.2.3 Excavation Controls. The control equipment shall integrate the method of excavation and removal of soil and its simultaneous replacement by a pipe. As each pipe section is jacked forward, the control system shall synchronize spoils removal, excavation, and jacking speeds.

Operations shall be stopped when they result in pipe damage or any surface disruption. The Contractor shall propose immediate action for review and approval by the Engineer to remedy the problem at no additional cost to the Agency.

306-8.2.4 Automated Spoils Transportation. The MTBM shall include one of the following:

a) **Slurry System.** The system shall be capable of measuring earth and groundwater pressure and making the adjustments required to counter-balance the earth and groundwater pressure to prevent loss of slurry or uncontrolled soil and groundwater inflow.

1) The slurry pressure at the excavation face shall be controlled by use of slurry pumps.

2) A slurry bypass method shall be included to allow for a change in direction of flow to be made and/or isolated.

3) Provide a separation process, properly sized for the tunnel being constructed, the soil type being excavated, and the workspace available at each area. Separate the spoil from the slurry so that slurry may be returned to the cutting face for reuse.

4) Monitor the composition of the slurry to maintain the slurry density and viscosity limits as approved in the submittals.

b) **Cased Auger System.** The system shall monitor and continuously balance the soil and groundwater pressure. The system shall be capable of adjustments required to maintain face stability for the particular soil condition to be encountered to prevent loss of soil or uncontrolled groundwater inflow.

1) Maintain the pressure at the excavation face by controlling the volume of spoil removal with respect to the advance rate. Monitor the speed of the rotation of the auger and the amount of water added.

2) Submit an evaluation of equipment's ability to balance earth and water pressure at the face, stability of the soils, and the significance of the groundwater present for the Engineer's review.

306-8.2.5 Active Steering Controls. A remotely controlled steering mechanism shall be provided that allows for the operation of the system without the need for personnel to enter the microtunnel.

The steering information shall be monitored and transmitted to the operation console. the minimum steering information available to the operator on the control console shall include the position of the shield relative to the design reference, roll, inclination, attitude, rate of advance, installed length, thrust force, and cutter head torque.

306-8.2.6 Guidance/Monitoring Equipment. The MTBM display equipment shall continuously show and automatically record the position of the shield with respect to the project design line and grade. The automated recording system shall include real time information such as earth and ground pressure, roll, pitch, attitude, rate of advance, installed length, cutter head torque, jacking loads, slurry pressure, slurry flow, and slurry valve positions.

Line and grade shall be controlled by a guidance system that relates the actual position of the MTBM to a design reference (e.g., by a laser beam transmitted from the jacking shaft along the line of the pipe to a target mounted in the shield). The line and grade tolerances of pipe installed shall be ± 1 inch (25mm) on grade and 1-1/2 inches (38mm) in line between shafts, unless otherwise stated in the Contract Documents or approved by the Engineer.

The rate of return to line and grade shall not exceed 1 inch in 25 feet (1:300), unless otherwise specified.

306-8.3 Methods. Prior to pipe installation, the Contractor shall implement the approved plan submittals to monitor ground movement.

306-8.3.1 Intermediate Shafts. If an intermediate shaft is requested, the Contractor shall obtain a written approval from the Engineer. The intermediate shaft shall not be located in areas prohibited the Contract Documents. The Contractor's request shall include all necessary permits and approvals, minimize public inconvenience and minimize impacting existing facilities.

306-8.3.2 Annular Space Grouting. The annular space created by the overcut of the MTBM in excess of 3/4 inch (19mm) shall be filled with an approved material, unless otherwise specified in the Contract Documents.

When grouting is specified, pressure-injected grout shall fill voids outside the limits of the excavation created by caving or collapse of earth cover over the excavation.

The Contractor shall furnish and operate suitable equipment for any required grouting operations depending on the condition of the application. The grouting operation shall not damage adjacent utilities or other properties. Grout shall be injected at a pressure that will not distort or imperil any portion of the work or existing installations or structures.

306-8.3.3 Work Hours. Work hours are not restricted unless stated otherwise in the Contract Documents. Multiple shifts may be used where permitted by the Contact Documents and if noise levels do not exceed local ordinances. Continuous microtunneling will be permitted where:

a) Expansive soils are encountered; or

b) The actual jacking forces required approach either the capacity of the jacking system or the designed jacking capacity of the pipe.

306-8.3.4 Construction Zone. Any microtunneling construction zone in the public right-of-way shall be limited to one lane traffic, or the Contractor shall maintain a minimum of one lane of traffic in each direction. The Engineer may specify a larger or smaller zone if circumstances warrant.

306-8.3.5 Shafts. Shafts shall be of a size commensurate with safe working practices and located as described in the Contract Documents. With the written approval of the Engineer, the Contractor may relocate shafts to better suit the capabilities of the microtunneling equipment proposed.

Shaft locations shall, where possible, be kept clear of road intersections and within a single traffic lane, in order to minimize disruption to the flow of traffic.

The design of the shafts shall ensure safe MTBM exit from the driving shaft and entry into the receiving shaft The Contractor shall furnish and install equipment to keep the jacking shaft free of excess water. The Contractor shall also provide surface protection during the period of construction to ensure that surface runoff does not enter shafts.

All shafts shall be backfilled per 306-1.3. All shoring materials, bracing, temporary supports, rubbish, and construction materials shall be removed from the jobsite and disposed of.

306-8.3.6 Installation and Field Testing. The pipe installation shall be tested in accordance with 306-1.4.

306-8.4 Payment. Unless the Specifications provide for Contract Unit Prices for individual work items included in microtunneling work, the lump sum or Contract Unit Prices per linear foot for microtunneling as set forth in the Bid shall include full compensation for grouting and lubricants; providing jacking/receiving/recovery shafts including excavation, disposal, dewatering, backfill and replacement of surface or other improvements; furnishing and installing pipe, excavating, and disposal of materials encountered by installation of the pipe; and all other work appurtenant to microtunneling within the limits described in the Contract Documents.

306-8.5 Pipe Specification. In general, pipe used for this subsection shall be specifically designed for microtunneling by the pipe manufacturer. The pipe shall be round, smooth, and with flush-jointed outer surfaces. The ends of the pipe shall be perpendicular to the longitudinal axis of the pipe with a maximum deviation of no more than 1/16 inch per foot (5mm/m) of pipe diameter, with a maximum of 1/4 inch (6mm), measured with a square and a straight edge across the end of the pipe. Pipe ends shall be square and smooth so that jacking loads are evenly distributed against the pipe end faces without point loads when the pipe is jacked. Pipe used for microtunneling shall be capable of withstanding the jacking forces imposed by the process of installation, as well as the final in-place loading conditions. The driving ends of the pipe and intermediate joints shall be protected against damage. The detailed method proposed to cushion and distribute the jacking forces shall be submitted to the Engineer for approval.

Damaged pipe shall be jacked through to the reception shaft and be removed. Other methods of repairing the damaged conduit may be used, as recommended by the manufacturer and approved by the Engineer.

The pipe manufacturer's design jacking loads shall not be exceeded during the installation process. The pipe shall be designed to take full account of all temporary installation loads. The pipe materials acceptable for microtunneling will be specified in the Contract Documents.

The maximum jacking capacity used shall not exceed the allowable jacking capacity of the pipe that has a minimum factor of safety of 2.5.

SECTION 307 - STREET LIGHTING AND TRAFFIC SIGNAL SYSTEMS

307-1 GENERAL. The work shall consist of furnishing and installing, modifying, or removing one or more street lighting and/or traffic signal systems, as shown on the Plans and specified in the Specifications. The work shall conform to the following codes:

a) California Administrative Code, Title 8, Chapter 4, Subchapter 5, and

b) NEC.

Incidental parts that are not shown on the Plans or specified in the Specifications and are necessary to complete the Work, shall be furnished and installed as though such parts were shown on the Plans or specified in the Specifications.

Unless otherwise approved by the Engineer, the Contractor shall submit a list of equipment and materials to be installed in accordance with 2-5.3. The list shall include the name of the manufacturer, size, and identifying number of each item. In addition, the Contractor shall, in accordance with 2-5.3, submit detailed Shop Drawings and wiring diagrams for the electrical equipment to be used.

If requested by the Engineer, the Contractor shall submit for review samples of the material proposed for use. After review, the samples will be returned to the Contractor.