in typical waterworks projects. Direct references to the sample project in which DIP was installed are interlaced within the following text to make the recommendations more realistic.

The project consisted of the following components:

- 20,000 ft (6,000 m) of 30-in. (750-mm) Class 250 DIP
- 2,000 ft (600 m) of 30-in. (750-mm) Class 300 DIP (for deeper segments)
- 2,500 ft (760 m) of 16-in. (400-mm) Class 250 DIP
- 500 ft (150 m) of 12-in. (305-mm) Class 250 CIP (for connection to existing water mains)
- 4 tapping valves and sleeves for end connections
- 10 air release valve (ARV) structures (at high points)
- 7 blow-off (BO) valve structures (at low points)
- 10 high-pressure 30-in. (750-mm) in-line butterfly valves
- 300 ft (90 m) of bored and jacked casing for three stream crossings
- 500 ft (152 m) of bored and jacked casing under a state highway

The project was built in two phases (i.e., by two independent constructors). Each phase had 270 days allocated for final completion after notice to proceed. The first phase was completed a few days ahead of schedule; the second phase, which involved more difficult traffic control and significant buried utilities, was completed 4 months ahead of schedule because of the utility contractor's extensive experience. Most of the pipe was installed using open trench, and the stream and highway crossing was installed in a bore/jack casing. Figure 12-2 shows a typical trench detail and provisions for sand backfilling the entire depth under state roads.

12.4 DELIVERING PIPE TO THE JOB SITE

12.4.1 Marking Each Piece

All pipe sections are marked and labeled according to *ANSI/AWWA C 151/A 21.51* standard requirements and, if applicable, to a pipe laying schedule prepared by the manufacturer for the specific project. This standard requires marking the weight, class or nominal thickness, and casting period on each pipe. Additionally, the manufacturer's mark, country where cast, year in which the pipe was produced, and the letters "DI" or "DUCTILE" are cast or stamped on the pipe. Pipes of similar joint, length, and class are often marked with the same number to provide storage and handling flexibility in the field.

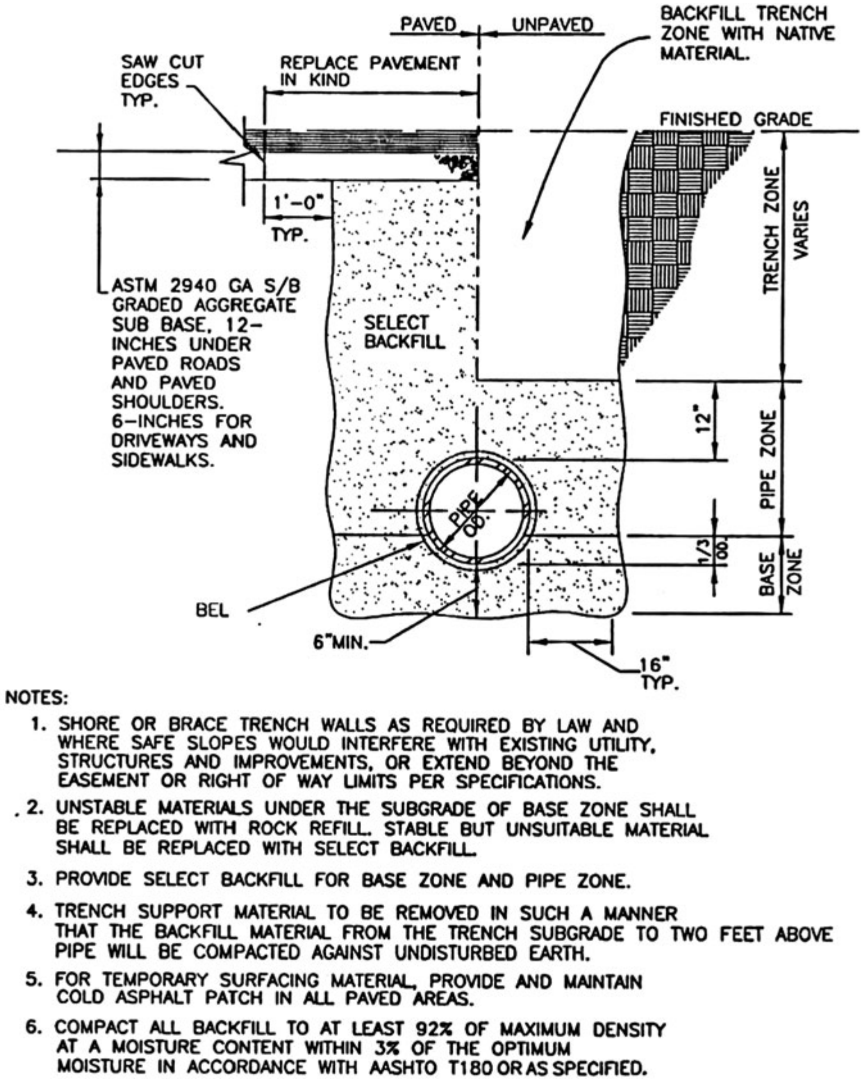

Figure 12-2. Trench detail for the sample project. Courtesy of the Watek Engineering Corporation.

12.4.2 Transporting Pipe Units

Pipes are normally shipped on a flatbed truck with spacers. On some large projects, pipe is shipped by rail car, if available. Pipe with special linings and/or coatings that are sensitive to UV or other damage are occasionally required to be shipped with end caps or other protection. Depending on the pipe size and number of tiers in a package, the bundles may be stacked in two or more high and secured to the truck bed by nylon straps. In making up tiers of pipe, every other pipe is usually turned so that at each end of the tier, the pipe is alternately bell and plain end. Loads on trucks or trailers are usually secured by nylon straps. Loads on rail cars are usually fastened to the car with steel strapping.

12.4.3 On-Site Inspection and Storage

The owner's representative can perform and witness various quality control tests of the piping at the pipe manufacturer's facility if required. Various inspections, such as coating and pipe thicknesses, and other testing to indicate specification conformance, can also be performed at the job site. In addition, the purchaser's representative should verify each shipment against shipping papers for any shortages or errors, which should also be recorded on the bill of lading by the carrier's agent. The purchaser may make tests specified in the applicable standard to ensure compliance. The manufacturer or contractor is responsible for replacing defective materials. All unusable defective material caused by manufacture or damage in shipment should be rejected and recorded on the bill of lading. Gaskets, polyethylene wrap, and nuts and bolts should be stored in a dry location out of direct weather and sunlight.

If the project site allows, the ideal case is for the pipe to be strung out along the work area. This method was generally used in the sample project, as shown in Fig. 12-3. Safety signs, pipe supports, etc. were used to prevent rolling and possible pedestrian or traffic hazards. Pipe storage along the edge of the travel-bed road was generally successful except in certain segments where right-of-way was fairly narrow. In those cases, accommodating vehicle traffic and pedestrians required storage at an off-site facility, and the pipe was brought to the site as needed.

Figure 12-3. Pipe storage on the job site. Courtesy of the Watek Engineering Corporation.

12.4.4 Unloading

Proper unloading of DIP is critical to prevent personnel injury and damage to the pipe or property. Pipe loads are often shipped with warning labels. The construction personnel must be familiar with and follow these procedures. Pipe should never be rolled off or dropped; a forklift or crane should be used for unloading. Before any length of pipe is lowered into the trench, it should be inspected for damage and the inside of the pipe should be inspected for loose dirt and foreign objects. If mud or trench water has been permitted to flow through the pipe, the inside should be scrubbed with a strong chlorine solution (for water mains) and flushed clean. This precaution will save time and expense when disinfecting the completed water main.

12.4.5 Stacking

DIP can be stacked if long-term storage is required. For safety and convenience, each pipe size is normally stacked separately. Refer to manufacturer's guidelines and DIPRA recommendations for maximum allowable stacking heights.

12.5 LAYING PIPE

12.5.1 Site Verification and Utility Conflicts

A sample of the plan and profile sheets used for the project is shown in Fig. 12-4.

An aerial survey with a 1-ft (0.3-m) contour accuracy was used during design of the sample project. The maps were digitized and various utilities and right-of-way information were shown on both plans and profiles based on available records. Data on critical crossings and connections were based on test pits. This degree of detail made the site verification and potential utility conflicts insignificant. Limited site investigations were conducted to minimize conflict with utilities and traffic impacts as well as to establish exact location and procedures for boring and jacking pits.

All curves and deflections were defined with coordinates during design. This procedure made it easy to set construction staking every 50 ft (15 m) and to control line and grade. The stakes were offset 10 ft (3 m) to minimize disturbing them.

All utilities were marked with different color paints by "Miss Utility" (the local One-Call service) prior to start of any work. During a boring and jacking operation, a group of telephone conduits and wires was cut despite the fact that the phone lines were located almost exactly where

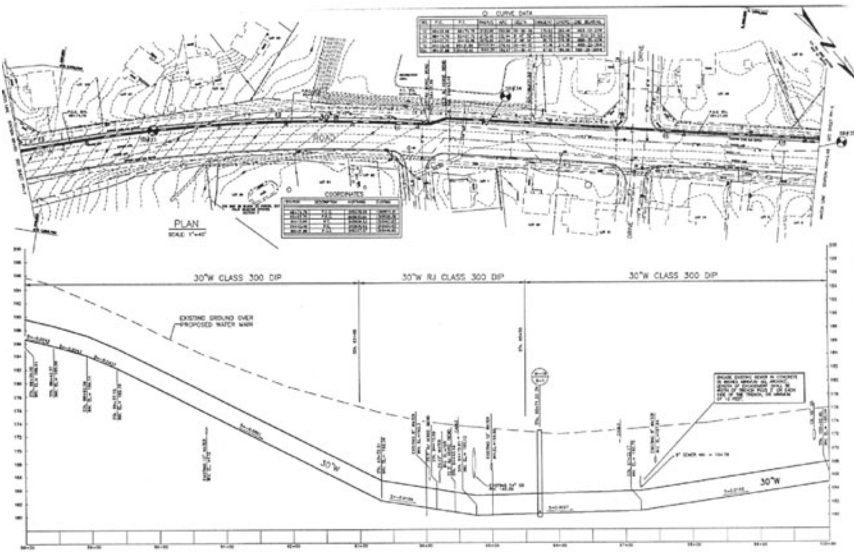

Figure 12-4. A typical plan and profile sheet for the sample project. Courtesy of the Watek Engineering Corporation.

they were marked. The main problem was lack of communication between various team members and the staff marking the utilities. A shallow storm drain immediately adjacent to phone cables had not been marked, and the cables were damaged because the constructor assumed the marks only showed the storm drain.

12.5.2 Details of Pipe Laying

Many of the general installation practices for DIP, such as trenching, dewatering, bedding, backfilling, and compaction, have been discussed in Chapters 3 through 8 of this manual. Other details can be obtained from the pipe manufacturer, DIPRA, and AWWA guidelines.

DIP should be lowered into the trench with slings or pipe tongs. Under no condition should it be pushed off the bank and allowed to fall into the trench. A variety of slings are available for handling DIP. Nylon slings are particularly well suited for lifting DIP and appurtenances. Several patented lifting tongs or clamp devices are available that release the pipe automatically whenever the hoist cable is slack. Care should be taken when using pipe tongs near trenches that have bracing protruding above ground. If the pipe contacts trench bracing or other similar components, the pipe tongs may release the pipe prematurely, which could result in personnel injury and pipe damage. When pipe is furnished with special exterior coatings, slings, tongs, or other handling devices should be padded to prevent damage to the coatings. Care should also be taken such that the steel hooks or chains used in lifting do not damage the interior lining of the pipes and fittings.

Although pipe is commonly laid with the bells facing the direction in which work is progressing, this practice is not mandatory. The direction of the bells is not functionally related to the direction of flow within the main. On larger diameters, the engineer or manufacturer may require that the bells face the direction of work to reduce loading on the spigot end. When pipe laying is not progressing, the open end of the pipe should be closed by a watertight plug or other approved methods. Depending on the pipe size and class, care must be taken to prevent pipe flotation if the trench floods while the pipe is plugged.

DIP joints should be assembled in accordance with *ANSI/AWWA C 600* and the manufacturer's recommendations. All spigots should be checked to ensure roundness prior to attempting joint assembly. The pipeline must often divert from a straight line when following the curvature of streets and roads. Push-on, mechanical, and many styles of restrained joints are well suited to applications where such joint deflection is required. On curves, the trench should be excavated wider than normal to allow for straight-line assembly before deflection. The deflection should not exceed that recommended by the pipe manufacturer.

DIP can be cut in the field using an abrasive cut-off saw, a rotary wheel cutter, a milling wheel saw, or any other device acceptable for cutting DIP. Cut ends and rough edges should be ground smooth. The cut end of push-on-type connections must be beveled slightly. The ANSI/AWWA standards for DIP require factory gauging of the spigot end of the pipe. Accordingly, pipe selected for cutting should be field-gauged. A mechanical joint gland inserted over the pipe barrel often serves as a convenient indicator for field gauging, although other procedures are available.

The following is a general sequence of DIP installation and is presented here only as a guide, not a procedure:

1. Excavate trench as required for the specified alignment, depth, and width. Provide trench support for safety as well as protection of the adjacent utilities, structures, and property, following the OSHA standards and project specifications. Provide temporary support of rails, tracks, power poles, etc. (if applicable) per agency requirements.
2. Remove and dispose of all rock, ashes, cinders, refuse, and organic or other unsuitable material to a minimum of 6 in. (150 mm) below pipe bottom.
3. If subgrade is unstable, provide a foundation for the pipe (e.g., large aggregate, concrete) as specified.

4. Excavate for bell holes at each joint, but not more than necessary to allow pipe to rest on its full length and not on the bells.
5. Dewater the trench and direct discharge away from the trench. Provide water quality and quantity control per specifications.
6. If the trench passes over or under other existing utilities, provide adequate clearances and compact the bottom of the trench as required to provide support equal to that of native soil.
7. Pipe is commonly laid with the bells facing the direction in which work is progressing. Check specifications for requirements.
8. Protect ends when pipe laying is not in progress. Foreign matter in the socket and spigot ends should be removed prior to gasket installation. The gasket should be wiped clean, flexed, and then placed in the socket. Looping the gasket generally will facilitate insertion.
9. Apply lubricant with a brush per manufacturer's recommendations.
10. The spigot should not be allowed to touch the ground or trench side after it is lubricated.
11. Joint assembly is performed by forcing the spigot end past the painted stripes. Refer to manufacturer's literature for paint mark descriptions and applying paint marks in the field for cut pipe sections.
12. When the pipe is deflected at the joints in a vertical and/or horizontal plane, comply with the maximum deflection allowances in the specifications.
13. DIP can be cut using an abrasive pipe saw, rotary wheel cutter, guillotine pipe saw, milling wheel saw, or a torch (if allowed by the manufacturer). Cut ends must be ground smooth and beveled. Follow manufacturer's recommendations for repairing and patching coating and lining. Note that some linings and coatings are heat-sensitive.
14. Backfill and compact the trench in accordance with the specifications.

DIP installation problems are often caused by the installer's lack of knowledge of the pipe joints and proper installation procedures. The larger a pipe is, the more difficult the installation. Careful consideration should be given to use trained installers with experience in the type of joint being installed.

Some linings and coatings are fragile and cannot tolerate abuse. Linings and coatings are subject to damage caused by methods of shipment, storage, handling at the site, installation, and welding (sometimes required for cathodic protection).

All the procedures recommended by the manufacturer must be reviewed and followed, and a trial run should be performed on a sample pipe to optimize the techniques before any pipe is installed. A manufacturer's representative and the design engineer can provide guidance during this practice procedure.

Figure 12-5. A typical pit for earth boring and pipe jacking. Courtesy of the Watek Engineering Corporation.

On the sample project, a trial run, including installation of the restrained joint pipe, welding a thermite weld wire, trench, and backfill was performed with the owner, inspector, and design engineer present. This procedure proved to be informative and useful.

A Komatsu PC300 LC backhoe with a 5-ft (1.5-m)-wide bucket was used for excavation, pipe installation, and backfill of the sample project. A 6-ft (1.8-m)-wide trench box was used except where the trench had to be sheeted and shored for boring and jacking pits, as shown in Fig. 12-5.

The sample project contract documents required backfilling the trenches daily and providing cold asphalt patch in the roadways because of neighborhood traffic and sediment control concerns. Therefore, dump trucks were loaded with excess soil excavated from the trench on a routine basis and taken off-site for disposal. This method of backfilling trenches and patching pavement daily greatly reduced sediment and traffic control impacts.

Pipe installation generally proceeded with minimal difficulties at a rate of about 200 ft (60 m) per day in nonpaved areas and 140 ft (42 m) per day in paved areas requiring traffic control and significant utility crossings.

Figure 12-6. Pipe-laying activity using a trench box. Courtesy of the Watek Engineering Corporation.

Soil boring logs were available about every 500 ft (150 m) and at each end of bored and jacked casings. Soil tests showed that the majority of the soils in the area were acceptable for the trench zone backfill. Figure 12-6 shows typical trench and pipe installation activity.

Minor problems occurred with installing the polyethylene encasement (poly-wrap) in difficult and wet areas. The encasement supplied was a bag type, which was difficult to pull over the pipe and fittings in certain areas. Flat sheets may have worked better in such areas. *AWWA C 105* procedures should be followed in installing poly-wrap.

12.6 TAPPING

12.6.1 Small Taps

Small service taps and house connections can easily be made either before or after pipe installation. All available pressure classes of DIP can be tapped for 0.75-in. (19-mm) service, and 1-in. (25-mm) taps can be made into 6-in. (150-mm) and larger pipe. Some utility companies and engineers prefer saddles instead of tapping, regardless of size. Two or more wraps of polyethylene adhesive tape is recommended around the pipe where the tapping machine and chain will be mounted (if polyethylene encasement is used). Double-wrap Teflon tape and/or sealant is used on the corporation threads(fittings with three-step plating).

When frost and freezing of service lines may be an issue, the tapping should be installed horizontally at the 3 o'clock or 9 o'clock position on the DIP to maximize available cover over this service line.

12.6.2 Large Connections

Larger connections to DIP can be made using tees, outlets, tapping sleeves, or tapping saddles with various types of outlets, such as flange and mechanical joints.

12.7 CONNECTIONS TO STRUCTURES

In the sample project, flanged and grooved end joints were used within the vaults and structures. Buried pipe was primarily unrestrained push-on joint, except where restrained joints were required on either side of valves and changes in direction. Length of the restrained sections depended on the type of soil, bedding/backfill conditions, internal pressure, and type of bend or fittings. All the details and types of joints were clearly indicated on the manufacturer-prepared layout drawing, which was completed in accordance with the project drawings and specifications.

12.8 INSTALLING IN TUNNELS AND CASINGS

Usually, a casing pipe must be installed under a highway, railroad, or stream crossing with the carrier pipe inside the casing. Casing pipe installation methods vary by pipe size, casing length, soil conditions, available machines, preferences, and so forth.

Carrier DIP may be pushed or pulled through the completed casing depending on the design of the annular space. Carrier-to-casing contact must be avoided by using wood chocks or manufactured skids. Certain types of joints, such as restrained joints, require pulling after the joint is made. Consult with the pipe manufacturer regarding pulling or pushing limitations as a function of carrier pipe length.

At several locations in the sample project, such as highway and stream crossings, the DIP was used as a carrier pipe in a concrete casing pipe (installed by boring and jacking operation). Conventional concrete cradles and modern casing spacers were reviewed during design based on construction safety, capital cost, future flexibility, and other factors. Casing