



Design Guidelines for Water and Sewer Facilities

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WATER AGENCIES' STANDARDS

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SECTION 2.1 PROCEDURAL GUIDELINES

2.1.1 PURPOSE

The purpose of the Procedural Guidelines section is to provide an Engineer of Work guidance for preparing development improvement plans. The goal of Section 2 is to provide an overview of development processing from "service inquiry" through "acceptance of construction work" in order to obtain water and/or sewer service for a development. Figure 1 lists other sections in the Design Guide that may be needed to help facilitate development processing.

**Figure 1
Reference Sections**

Subject	Reference Section	When Applicable
Drafting Guidelines	Section 1.1	Preparing improvement plans-general information
AutoCAD Guidelines	Section 1.2	Preparing improvement plans using AutoCAD
MicroStation Guidelines	Section 1.3	Preparing improvement plans using MicroStation
Easements and Encroachments	Section 1.5	Water, sewer or recycled water not within public right-of-way
Survey Standards Guideline	Section 1.6	Preparing plans from survey data.
Record Drawing Guidelines	Section 1.7	Preparing as-built record drawings.
Water Planning	Section 4.1	Determining peaking factors, velocity and fire flow criteria for water pipelines
Sewer Planning	Section 4.2	Determining peaking factors, slope and velocity criteria for sewer pipelines
Recycled Water Planning	Section 4.3	Determining peaking factors and velocity criteria for recycled water pipelines
Sub Area Master Plan Development	Section 4.4	Preparing water or sewer studies for large/complex developments
Environmental Review and NPDES	Sections 4.5 and 4.6	Applicable for projects subject to CEQA & NPDES
Water Pipeline Design	Sections 5.1 thru 5.11	Designing water pipelines and appurtenances
Sewer Pipeline Design	Sections 6.1 thru 6.5	Designing sewer pipelines and appurtenances

2.1.2 STANDARD TERMS AND DEFINITIONS

Wherever technical terms or pronouns occur in these guidelines or in related documents, the intent and meaning shall be interpreted as described in Standard Terms and Definitions.

2.1.3 GUIDELINES

A. Service Inquiry:

The AGENCIES provide water and/or sewer service to properties within their service area boundaries and may service areas outside their current boundaries in limited circumstances. For confirmation of service availability, the applicant should call or visit the AGENCY listed. Information on how to contact each AGENCY can also be obtained at <http://www.sdcwa.org>. When visiting, a location map of the proposed project with the nearest major cross street intersection and/or the assessor's parcel number will be used to determine availability. Each AGENCY provides water and may provide recycled water or sewer collection depending on their organizational authority.

AGENCY NAME	ADDRESS	CITY, STATE, ZIP	PHONE NUMBER
Helix Water District	7811 University Avenue	La Mesa, CA 91941-4927	619-466-0585
Lakeside Water District	10375 Vine Street	Lakeside, CA 92040	619-443-3805
Otay Water District	2554 Sweetwater Springs Blvd.	Spring Valley, CA 91978-2096	619-670-2222
Padre Dam Municipal Water District	9300 Fanita Parkway Santee, CA 92071	Santee, CA 92072-9003	619-258-4635
Ramona Water District	105 Earlham Street	Ramona, CA 92065	760-789-1330
Santa Fe Irrigation District	5920 Linea del Cielo P.O. Box 409	Rancho Santa Fe, CA 92067-0409	(858) 756-2424
Sweetwater Authority	505 Garrett Avenue	Chula Vista, CA 91912	619-420-1413

B. Annexation To Improvement District/Service Area/Assessment District Inside Agency Boundary:

If a proposed development is within an AGENCY's jurisdictional boundary but not in an Improvement District (ID), Service Area (SA), or Assessment District (AD), the developer must file a formal application for annexation to the nearest existing ID/SA/AD. Each AGENCY shall be contacted to determine the process.

C. Annexation of Property Outside Agency Boundary:

If a proposed development is not within an AGENCY's jurisdictional boundary and the developer desires to annex, the developer may need to obtain multiple levels of approval and file an application for annexation to the AGENCY, County Water Authority, the Metropolitan Water District, and the Local Agency Formation Commission (LAFCO). Each AGENCY shall be contacted to determine the process.

D. Project Facility Availability Form:

1. In general, the County or City may require a letter from the AGENCY before the developer submits a Tentative Map for development review. For proposed developments within the boundary of an AGENCY's ID/SA/AD, the developer must request an "availability" form from the AGENCY. The request for an availability letter must have a detailed location map and project detail map attached in order for the AGENCY to determine service(s) available and conditions.
2. The project facility availability form will only be signed by the AGENCY upon payment of AGENCY fees. The Facility Availability Form is generated by the County or City.

E. General Planning Data:

1. Generally, during tentative tract map development, conceptual sizing and layout of the water and sewer systems should be shown along with dwelling unit densities, demand quantities, service locations, and points of connection to existing facilities. In addition, the normal information required on tentative tract maps is also required and a letter from the governing fire department indicating the required fire flows and hydrant spacing. The AGENCY's Engineering Department will review the system design taking into consideration the AGENCY's Master Plan, if applicable, and other factors. No action will be taken by AGENCY's staff unless all applications, fees, and deposits have been provided by the developer for services to be provided.
2. The developer is responsible for the payment and/or installation of all water, sewer, and recycled water facilities within and/or adjacent to their development including extension of lines to properties that may be served in the future. All work is to be coordinated with the AGENCY to minimize impacts and service outages to existing customers.
3. The necessity of a Sub-Area Master Plan (SAMP) will be determined solely by the AGENCY. Necessity is based upon but not limited to size of project, Code requirements, project location and/or size of existing sewer collection, or water distribution facilities, location within an ID/SA/AD or drainage basin or other determining factors as specified by the AGENCY. See Section 4.4 for more detailed information required when preparing a SAMP.

F. Project Facility Commitment Form:

1. The County or City, as part of the final map or grading plan approval process may require a project facility commitment form from the AGENCY. A request for facility commitment addressed to the AGENCY's Engineering Department shall be accompanied by a minimum 8-1/2 x 11 vicinity map and the tentative tract map and/or site plan.
2. Upon the execution of a binding water or sewer service agreement by the developer and/or approval of the conceptual water and/or sewer plan, the AGENCY will either sign the tentative map or SAMP, or provide a project facility commitment form to satisfy the County or City. The AGENCY reserves the right to change the conditions, proposed water, sewer or recycled water line sizes and/or locations after signing the tentative map, SAMP, or project facility commitment form.

G. Fire Flow Verification Form:

Proof of fire flow may be required by the governing fire department. Fire flow verification may be requested at various times during the process. The fire flow verification form is completed by the AGENCY and can be accomplished in a number of ways including field flow and pressure test, hydraulic modeling, or hand calculation. If a field flow and pressure test is conducted, it shall be done under the control of the AGENCY. Following the test or analysis, the AGENCY will provide the fire flow verification form with the results. A fee will be charged for field flow and pressure tests.

H. Service Verification Form:

In some areas the County or City may require verification that the AGENCY is willing to provide service to the proposed project prior to issuing a building permit. The developer shall provide the City/County service verification form for AGENCY signature or put in a written request to the AGENCY for service verification. The AGENCY will confirm that service is available to the parcel/area and provide a written response to the requestor. The approval may be given by the AGENCY even if the facilities are under construction and not completed at the time the service verification form is signed by the AGENCY.

I. Processing Improvement Plans:

1. Improvement plans shall be prepared in accordance with Section 2.2.

2. Deposits/Fees:

a. The AGENCIES collect deposits/fees for improvement plan checking and inspection at different times during the process depending on the size or complexity of the development. See each AGENCY for amounts, types of deposits/fees, and when deposits/fees are collected.

b. The AGENCIES will prepare or have the Engineer of Work prepare an estimate for construction using the current unit prices using those listed in Appendix 2.2.C as a minimum. When an item is not listed in Appendix 2.2.C and/or the unit price chosen by the Engineer of Work is not consistent with current construction costs, the AGENCY will make the final determination of the unit price. The estimate will be used to determine bond amounts, and for some AGENCIES, the estimate will be used to determine plan check, inspection deposits, and work to be performed by the AGENCY.

3. Plan Check:

The improvement plan check process will begin when the developer or Engineer of Work provides communication to the AGENCY to commence and after fees/deposits and applications have been made. The plan check process includes AGENCY review of the improvement plans prepared by the Engineer of Work, completing performance and labor and material bonds as well as easements, and encroachment permits. See Section 2.2 for Development Plan and Permit Processing.

4. Bonding and Agreements:
 - a. Bonds and agreements shall be processed in accordance with the Subdivision Map Act. Typically, the bonds and agreements shall be executed and endorsed properly by the developer and returned to the AGENCY before the AGENCY will sign the improvement plans. Should corrections during plan check be extensive enough to affect the total quantities of the facilities to be constructed, each AGENCY reserves the right to postpone the preparation of the bonds and agreements until such time as the quantity of work is finalized.
 - b. When construction has been successfully completed and the final inspections have been performed, the AGENCY's Inspector will notify the developer and AGENCY's Engineering Department. The AGENCY's Engineering Department will verify that all acceptance procedures have been finalized and process the Notice of Completion. Depending on the AGENCY, bonds may be reduced upon the filing of the Notice of Completion with a portion of the bond being retained during a one (1) year warranty period.

5. Reimbursements:

- a. Following final inspection, the developer will be required to prepare a Cost of Construction Statement on reimbursable projects. Those projects have a signed developer reimbursement agreement for the project and can include AGENCY Capital Improvement Program projects. The facilities can then be dedicated to the AGENCY. Details of this procedure are included in Section 2.2 under Acceptance of Work.
- b. Private party reimbursement agreements may be prepared and administered by the AGENCY. Reimbursement agreements may be applicable if the AGENCY requires a developer to oversize a facility, build a non-Capital Improvement Program pipeline, or construct a facility that benefits an adjacent future development.

J. Project Facilities Implementation:

1. Pre-Construction requirements per Section 2.2.
2. Construction:

The Water Agencies Standards (WAS) shall be used as the standard for all construction. See Section 2.2 for "permit" to construct requirements.

K. Individual Service Requests

1. See Section 2.2 for individual parcel service requests
2. See Section 2.5 Recycled Water Facilities for individual recycled water requests.

2.1.4 REFERENCE

- A. Should the reader have any suggestions or questions concerning the material in this section, contact the member Agency where the project is located.

B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the users convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.

1. Water Agencies Standards (WAS):

a. Design Guidelines

1. Section 2.2, Development Plan and Permit Processing
2. Section 2.5, Recycled Water Facility Guidelines
3. Section 4.4, SAMP Development (Master Plan)

END OF SECTION

WATER AGENCIES' STANDARDS

Design Guidelines for Water and Sewer Facilities

SECTION 2.2 DEVELOPMENT PLAN AND PERMIT PROCESSING PROCEDURES

2.2.1 PURPOSE

The purpose of this section is to help facilitate development plan and permit processing.

2.2.2 DEPOSIT AND/OR FEES

The AGENCIES collect deposits and/or fees for development review, improvement plan check and inspection, or any other tasks that require staff time. See each Agency for amounts and when deposits/fees are collected.

2.2.3 SUB-AREA MASTER PLAN (WATER, SEWER, RECYCLED WATER STUDY)

The necessity of a SAMP will be determined solely by the Agency. Necessity is based upon, but not limited to, Code requirements, size of project, project location and/or size of existing sewer collection, or water distribution facilities, location within an Improvement District/Service Area/Assessment District or drainage basin or other determining factors.

However, for all development, developers are responsible to size pipelines to meet current fire flow requirements, water quality conditions, and current design criteria. When an Agency determines that a SAMP is necessary, the developer shall provide the detailed information listed in Section 4.4. Some Agencies require a SAMP to be prepared by the Agency or a consulting engineer hired by the Agency. In all cases, the cost of the SAMP shall be the responsibility of the developer.

General information regarding SAMP's follows:

A. Water and/or Sewer SAMP's:

1. A water and/or sewer SAMP for the proposed development shall be submitted to the Agency for review at least sixty (60) days prior to filing a tentative map for the development, accompanied by a written request for the AGENCY's "facility commitment" form.
2. Correction comments will be indicated on the SAMP and returned to the Engineer of Work. Depending on the complexity of the development, more than one submittal may be necessary.

B. Recycled water landscape irrigation plans shall be as required in Section 2.5.

2.2.4 GENERAL RESIDENTIAL IMPROVEMENT PLAN PROCESSING GUIDELINES

A. Pre-Improvement Plan Check Submittal:

1. Preliminary plans may be required by an Agency to determine the plan check, construction inspection deposit and bond amounts. The Agency will use the unit prices listed in Appendix 2.2.C as a minimum or established prices not listed in the table for estimating construction cost and deposits and/or fees. See Agency for current or updated unit costs.

2. Contact Agency to determine if a pre-improvement plan check or construction cost estimate submittal is required.
3. If a pre-improvement plan submittal is not required, the Engineer of Work shall provide a construction cost estimate with the second improvement plan check using the unit prices listed in Appendix 2.2.C as a minimum. Once the Agency is satisfied with the construction cost estimate, performance and labor and material bond amounts will be established based on the quantities and unit prices.

B. AGENCY Processing Time:

1. The Agency will diligently pursue completion of the first plan check of the utility improvement plans within twenty (20) working days of the submittal date, provided that all of the required information is submitted at first plan check, and the plans are sufficiently complete to review. Subsequent plan checks generally take ten (10) working days. Turnaround of plans will depend upon the extent of the corrections required on a plan set and the current workload of the Agency.
2. Status of plans currently in for plan check can be obtained by contacting the Agency.
3. Plans submitted after the first plan check submittal shall be rejected if comments from previous check set are not addressed. If the Engineer of Work disagrees with a comment made in a prior plan check, the consultant shall contact the plan checker (include sheet number, comment, and design engineer's response) to discuss the issue prior to resubmittal of plans to the Agency. A note shall be made on the redline set of plans by the Engineer of Work as to the outcome of the conversation and include the written response from the Agency for any deviation from the comment in the previous plan check.

C. First Improvement Plan Check Submittal:

The Engineer of Work shall submit the following items for first review of any residential, commercial, or industrial development (See each AGENCY for number of plan sets required):

1. Utility improvement plans, size as listed in Section 1.1.
2. Tract/parcel map showing gross acreage, street names, and water, sewer, and recycled water easements with provision for the Agency's execution.
3. Grading plans.
4. Transmittal letter from the developer or Engineer of Work requesting the commencement of the Agency's plan check process.
5. Irrigation/Landscape Plans.

After first plan check, the Agency will return one (1) red-lined set of the utility improvement plans and tract/parcel map, and grading plans to the Engineer of Work for corrections.

Grading plans are required if the developer's grading operation will interfere with existing water, sewer, or recycled water pipeline easements or when new pipeline and/or access roads in easements will be granted from the developer to the AGENCY. In some instances, the City or County may request that the Agency sign the grading plans even if the aforementioned circumstances do not exist. See Appendix 2.2.B for notes. If, after first plan check, it is determined that the grading plans will not affect pipelines or contain new Agency pipeline easements and/or access roads, a note will be made on the grading plans that no further submittal is required.

Landscape irrigation plans are required if it is determined that recycled water is or will become available to a project in accordance with Section 2.5 or as required by the Agency.

D. Subsequent Improvement Plan Check Submittal:

The Engineer of Work shall submit the following items with second and subsequent plan checks for residential, commercial, or industrial subdivision:

1. Revised utility improvement plans, tract/parcel map, landscape irrigation, and grading plans. Some Agencies require the plans to be signed by the governing fire department prior to the second plan check.
2. Check print from the first and subsequent checks and any comments by the Engineer of Work on items for design elements that vary from the previous plan check.
3. Easement documents (if required) shall be as noted in this Section.
4. Cost estimates prepared by the Engineer of Work for water, sewer, and recycled water facilities as required by the Agency. Use unit prices listed in Appendix 2.2.C.

When the plans are substantially complete, with only minor revisions remaining, the Agency will complete the bonds (Labor and Materials, Performance) and agreements (Construction, Reimbursement (if needed), other) or have the Developer complete and submit the bonds and agreements for Agency approval. One (1) red-lined set of plan check comments will be returned to the Engineer of Work for corrections upon completion of the second and any subsequent plan check. In some cases, the Agency will have joint bonds with the City or County.

E. Easements:

Refer to Section 1.5 for easement width and location requirements.

Dedication of easements can be done by separate document or by map dedication.

When dedicating by separate document the following applies:

1. Copies of easement legal descriptions with accompanying plat map shall be prepared by the Engineer of Work and submitted to the Agency for review.
2. Legal descriptions for easements shall be in a form acceptable to the Agency and shall be accompanied by a current title report (within 3 months) to be checked by the Agency for current ownership.

3. For easements that have been dedicated by separate document, a call out with the document number and date shall be shown on the improvement plan sheets and on the index map to identify that the easement has been dedicated by separate document.
4. Improvement plans for the Agency facilities will not be approved until all required easements have been dedicated to the Agency along with any necessary reconveyances or subordination agreements.
5. Easement exhibit size shall be per Section 1.1.

When dedicating by tract or parcel map the following applies:

1. Tract or parcel map shall be prepared by the Engineer of Work and submitted to the Agency for review.
2. Appropriate certificates shall be shown on the map for Agency acceptance.
3. Easements shall be shown on the improvement plan sheet and on the index map and identify the tract or parcel map number where the easement is being dedicated.
4. All easements shall be shown with bearings, distances, and dimensions.

An easement grant/quitclaim deed package is available from each Agency. In some cases, it is necessary for the Agency to quitclaim or vacate easements to a developer when water or sewer utilities are being relocated into public right of way. Quitclaim of easements needs to be done prior to tract or parcel map recording because the new subdivision can cut the easement into segments. The vacation of easements may require approval from the Agency's Board of Director's.

F. Improvement Plan Approval and Permit to Construct:

The Agency and, if necessary, the County or City shall approve improvement plans before a pre-construction meeting can be scheduled. Approval by the Engineer will be contingent upon satisfying the following requirements:

1. All required corrections have been made on the utility improvement plans, and all systems are in conformance with the Agency.
2. The water, sewer, and/or recycled water Construction and Dedication Agreements have been executed.
3. If applicable, the water, sewer, and/or recycled water Developer/Agency Reimbursement Agreement has been executed. The reimbursement agreement applies to reimbursable projects such as Agency Capital Improvement Program projects that will be built by a developer for the AGENCY.
4. The governing fire department, developer, and Engineer of Work have signed the plans.
5. All required easement documents have been executed and delivered to the Agency. When required, the Engineer has signed tract/parcel maps.
6. The developer has paid all required deposits/fees.
7. Labor and material, and performance bonds have been posted.

8. A copy of the Contractor's insurance certificates has been provided to the Agency.
9. All electronic data has been submitted in accordance with this Section.

When these requirements have been satisfied, the original mylar title sheet, a clean bond set of plans and the latest plan check comments shall be submitted to the AGENCY. When the plans have been approved, the Engineer of Work will be notified. Engineer of Work shall provide the Agency with signed copies of improvement plans. In some cases, the Agency may request that an original mylar or photo mylar copy be submitted.

The approved plans shall constitute a "permit" to construct water, sewer, and/or recycled water facilities as referenced in the Agency's Rules and Regulations.

2.2.5 DETAILED RESIDENTIAL IMPROVEMENT PLAN REQUIREMENTS

All plans submitted to the Agency for plan check and approval of water, sewer, and/or recycled water facilities shall conform to the standards of the County or City where the improvements will be constructed. The plans shall also contain the information detailed herein. A checklist of the items to be reviewed by the Engineer of Work is provided in Appendix 2.2.A. If all the items can be checked off as fully satisfied or not applicable, the plan-check corrections should be minor in nature.

A. Title Sheets:

Title sheets for utility improvement plans shall contain the following information as a minimum:

1. Project identification legal description, assessor's parcel number(s), tract/parcel map number, project name, assigned plan check number, and site address.
2. Vicinity map per Section 1.1.
3. *A key map per Section 1.1 with the following additional information for development projects:
 - a. The size of all pipelines.
 - b. The direction of flow for all sewer lines and the manhole numbers.
 - c. Lot lines for the proposed development, driveways, footprints of buildings, and service lateral locations for each lot.
 - d. Existing and proposed easements for AGENCY facilities.
 - e. Map numbers and records of survey for adjacent properties.
4. Sheet index per Section 1.1.
5. General notes per Section 1.1 and Appendix 2.2B.
6. Dig alert symbol per Exhibit 1.1-D.
7. Horizontal and vertical control per Section 1.1 and 1.6.
8. Water Agencies' Notes. Work to be Done and Water Agencies' Notes are shown in Appendix 2.2.B. Standard notes go on all improvement plans. Water, sewer, and recycled water notes need to be included on the improvement plans when those types of public improvements will be constructed. Standard, water, sewer, and recycled water notes shall appear under separate headings and not be co-mingled.

9. Signature block for AGENCY approval to be provided by the AGENCY.
10. Signature block for the governing fire department.
11. Signature block for County or City if an improvement plan is required by them.
12. Revision Block for Construction Changes.
13. Engineer of work's name, address, phone number, California registration number, expiration date, stamp, signature, date of signature, declaration of responsible charge, and name of engineering firm.
14. Name, address, phone number, and contact person of the property owner or developer.
15. *Legend with quantity estimates.
16. *Construction notes.
17. Grading plan, permit number, and/or drawing number.

* Denotes may be placed on a second sheet if insufficient space on cover sheet.

B. Second Sheet:

Typically the second sheet of the plan set will have the following information:

1. Legend with quantity estimates, if not on the title sheet.
2. Continuation of notes and construction notes.
3. Typical street cross sections showing all utilities, right-of-way widths, and sidewalks.
4. Detail drawings.

C. Plan View and Profile Sheets:

Provisions and requirements of Water Pipeline Design Section 5 and Sewer Pipeline Design Section 6 shall be adhered to in designing water, sewer, and recycled water facilities.

1. Profile: Provide information on profiles per Section 1.1.
2. Plan View: Provide information on plan view per Section 1.1 with the following additional information for development projects:
 - a. Data tables for Agency utilities that include:
 1. Bearing of line or delta.
 2. Radius.
 3. Length.
 4. Comments to include pipe size, class, and type of pipe.
 - b. Existing water, sewer, and recycled water facility tie-in locations. Indicate size, class, and type of pipe for these facilities and the AGENCY drawing number. Proposed development adjacent to subdivision boundary shall be shown.

- c. Subdivision boundary, lot lines and lot numbers.
- d. Pressure zone (tank overflow elevation).
- e. Fire hydrant flange elevation per WAS Standard Drawings WF-01, WF-02, or WF-03.
- f. Station for change of pipe size, class, direction, and type of pipe.
- g. Existing easements with document number and date and proposed easements to be dedicated to the AGENCY for sewer, water, and recycled water facilities shall be shown on the plan.
- h. Proposed building or dwelling unit pad elevations shall be shown.

D. Electronic Data Submittal:

- 1. The Engineer of Work will be requested to submit both the tract/parcel map and improvement plans in electronic format. If the County or City requires electronic submittals, the Agency will accept the electronic file in the same format as the County or City format. If the County or City does not require electronic submittals, the format for layers, line types, etc. listed in Section 1.2 shall be used.

- 2. Data Accuracy and Coordinate System:

The accuracy of data submitted in accordance with these specifications shall be consistent with data converted directly from COGO and may be used for computational purposes during the plan check and construction phase of the submitted project.

- 3. File Formats and Media Requirements:

Digital files shall be submitted in Agency approved formats. Digital files should be submitted on Compact Disk.

- 4. Checking of Digital Data:

Digital data will be checked for the following:

- a. Correct layering.
- b. Verification that annotated and calculated data are consistent.
- c. Verification that digital and hard copy plans are consistent.
- d. Verification of correct coordinate system.
- e. Verification that pipeline plan and profile drawings are shown in one drawing file.
- f. Verification that digital files do not contain unresolved line types, font files, and cross-references.

2.2.6 GENERAL COMMERCIAL/INDUSTRIAL IMPROVEMENT PLAN PROCESSING GUIDELINES

A. Water and Sewer Service Requirements:

All commercial and industrial water services will require that a reduced pressure backflow prevention device (RPBD) be installed downstream of the water meter. The device shall be installed in accordance with WAS Standard Specification 15112 and Standard Drawing WR-01 or WR-02. The assembly shall be above ground and not in an underground vault. If applicable, Appendix 2.2.C shall be used for estimating construction cost and for bond amounts.

Items required to make application for commercial/industrial service are:

1. Improvement plans with water and sewer service lateral location stationed and called out. Number of plan sets to be determined by AGENCY.
2. Plumbing plans showing the number of fixtures units/estimated water usage. Number of plan sets to be determined by AGENCY.
3. Irrigation plans showing the estimated annual irrigation demand and maximum flow rates for each irrigation zone.
4. A letter from the developer or Engineer of Work requesting a (size) meter, not to exceed (quantity) gpm, to serve (company name) at (address) and payment for the cost of installation.

The Engineer must approve any written request from a developer to use potable water for irrigation. All irrigation services using potable water shall be equipped with approved backflow prevention devices per WAS Standard Specification 15112 and Standard Drawing WR-01 or WR-02. Recycle water shall be used for irrigation when available. See Section 2.5 for Recycled Water Facility Guidelines.

B. Private Fire Protection Systems:

Check with the Agency to verify the limits of a "Private Fire Protection System". All private fire protection systems shall be made through a double check reduced pressure backflow prevention device with bypass meter as shown on WAS Standard Drawing WF-05. These assemblies can be installed in such a manner as to be screened from view, but shall be accessible to the governing fire department and the AGENCY's personnel at all times. There shall be five feet (5') of clearance on all sides of the assembly installed above ground. An agreement between the Agency and owner may be required to be executed for each fire protection system.

The plan check submittal package, if required based on AGENCY's discretion, shall include a site utility plan showing:

1. Property lines and required easements.
2. Building footprint.
3. All on-site private fire protection systems.
4. Stamp or signature of governing fire department.
5. Address of the building.
6. Assessor's Parcel Number.
7. Owner/Developer.
8. Location of fire service lateral and backflow prevention device.

C. Public Fire Hydrant Systems:

Where public fire hydrant system(s) are being installed and a public distribution pipeline needs to be extended parallel with the street to reach the property being served or when street improvement will occur, water improvement plans are required and the developer's contractor shall install the improvements. Process improvement plans in accordance with this Section.

The plan check submittal package for installation of public fire hydrants without a public extension, if required based on Agency's discretion, shall include a site utility plan showing:

1. Property lines and all existing and proposed easements.
2. Building footprint.
3. Locations and flow requirements for fire hydrants. Must be approved by the governing fire department.
4. Payment of all required plan check or field estimate deposits/fees to Agency. The developer shall bear the responsibility and cost of installing the fire hydrant after the plans are approved by the Agency. In some cases, the Agency will install the fire service lateral and hydrant. Fire hydrant will be installed after deposit/fee has been made. Plans are required if a water pipeline needs to be extended for the fire hydrant installation or when there is street improvements.

D. Recycled water service requirements shall be in accordance with Section 2.5.

2.2.7 DETAILED COMMERCIAL/INDUSTRIAL IMPROVEMENT PLAN REQUIREMENTS

Improvement plans are required for commercial/industrial developments with the following additions:

Commercial/Industrial improvement plans shall be process in accordance with this Section and shall also generally follow in accordance with Sections 2.2.4 and 2.2.5.

- A. See Agency for water meter sizing standards.
- B. Deposits and/or fees will be determined by the Agency for service installations. The service will be installed by the Agency if the service lateral will be connected to an existing pipeline or by a contractor hired by the developer if a new pipeline is being constructed. If the developer hires a contractor, the contractor shall construct the facilities on the improvement plans including the services and the Agency will inspect the work. All wet taps will be performed by the Agency.

2.2.8 INDIVIDUAL SERVICE REQUESTS

- A. Individual service requests shall be made in writing and, such projects depending on the complexity of improvements, may be required to have an improvement plan. After the plans depicting the service connections are approved, the developer shall prepare a service request application. Fees and/or deposits will be required at the time the service application is submitted.
- B. Once the service application is approved and the developer has paid fees, the service will be installed by the Agency.

2.2.9 SUPPLEMENTAL INFORMATION FOR RESIDENTIAL, COMMERCIAL/INDUSTRIAL PROJECTS

- A. The developer/owner will install water, recycled water, and bypass meters on backflow prevention devices at unmetered connections. This is because backflow prevention devices come with a preinstalled meter.

- B. Depending on the Agency, plans will be valid for a period of one (1) to two (2) years from the date of the Agency's approval. If construction has not started within this timeframe, the approval of the plans becomes null and void. In this event, the Agency will require that the plans be re-checked. Recheck may require additional plan check fees and/or connection fees. Bonds and agreements shall also be renewed. New updates to the WAS during the lapse shall be included during redesign and construction of the public improvements.
- C. An increase in the number of units to be served by the system will not be allowed without approval from the Agency.
- D. Contractor material submittals and shop drawings shall be provided to the Engineer of Work for review and approval. The Engineer of Work shall review and mark the submittals as either approved or denied and submit them to the Agency for review. The Agency will return the submittal to the contractor.
- E. Pre-Construction Meeting for Public Improvements shall be in accordance with WAS Standard Specification 01000.
- F. Construction Schedule for Public Improvements shall be in accordance with WAS Standard Specification 01000.
- G. Construction Changes:

During construction, if circumstances or conditions require that pipeline horizontal or vertical alignments need to change, water or service later locations need to be moved, fire hydrant locations need to be changed, or any other deviations that in the opinion of the Agency's Inspector or Engineer warrants a change to be shown on the plans, the Engineer of Work shall prepare a construction change showing the proposed location, alignment or discrepancy on the original mylar improvement plans. The construction change shall be signed by the Engineer prior to the work being completed. The Agency's Inspector shall determine whether a construction change is warranted and may elect to as-built changes rather than require a construction change. Under no circumstance shall field revisions be made without prior written approval of the Design Engineer and Agency.

- H. Agency Authority:

The AGENCY shall have full access to the work at all times during construction and shall be furnished with every reasonable facility for ascertaining full knowledge of the progress, workmanship, and character of materials used and employed in the work.

The Agency's Inspector shall have the authority to suspend the work completely or in part for such time as they may deem necessary if the contractor fails to carry out instructions given by the Agency's Inspector. The contractor shall immediately comply with a written order of the Agency's Inspector to suspend the work completely or in part. The work shall be resumed when improper methods or defective work are corrected as ordered and approved in writing by the Agency's Inspector.

- I. Service Prior to Acceptance:

The Agency may approve putting newly installed water, sewer and recycled water lines into service after compaction has been approved by the Geotechnical Engineer and/or County or City and the portions have been pressure tested, chlorinated, flushed, potable water pipelines have passed the bacteriological test, and all required fees have been paid. The Agency shall grant this partial acceptance only upon written request from the developer and subsequent approval. Upon this written approval for partial acceptance of facilities, the developer shall be relieved of the duty to maintain the portions so used or placed into operation provided that nothing shall be construed as relieving the developer of full responsibility for completing the work in its entirety, for making good any defective work and materials, for protecting the

work from damage, and for being responsible for damage and for work as set forth in the agreement and other contractual documents; nor shall such action by the AGENCY be deemed as full acceptance, and such action shall not relieve the developer of the guarantee provisions of their Agreement with the Agency.

J. Acceptance of Work:

Upon filing of the notice of completion, satisfactory completion of construction and acceptance by the Agency, the facilities shall be conveyed to the Agency. Some Agencies require an Offer of Dedication to be executed prior to job acceptance. Where capital improvement projects are funded by developers and reimbursed by an Agency, the developer shall supply a Cost of Construction Statement (CCS) supplied by the Agency for reporting the actual cost of construction. Completed forms shall be submitted to the Agency within thirty (30) days after completion of the final inspection and prior to the release of the final dwelling units along with "Record" mylars of the improvement plans and a compact disc (CD) of the electronic plans for the street, water, sewer and recycled water improvement plans. Upon receipt of these items, the Agency will approve the release of the bonds posted for construction of the sewer, water, and/or recycled water facilities except for Performance bonds, which shall remain in effect for a period of one year after the Notice of Completion date. For information regarding "Record" mylars refer to Section 1.7.

K. Release Given to County or City:

After final inspection has been completed and punch list items have been substantially completed, Notice of Completion recorded, and the requirements outlined in this Section fulfilled, the Agency will provide notification of its final acceptance to the County or City to facilitate the partial release of the developer's bonds for water, sewer, and recycled water facilities, except for the bonds which will remain in effect for the one (1) year warranty period after the Notice of Completion. At the discretion of the Agency, a unit of the development, may be held and not released for occupancy until all items on the final punch list have been completed to the satisfaction of the Agency's Inspector. The unit cannot be sold or occupied prior to the completion of all punch list items.

2.2.10 AGENCIES REGULATION REGARDING CROSS-CONNECTIONS

All potable water services shall be subject to the provisions of an Agency's Rules and Regulations regarding water backflow prevention. The following summarizes those provisions:

- A. Cross connections of any type that permit a backflow condition from any source or system other than that of the Agency's potable water pipelines to the potable water system are prohibited. A connection constituting a potential or actual backflow hazard will not be permitted unless a backflow device or air gap, which is approved by the California State Department of Health and local health agency and complies with Title 17 of the California State Administrative Code, is installed. Such an installation shall at all times be subject to inspection and regulation by the Agency for the purpose of avoiding possibility of backflow. A person from each Agency is available for consultation on any question regarding cross-connections.
- B. The Agency will not provide water service to any premises unless the public water supply is protected as required by State, County, and Agency regulations. Besides special situations, backflow devices are required as per WAS Standard Specification 15112.

- C. Backflow prevention devices shall be as approved in the WAS and shall be installed by, and at the expense of, the customer. The customer shall have the device tested at least once a year by a tester certified by the San Diego County Department of Environmental Health (DEH) and service such devices to maintain them in satisfactory operating condition and shall overhaul or replace such devices if they are found defective. Records of such annual tests, repairs, and overhauling shall be kept by the customer and copies forwarded to each AGENCY and DEH.
- D. Water service to any premises may be discontinued by the AGENCY, after notice, if a backflow prevention device required by an Agency's Rules and Regulations is not installed, tested, and maintained; if any defect is found in an installed backflow prevention device; if it is found that the backflow prevention device has been removed or bypassed; or if unprotected cross-connections exist on the premises. Service will be restored only when such conditions or defects are corrected to the satisfaction of each Agency.
- E. Each Agency further defines how water lines shall be marked where multiple water systems are in use, and outlines the duties and responsibilities of a property's water supervisor. Additional references for guidelines as to when, why, and what types of backflow and cross-connection control devices are approved may be found in:
 - 1. Regulations Relating to Cross-Connections, California Administrative Code - Title 17 - Public Health.
 - 2. Manual of Cross-Connection Control, published by Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, University Park, Los Angeles, California 90007.

2.2.11 REFERENCE

- A. Should the reader have any suggestions or questions concerning the material in this section, contact one of the member agencies listed.
- B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the user's convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.
 - 1. Water Agencies Standards (WAS):
 - a. Design Guidelines:
 - 1. Section 1.1, Drafting Guidelines
 - 2. Section 1.2, AutoCAD Guidelines
 - 3. Section 1.5, Easements and Encroachments
 - 4. Section 1.6, Survey Standards Guideline
 - 5. Section 1.7, Record Drawing Guidelines
 - 6. Section 2.5, Recycled Water Guidelines
 - 7. Section 4.4, SAMP Development (Master Plan)

- b. Standard Specifications:
 - 1. Section 01000, General Requirements
 - 2. Section 15112, Backflow Preventers
 - c. Standard Drawings:
 - 1. WF-01, WF-02, WF-03 and WF-05
 - 2. WR-01 and WR-02
- 2. Regulations Relating to Cross-Connections, California Administrative Code - Title 17 - Public Health.
 - 3. Manual of Cross-Connection Control, published by Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California.

END OF SECTION

WATER AGENCIES' STANDARDS

Design Guidelines for Water and Sewer Facilities

SECTION 4.1 WATER PLANNING

4.1.1 PURPOSE

This section outlines planning data to determine average, maximum day, and peak hour water demands, fire flows, pipeline velocities, system pressures, pump station capacities, and reservoir storage volumes.

- A. The purpose of this section is to identify general water planning and pre-design information for use in developing AGENCY Capital Improvement Program (CIP) and developer projects. This section will help develop uniformity and consistency in projects and to assist in providing uniform and workable facilities including pipelines, pressure control facilities, pumping stations, and storage reservoirs.
- B. The Engineer of Work shall incorporate the planning criteria presented in this section as a basis for design. Sometimes the criteria are given in ranges, in which case the final criterion is selected within the indicated range. In other cases, specific criteria have been given and are to be followed by the Engineer of Work.
- C. If the Engineer of Work desires to deviate from the criteria presented in this section only the Engineer can approve the change.

4.1.2 UNITS OF MEASUREMENT

Units of measurement to be used in design calculations are listed in Appendix B.

4.1.3 GENERAL

It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document. The Engineer of Work may not deviate from the criteria presented in this section without prior written approval of the Agency Engineer.

4.1.4 PLANNING AREA AND WATER DEMAND GENERATION

- A. Development Projects:
 - 1. Planning areas and other detailed information required for development projects shall be defined in SAMPs or may have been defined in an AGENCY's master plan. See Section 4.4 Sub-Area Master Plan Development for undefined planning areas.
 - 2. In the absence of more refined demand data from the AGENCY, development projects shall use the Residential Water Demand and/or Non-Residential Water Demand Tables 4-1-1 and 4-1-2, respectively.

- B. AGENCY Capital Improvement Program (CIP) Projects:
1. For the majority of AGENCY CIP projects, the AGENCY has previously defined planning areas through master-planning or other means. When this is not the case for a CIP project, the AGENCY may have the Engineer of Work define the planning area.
 2. In the absence of more refined demand data from the AGENCY, CIP projects shall use the Residential Unit Water Demand and/or Non-Residential Unit Water Demand Tables 4-1-1 and 4-1-2, respectively.

4.1.5 LAND USE

The Engineer of Work collects and organizes existing and ultimate land use data for the geographic area to define the following land use categories: residential, commercial, institutional, parks, hospitals, hotels, industrial, office, and schools. The local Cities or County can provide the information regarding zoning and dwelling unit density.

4.1.6 DWELLING UNIT DENSITY AND RESIDENTIAL UNIT WATER DEMAND

The Engineer of Work shall estimate the residential population in the service area based on existing and ultimate allowable land use. Unless otherwise provided by the AGENCY, unit water demands shall be estimated based on dwelling unit density in Table 4-1-1.

**Table 4-1-1
Dwelling Unit Density and Unit Water Demands**

Dwelling Unit Density (dwelling units/gross acre)	Unit Density (persons/dwelling unit)	Population Density (persons/gross acre)	Unit Water Demand (gallons/gross acre-day)
0.1	6.0	0.6	90
0.2	6.0	1.2	180
1	6.0	6.0	900
2	3.5	7.0	1050
3	3.5	10.5	1575
4	3.5	14	2100
8	3.5	28	4200
9	3.5	32	4800
14	3.2	45	6750
29	3.0	87	13050
43	2.6	112	16800
73	2.2	161	24150
109	1.8	196	29400
218	1.5	327	49050

4.1.7 NON-RESIDENTIAL UNIT WATER DEMAND

- A. Unless more accurate unit water demand estimates are available from the AGENCY, the non-residential unit water demands in the service area shall be estimated based on the land use categories in Table 4-1-2.

**Table 4-1-2
Non-Residential Unit Water Demands**

Land Use Category	Unit Water Demand
Commercial and Institutional	5000 gallons/net acre-day
Landscaped Park*	3000 gallons/net acre-day
Hospital**	8000 gallons/net acre-day/floor
Hotel**	7000 gallons/net acre-day/floor
Industrial	4000 gallons/net acre-day
Office	5000 gallons/net acre-day
School	4500 gallons/net acre-day

*Assumes zero recycled water demand on landscaped park area. For parks using recycled water, potable water usage=0 to 5% of unit water demand.

**For multiple story hospitals or hotels, multiply net area per floor by unit water demand by number of floors.

- B. If net acres are not known for non-residential land use categories, use Table 4-1-3 to convert gross acreage to net acreage.

**Table 4-1-3
Gross Acreage to Net Acreage Conversion**

Land Use Category	Gross Area	Net Area
Commercial and Institutional	1	0.30-0.40
Landscaped Park	1	0.40-1.00
Hospital	1	0.35-0.65
Hotel	1	0.30-0.50
Industrial	1	0.25-0.35
Office	1	0.30-0.40
School	1	0.30-0.40

4.1.8 AVERAGE ANNUAL WATER DEMAND

Average daily water demands are calculated as the sum of: (1) the residential water demand and (2) non-residential water demand for each land use category as follows:

- A. Average Daily Residential Water Demand (gallons/day)=Gross acres x Unit Water Demand (gallons/gross acre-day) for each Dwelling Unit Density.
- B. Average Daily Non-Residential Water Demand (gallons/day) = Net acres x Unit Water Demand (gallons/net acre-day) for each Land Use Category.
- C. Total Average Annual Day Water Demand (gallons/day) = Residential Water Demand + Non-Residential Water Demands.

On some projects, particularly large residential developments, using the unit water demands in Table 4-1-1 may generate unrealistically high estimates. For these large projects, the Engineer of Work may request that the Engineer approve an alternative approach. Similarly, the Engineer may also consider alternative unit water demand estimates for specific land use types where such estimates are based on detailed demand evaluations.

4.1.9 PEAK WATER DEMANDS

Peak hour and maximum day water demands are estimated using the peak factors presented in Figures 4-1-1 and 4-1-2. These peaking factors correspond to the AGENCY identified in Figure 4-1-3.

Peak water demands are calculated as follows:

- A. Peak Hour Demand = Average Day of Year Water Demand x Peak Hour Peaking Factor.
- B. Maximum Day Demand = Average Day of Year Water Demand x Maximum Day Peaking Factor.

4.1.10 HAZEN-WILLIAMS COEFFICIENTS

The Hazen-William's coefficients for water pipelines **equal to or less than 12-inch diameter** shall be as follows:

Pipe Material	Hazen William's "c" Coefficients
DIP (Lined)	120
HDPE	120
PVC	120
Steel (CML&C)	120

The Hazen-William's coefficients for water pipelines **greater than 12-inch diameter** shall be as follows:

Pipe Material	Hazen William's "c" Coefficients
DIP (Lined)	130
HDPE	130
PVC	130-140 (See Agency)
Steel (CML&C)	130

4.1.11 FIRE DEMANDS

- A. Before using Table 4-1-4 for fire flow rate, the governing fire department shall first be contacted to determine a rate. If the fire department cannot determine a rate, then minimum flows as set forth in Table 4-1-4 shall be used. The fire flow duration for planning purposes shall be two hours minimum.

**Table 4-1-4
Fire Demands for Design Purposes**

Development Type	Fire Demand (gpm)(1)
Single family residential	1,500
Duplexes	2,000
Condominiums and apartments	2,500
Commercial	3,500
Industrial	3,500
Resorts	5,000

(1) Fire Demands shall not include building sprinkler demands.

- B. As an alternate method, the Engineer of Work may estimate fire demands flows by using the *Fire Suppression Rating Schedule*, Edition 6-80, Section 1 (Public Fire Suppression), published by the Insurance Services Office.
- C. Should application of the ISO methodology result in figures lower than those shown in Table 4-1-3, the Engineer may approve the ISO figures on a case-by-case basis following submittal of supporting calculations.
- D. To calculate the fire flow volume required in operational storage reservoirs, see paragraph 4.1.15.
- E. The required fire flow demand shall be supplied from at least two fire hydrants (assumes ½ flow from each hydrant) within a maximum radius of 750 feet from the fire.
- F. Maximum fire hydrant supply, in some cases, can be obtained from the AGENCY. The supply will be based on an actual flow test if fire hydrants are in the vicinity of the desired location and a calculated flow rate at 20 psi will be provided. If hydrants are not available, then hydraulic modeling is required.

4.1.12 PRESSURE CRITERIA

- A. Static Pressures:
 - 1. Static Pressure is defined as the pressure in the system with no demand occurring in the distribution system.
 - 2. The basic pressure criteria for water system design are shown in Figure 4-1-4. It is desirable to have water distribution pipelines in each pressure zone capable of supplying a minimum static pressure of 65 psi.
 - 3. Generally, it is undesirable to have a maximum static pressure that exceeds 80 psi without a house regulator or 150 psi in the distribution system with a house regulator. The maximum static pressure in reservoir systems is determined from reservoir overflow elevations and/or the discharge control setting on pressure reducing valves, whichever is greater. The maximum static pressure in pumped systems is determined from reservoir overflow elevations or pump shutoff head, whichever is greater. In some instances the AGENCY may require the developer to build a pressure reducing station and create a closed zone to meet the criteria. The AGENCY will be responsible for operation and maintenance of these stations.
- B. Dynamic (Operating) Pressures:
 - 1. In analyzing the supply to a pressure zone, the minimum hydraulic grade line elevation available from the water source shall be used; a level that typically occurs during peak hour demand conditions.
 - 2. Operating pressures under peak hour demand conditions shall not fall more than 25 psi below the static pressure of 65 psi, equating to a residual water distribution pipeline pressure of 40 psi. Operating pressures are determined in the distribution system pipelines at the service connection or fire hydrant.
 - 3. Water systems shall be designed to meet the pressure criteria with one critical source out of service. When analyzing a system with one source of supply (either a reservoir or a pipeline) out of service, pressures may fall more than 25 psi below the static pressure of 65 psi, but in no event may the pressure fall more than 40 psi (keeping the minimum dynamic pressure at 25 psi in the distribution pipeline).

C. Pressure Requirements During Fires:

1. For the simulation of fire conditions, a minimum operating pressure of 20 psi is required in the distribution pipelines in the vicinity of the fire. The residual pressure is determined given the fire demand concentrated at a hydrant within a radius of 750 feet of the fire.
2. For water systems, the residual pressures in the distribution system during a fire shall be maintained given the following conditions:
 - a. The water level in the storage facility at the time of the fire is at the minimum operational level that typically occurs during peak hour demand conditions.
 - b. The prescribed fire duration as determined by the governing fire department is coincident with the maximum day demand condition.
 - c. All Agency booster pumps into and out of the pressure zone where the fire is occurring are off.
 - d. Areas outside of the fire circumference in the same pressure zone maintain a minimum pressure of 20 psi.

4.1.13 VELOCITY CRITERIA

A. Transmission Pipelines:

1. Transmission pipelines are defined as larger diameter pipelines (typically 12" or 16") as defined by the Agency or pipelines **of any size** that do not have connections to them such as fire hydrants, water services, or distribution tees, which serve to transfer water from one region to another.
2. The maximum transmission pipeline velocity shall not exceed 8 feet per second under peak hour flow conditions.
3. There is no minimum transmission pipeline velocity criterion.

B. Distribution Pipelines:

1. The maximum distribution pipeline velocity shall not exceed 8 feet per second under peak hour flow conditions or 10 feet per second under maximum day plus fire flow conditions.
2. There is no minimum distribution pipeline velocity criterion.

C. Fire Hydrant Laterals

The maximum fire hydrant lateral velocity shall not exceed 15 feet per second under maximum day plus fire flow conditions.

4.1.14 PUMP STATION CRITERIA

- A. Unless directed differently by the Agency, pumping stations that are connected to reservoirs shall be designed to pump the ultimate maximum day demand projected for the service area. Certain Agencies also require that for pumped zones that the ultimate maximum day demand plus fire flow recharge are met. See Agency for specific requirements.

- B. Where pump stations are pumping in series, the first-lift pump station shall be designed to pump the ultimate maximum day demand for all service areas served. The ultimate maximum day demand shall be calculated by summing all of the average day demands of the service areas served, then peaking the average demand using the maximum day peaking factor curve listed in Figure 4-1-2. The ultimate maximum day demand shall **not** be calculated by summing the ultimate maximum day demand of each service area.
- C. In some cases, it may be desirable to design a pump station with a higher capacity in order to receive better electrical energy rates. These energy periods have defined terms such as AL-TOU "Time of Use" by San Diego Gas and Electric Company. The AL-TOU and other rate structures allow AGENCIES to receive lower kilowatt-hour rates to pump water in a specified time. Many factors need to be considered when designing pump stations for the different rate structures including:
 - 1. Storage volume
 - 2. Pumping operation (On-off levels)
 - 3. Peaking factors of a system
 - 4. The on-peak hours demand
 - 5. Pump characteristic curves
 - 6. Seasonal demand
- D. If a pump station is being designed to use limited hours of pumping, the Engineer of Work shall provide a hydraulic modeling analysis for approval by the Engineer.
- E. Hydropneumatic pump stations shall be designed to pump ultimate peak hour demand (2 pumps, 1 duty, 1 standby each capable of pumping the peak hour flow rate) projected for the service area plus a fire flow pump capable of supplying the fire flow demand determined by the governing fire department. A general rule for sizing hydropneumatic tanks is to multiply the duty pump capacity in gallons per minute by 10. This will provide adequate unused, working, and safe limit volumes. In addition, certain Agencies require that a lower capacity pump equivalent to 30% of the average day demand be included in the design.

4.1.15 STORAGE CRITERIA FOR OPERATIONAL STORAGE RESERVOIRS

Unless directed differently by the Agency, the minimum operational storage volume within a pressure zone is the sum of three elements: operational storage, fire storage, and emergency storage.

- A. Operational Storage:
 - 1. Operational storage is defined as the volume of storage required to allow a reservoir's sources of supply to operate at a uniform rate throughout the day under ultimate peak hour conditions.
 - 2. Based on analysis and Agencies' experience and observations, it has been determined that 30% of a maximum day's volume is generally needed to handle the ultimate peak hour fluctuations. For this reason, operational storage in reservoirs shall be designed for 0.3 x ultimate maximum day demand. An example follows:

Ultimate average day demand of service area = 300,000 gallons

Maximum day peaking factor = 2.7

Ultimate maximum day demand = 300,000 x 2.7 = 810,000 gallons

Operational storage required = 0.3 x 810,000 = 243,000 gallons

B. Fire Storage:

1. The governing fire department shall provide the AGENCY with the fire flow rate and duration to determine fire storage. If a number cannot be obtained from the governing fire department, use the values listed in Table 4-1-4. Fire storage shall be provided in all reservoirs. Fire storage is equal to the product of the fire demand and the duration of the fire.

An example to calculate required fire storage volume follows:

Fire demand = 1500 gpm
Fire Duration = 2 hours

Fire storage = 1500 gpm x 2 hours x 60 minutes/hour
= 180,000 gallons, or 0.18 million gallons

2. When a reservoir has a redundant source(s) of fire storage, the required storage volume may be shared between two reservoirs or put in one reservoir at the AGENCY's discretion.

C. Emergency Storage Component of Operational Reservoir:

1. The AGENCIES differ widely in terms of being able to treat and store water. Some have large raw water lakes and their own treatment facilities. Other AGENCIES are solely dependent on imported water from the Metropolitan Water District and the San Diego County Water Authority. Because of the many differences, potable water emergency storage varies among the AGENCIES. Another factor that influences potable water emergency storage in operational reservoirs is that the San Diego County Water Authority recommends each member be able to withstand a 10-day planned or unplanned outage of the potable water aqueduct.
2. Table 4-1-5 lists the recommended emergency storage component of an operational storage reservoir by AGENCY.

**Table 4-1-5
Emergency Storage Volume Required
In Operational Storage Reservoirs per AGENCY**

AGENCY	Volume Required (In terms of being multiplied by an ultimate maximum day demand in a pressure zone)
Helix Water District	0.2
Lakeside Water District	0.2
Otay Water District	1.0
Padre Dam Municipal Water District	Gravity Zone 1.0, Pump Zone 1.5
Ramona Municipal Water District	1.0
Riverview Water District	0.2
Sweetwater Authority	0.7

An example on how to calculate emergency storage volume in a Helix Water District reservoir follows:

Ultimate average day demand of service area = 300,000 gallons

Maximum day peaking factor = 2.7

Ultimate maximum day demand = $300,000 \times 2.7 = 810,000$ gallons

Emergency storage volume required = $0.2 \times 810,000 = 162,000$ gallons

D. Minimum Operational Storage Volume Requirement (Example for Helix):

Assuming the two-hour 1500 gpm fire flow volume is included in the reservoir, the total storage volume for the Helix reservoir would be 585,000 gallons (243,000 gallon operational, 180,000 gallon fire flow, and 162,000 gallon emergency storage volume).

4.1.16 STORAGE CRITERIA FOR EMERGENCY STORAGE RESERVOIRS

See each AGENCY for criteria regarding potable water emergency storage reservoirs and raw water reservoirs.

4.1.17 REFERENCE

- A. Should the reader have any suggestions or questions concerning the material in this section, please contact one of the agencies listed.
- B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the user's convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.
 - 1. Fire Suppression Rating Schedule, Edition 6-80, Section 1 (Public Fire Suppression), published by the Insurance Services Office
 - 2. Water Agencies' Standards:
 - a. Design Guideline:
 - 1. Section 4.4, Sub Area Master Plans
 - 2. Appendix B, Units of Measurement

WATER AGENCIES' DESIGN GUIDE

Design Guidelines for Water and Sewer Facilities

SECTION 8.2 VAULTS

8.2.1 PURPOSE

The purpose of this section is to provide guidelines for the selection and placement of vaults and/or manholes on water/sewer pipeline projects.

8.2.2 STANDARD TERMS AND DEFINITIONS

Wherever technical terms occur in these guidelines or in related documents, the terms and meaning shall be interpreted as described in Standard Terms and Definitions.

8.2.3 GENERAL

It is the responsibility of the user of these documents to make references to and/or utilize industry standards not otherwise directly referenced within this document. The Engineer of Work may not deviate from the criteria presented in this section without prior written approval of the Agency's Engineer.

8.2.4 GUIDELINES

This section covers general design parameters for vault installation. In general, vaults or manholes are installed on distribution and transmission pipelines to provide access to appurtenances or pipelines for repairs, modifications, or maintenance work.

- Vaults shall be installed for valves twenty-four inches (24") or larger or otherwise directed by the Agency Engineer. The vault lid shall have a hole cored above the actuator nut to allow for an extension and portable motor operator to be used.
- Vault design plans and specifications shall reference WAS Standard Drawings and Standard Specifications where applicable.
- Vaults shall be sized appropriately to accommodate appurtenances and provide enough room for workability within the vault. Typically, horizontal clearance of twenty-four inches (24") is required between vault piping/valves and vault walls. Verify flange patterns and bolt/nuts to ensure bolts can be installed/removed in the space provided. Consideration shall be given for provisions for the removal of piping or valves from the vault.
- Vault plans shall be prepared in digital format, in accordance with Section 1.2 or Section 1.3.
- Vault buoyancy shall be evaluated for each vault considering groundwater conditions and conditions during construction. In high ground water situations, the vault may not rely on restraint from protruding pipes or other appurtenances to mitigate buoyancy.
- All joints and pipe penetrations shall be designed to be water tight.
- Vaults shall be installed on crushed rock base and backfill materials shall be in accordance with Water Agencies' Standards Section 02223.
- The vault must be designed for excavation, foundation stabilization, placement of base material, backfill, and compaction per Water Agencies' Standards. The excavation shall be large enough to accommodate the vault structure and permit grouting of openings and backfilling operations.

- The design of the vault shall take into account the geotechnical evaluation of the vault location.

8.2.5 VAULT PLACEMENT

- To the extent possible, vaults shall be placed within public right-of-way, Agency property, or easements. If the vault can not be installed within public right-of-way, Agency properties, or existing easements, provide adequate easements per Section 1.5.
- Vaults shall be placed with sufficient clearance from outside of traveled way for accessibility and maintenance.

8.2.6 VAULT TYPES

- A. Precast Concrete Vaults:
 - Precast concrete vaults may be used for pressure-reducing stations, turnout structures, valves, meters, pipeline access, or other appurtenances as Directed by the Agency Engineer.
 - Precast concrete vaults shall be in accordance with Water Agencies' Standards Section 03462.
- B. Cast-In-Place Concrete Vaults:
 - Cast-In-Place vaults may be used for pressure-reducing stations, turnout structures, valves, meters, pipeline access, or other appurtenances as directed by the Agency Engineer.
 - Cast-In-Place vaults shall be designed to accept engineering standards and Water Agencies' Standards with twenty-eight (28) day concrete compression strength of not less than 4,000 psi.
 - Cast-In-Place concrete vaults shall be in accordance with Water Agencies' Standards Section 03000.
 - Be designed for H-20 continuous traffic loading.
- C. Fiberglass Reinforced Plastic (FRP) Vaults:
 - FRP vaults may be used for potable water meters and recycled water meters 4-inches and larger or other applications as directed by the Agency Engineer.
 - FRP vaults shall be in accordance with Water Agencies' Standards Section 06620.
 - Be designed for H-20 continuous traffic loading.
- D. Precast Concrete Manholes:
 - Precast Concrete Manholes may be used to access water mains, sewer mains, and appurtenances.
 - Manhole shafts shall be fabricated only from precast sections, grade rings, and concentric shaft without cone sections for water transmission main applications unless otherwise directed by the Agency Engineer.
 - Precast Concrete Manholes shall be in accordance with Water Agencies' Standards Section 03461.

8.2.7 VAULT HATCH/DOORS/COVER

- Vault covers (access hatches) must be hinged and spring-assisted to accommodate "one person operation" must have hold open stay bars and safety railings when doors are in the open position, provide a locking ability, and designed to withstand H-20 traffic loadings unless otherwise directed by the Agency Engineer. Any cover panel must not be longer than eight feet in any direction.

- The design engineer shall identify if hatch covers require H-10 parkway loading, H-20 intermittent traffic rating or H-20 continuous traffic rating, and incorporate into the design.
- Vault hatch, doors, covers, or frames shall be in accordance with Water Agencies Standards.

8.2.8 VAULT ACCESSORIES

- Vault accessories shall be in accordance with Water Agencies Standards Section 11020.
- Electrical Components:
 - Electrical components shall be in accordance with Water Agencies' Standards Section 11020.
 - The design shall incorporate explosion-proof components as determined by the Engineer.

8.2.9 REFERENCES:

- A. Should the reader have any suggestions or questions concerning the material in this section, contact one of the member agencies listed.
- B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the user's convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.
 - 1. Water Agencies' Standards (WAS):
 - a. Design Guidelines:
 - 1. Section 1.2, AutoCAD Guidelines
 - 2. Section 1.3, MicroStation Guidelines
 - 3. Section 1.5, Easements and Encroachments
 - b. Standard Specifications:
 - 1. Section 02223, Trenching, Excavation, Backfill & Compaction
 - 2. Section 03000, Cast-In-Place Concrete
 - 3. Section 03461, Precast Concrete Manholes
 - 4. Section 03462, Precast Concrete Vaults
 - 5. Section 06620, Fiberglass Reinforced Plastic (FRP) Vaults
 - 6. Section 11020, Concrete Vault Accessories

END OF SECTION

WATER AGENCIES' STANDARDS

Design Guidelines for Water and Sewer Facilities

SECTION 12.2 TRENCHLESS CONSTRUCTION

12.2.1 PURPOSE

The purpose of this section is to provide guidelines for the use of trenchless construction in pipeline installations where standard open cut excavation methods are not feasible.

12.2.2 STANDARD TERMS AND DEFINITIONS

Wherever technical terms occur in these guidelines or in related documents, the intent and meaning shall be interpreted as described in the Standard Terms and Definitions.

12.2.3 GENERAL

Trenchless technology construction methods may be required for special crossings and conditions. Examples include:

- A. The pipeline depth is excessive due to site conditions, making conventional excavation uneconomical when considering materials handling and shoring requirements.
- B. Environmental conditions such as riparian habitat at stream crossings do not permit conventional construction.
- C. Disturbance caused by conventional construction to suburban, urban, or business community is not permissible.
- D. At congested intersections where from traffic or a utility standpoint, costly utility relocation, utility support/underpinning, or traffic control is avoided.
- E. At high points in the pipeline due to hydraulic conditions.

Because of increased urbanization, utility networks are growing in size and complexity. As these networks grow, the need for special crossings by trenchless construction methods is becoming more popular due to their inherent advantages. Trenchless excavation construction methods may be divided into three basic categories: pipe jacking, conventional tunneling, and horizontal boring.

The direct costs of trenchless construction are more expensive than conventional cut-and-cover pipe construction. However, social costs, environmental impact, and other indirect costs due to noise, dust, loss of business, parking revenues, traffic delays, may make trenchless construction desirable. The District Engineer shall determine the proposed construction method for each project on a case-by-case basis and may prepare bid documents that allow prospective contractors to provide bid prices using both conventional and trenchless technology.

The following list of trenchless construction methods is not intended to be all encompassing, and is primarily intended for pipes in the 4-inch to 50-inch diameter range anticipated for water mains.

- Pipe Jacking
- Tunneling
- Horizontal Boring
 - Auger method
 - Micro tunneling
 - Slurry method
 - Directional drilling
 - Compaction/Pipe ramming
 - Percussive drilling

These categories are chosen for convenience. Many contractor and manufacturer innovations are occurring in this growing industry. Because of the nature of the industry, these categories are not necessarily discrete, but represent more or less a continuum of possibilities. Key to the success of these trenchless construction methods is defining the subsurface conditions; therefore each project is site-specific. Consequently, the Engineer should become familiar with possible construction methods and should refer to the latest information available within the industry. Included at the end of this section are some technical references as well as sources for additional information. However, the Engineer and geotechnical consultant should not provide direction as to the means and methods for construction, but specify performance requirements and limitations as required for the specific project (as set forth in the guideline specifications).

12.2.3 GUIDELINE

It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document. The Engineer may not deviate from the criteria presented in this section without prior written approval of the Agency.

A. Pipe Jacking

Pipe jacking according to some classifications is distinguished from horizontal boring in that pipe jacking allows for personnel entry to assist in performing the advance, whereas horizontal boring does not allow for personnel access. On the other hand, horizontal boring methods such as the auger method or microtunneling utilize hydraulic jacks similar to pipe jacking to advance the pipe, carrier pipe, or conductor casing. In essence, microtunneling and auger methods just have a more sophisticated method of advancing the pipe and removal of spoils. Regardless of the nomenclature, the minimum pipe diameter for conventional pipe jacking for personnel entry is about 30 inches for short distances and 6 feet for longer distances. Common sizes are 48 inches to 72 inches. Although there is no limit to the size of pipe that can be jacked, the largest is usually about 144 inches. Also, with all these pipe jacking methods, the Contractor must design the jacks to overcome the skin friction developed between the pipe and the surrounding ground.

Friction acting on steel pipe jacked through fills typically ranges from 100 to 600 psf of external surface area. Bentonite injected near the cutting edge of the pipe may reduce friction to about 100 psf. The development of special mud polymer lubricants has reduced the skin friction to about 25 to 50 psf where there has been a need. In many situations in firm soil, water alone is used as the lubricant. Because soil friction may increase with time, jacking operations should be uninterrupted. However, maintaining accurate line and grade and proper steering is as much a factor (if not more of a factor) of minimizing jacking forces as overcoming skin friction. After the pipe has been jacked, the lubricant may be replaced with grout.

For most situations, the practical limit for jacking is 1,000 to 1,200 feet. Intermediate jacking stations may be used; however, the shorter stroke length cuts the efficiency of the operations, thus increasing costs. Also, electric modifications, pumping considerations, laser limitations, hydraulic constraints, and reduced production make jacking long lengths uneconomical. Therefore, when long distances are involved, additional shafts should be considered. Alternatively, other methods such as tunneling or directional drilling require consideration.

Typically, the conductor casing or pipe is fitted with a simple cutting shoe or a small open shield to overcut the excavation and protect the leading edge of the pipe. During jacking in firm ground, soil materials are trimmed with care. The excavation face is also not advanced ahead of the jacking operation to minimize soil disturbance and loss of ground around the pipe. Some settlement can be expected, depending on the depth and diameter of the pipe.

Open shields have the advantage of accommodating the removal of cobbles, boulders, and obstructions. For larger diameter pipes above the groundwater table, where soils are susceptible to raveling, running, or sloughing, pipe jacking operations incorporate a shield with breasting tables and/or boards to minimize settlements. In firm ground, even wheel excavators are incorporated.

Spoil removal for conventional pipe jacking is by small muckers, rubber-tire low-profile load-haul-dump vehicles, rail, conveyor, or small cart. For smaller diameter pipes, slushers on pulleys have also been used.

B. Tunneling

Tunneling, like pipe jacking, implies personnel entry according to some classification systems. Unlike pipe jacking, curved alignments can be accomplished and excavation is feasible in hard rock. Also, the length of tunnel is not limited by the thrust of the pipe jacking rams.

As with pipe jacking, the means and methods of advancement and the initial support is the Contractor's responsibility. The Engineer and geotechnical consultant are responsible for performance requirements and limitations applicable for each project.

Tunneling excavation and initial ground support methods are broadly classified into hard rock, soft/weak rock, and soils. The methods can be further subdivided under mechanized excavation or conventional excavation. Mechanical excavations may be by tunnel boring machines (TBM), shields, or mechanical excavators, of which there are a multitude of types. Conventional excavations may be by drill-and-blast construction or by hand construction, spaders, or other small equipment.

The smallest practical size for conventionally excavated tunnels is about 5-feet wide by 7-feet high, while for a circular shield or TBM excavated tunnel, the smallest practical diameter is about 4.5 to 6 feet, depending on the length of the tunnel. With the availability of used TBMs, drive lengths of less than 2-mile is competitive with conventionally driven small tunnels. TBMs also have the advantage of causing fewer disturbances to humans compared with drill-and-blast excavations when advancing through hard rock. While the guideline specifications provide for controlled blasting to limit peak particle velocities and damage to adjacent structures, the vibrations can disturb nearby residents. Where required, the Engineer should make a concerted effort and public outreach to educate affected parties about potential impacts. Nevertheless, unless there are special overriding considerations, as with all means and methods of trenchless construction, the Engineer should specify the use of either conventional or mechanized excavation. The marketplace, the Contractor's experience, and the Contractor's equipment dictate the methods.

Initial ground support depends on ground conditions. In hard rock, common support types are no support, patterned or random rock bolts and wire mesh, mine straps as required by ground conditions. In soft or weak rock, common support types include patterned or random rock bolts and wire mesh or mine straps as required; shotcrete; ribs and lagging; segmented concrete or steel liner; steel casing spilling and/or crown bars; and other combinations of these, as required by ground conditions. Soil requires similar initial support systems as for soft or weak rock; however, rock bolting methods and sparse support are generally not acceptable. The standard tunnel design practice is to not specify initial support unless incorporated into the final liner. Standard practice is for the Engineer to require submittal of the Contractor's tunnel work plan including initial support (to verify that the submittal meets industry standards without accepting responsibility for means and methods) under the category Review Submittal.

The conveyance of spoils depends on the excavation method but is typically performed by rubber-tire low-profile load haul dump vehicles, conveyors, or rail cars for the anticipated tunnel diameter.

After tunnel excavation is completed, the pipe is installed or placed on saddles, cradles, or rollers, and backfilled with cementitious materials such as grout or cellular concrete. Since in some situations, the diameter of the final pipe is small in comparison to the diameter of the tunnel, the Engineer should investigate any cost savings or other benefits to be derived using this corridor for other utilities. In very special circumstances, a utility corridor with access may be considered or even required.

C. Horizontal Boring

Horizontal boring is common in earth. Recently, horizontal boring methods have also been used in rock; however, there are practical limitations for rock. Horizontal boring methods are distinguished from pipe jacking and tunneling in that personnel do not enter the excavation. From this standpoint, horizontal boring methods would classically limit the diameter of such operations to less than about 30 inches. With the advent of computerized steering and guidance systems, horizontal boring by the non-personnel entry definition have encompassed projects up to 12.5 feet in diameter.

Horizontal boring techniques briefly described in the following paragraphs include: auger method, micro tunneling, slurry method, directional drilling, compaction/pipe ramming, and percussive drilling.

1. *Auger Method*

The auger method is a pipe jacking method in which removing spoils is accomplished by a continuous flight auger. The auger also transmits torque to the cutting head from the power source in the jacking/bore pit. The auger may be powered pneumatically, hydraulically, or by an internal combustion engine through a mechanical gearbox. Similar to conventional pipe jacking, the leading edge of the pipe is typically equipped with a cutting shoe. Bentonite is also used to lubricate the pipe and minimize sloughing. The Contractor must carefully monitor the position of the casing and the advance of the auger and cutting head to minimize the risk of unsupported excavated ground and potential settlements.

A steering apparatus attached to the outside of the casing at the cutting head and a water level sensing device for vertical control is commonly used to make minor grade adjustments. The horizontal alignment can be corrected to a minor amount on larger casings by withdrawing the augers and sending personnel through the casing to the leading edge to manually excavate and install wedges on the appropriate side. Water lines are sometimes added behind the steering head to facilitate spoil removal.

The horizontal boring equipment is commonly mounted on a track, but in some applications where large rights-of-ways are available, it is supported by a cradle suspended from a crane. Cradle-type horizontal boring operations are commonly referred to as “side boom” or “swinging” methods. Consequently, the jacking/bore pit construction is not as critical as for a conventional pit, since all preparatory work is done outside the pit and no workers are permitted to enter the pit. No foundation or thrust reaction structures are required; however, a jacking lug or deadman is installed at the bore entrance. Water level and steering apparatus systems for track-type horizontal boring is not appropriate for the cradle-type method. Cradle-type operations require pressurized steering systems. In urban and suburban areas, cradle-type operations are not feasible. Also, water utility lines tend to run parallel to roads and then turn, and large right-of-ways are not available.

2. *Micro tunneling*

Micro tunneling machines have taken sophisticated, hydraulically operated, and automated soft-ground tunnel boring machines such as slurry tunneling machines and scaled them down for diameters as small as 8 inches for excavation and spoil removal. Micro tunneling, as with horizontal boring, in some classification systems, has evolved to encompass non-personnel entry of pipe jacking operations for which the record is about 12.5 feet in diameter. Micro tunneling is considered a misnomer by some and is simply pipe jacking with an automated miniature tunnel boring machine ahead of the jacked pipe.

With the numerous manufacturers of micro tunneling machines worldwide and the advent of trenchless construction, micro tunneling is particularly advantageous for difficult ground conditions without the use of expensive dewatering systems or compressed air. Micro tunneling also has extremely accurate alignment tolerances for long drives, making conventional horizontal boring and pipe jacking competitive for only the best of soil conditions and the shorter drives. Although most of the micro tunneling equipment is designed to operate in soft ground soil conditions, there has been an increased demand for micro tunneling machines which can also excavate soft/weak rock and even hard rock (within certain limitations).

Soft-ground micro tunneling machines use the principle of “earth-pressure balance” TBMs in which the pressure applied to the cutting face equals the pressure from the ground against the cutting face, thereby providing full face control and preventing loss of ground and settlement. Some machines use pressurized water to assist in excavation. In competent firm ground this may be acceptable; however, in loose, running, or flowing ground, the principle of earth-pressure balance is not achieved and can lead to unacceptable settlements.

Because micro tunneling machines are jacked, they have the same limitations with respect to jacking distances (1,000 to 1,200 feet) and curves as for pipe jacking.

Cobbles and boulders can make excavation difficult if not planned. Micro tunneling machines can handle boulders and obstructions typically 1/5 to 1/3 of the diameter of the cutter head depending on the type of cutter head. To handle coarse-grained materials, micro tunneling machines are typically equipped with eccentric cone-type crushers, jaw crushers, strawberry cutters (button bit carbide inserts), or multidisc kerf-type cutters with carbide inserts to break up cobbles/boulders prior to ingestion behind the cutter head. The cutter head is also armored with hard facing.

For the smaller diameter machines (less than about 4.5 to 6 feet), minidisc cutters 6 inches in diameter have been employed for short drives in hard rock. These disc cutters if worn cannot be replaced without removing the entire machine or installing a rescue shaft. The small bearing areas of minidisc cutters have experienced problems with their mounts and bearings in the past.

Torque is applied through an auger and thrust through the casing. The life of the cutter depends on the hardness and abrasiveness of the rock. The longest successful mini-hard rock TBM drive is less than 300 feet. The smallest diameter is about 24 inches. Although this technology is evolving and improvements are being made, where longer drives are anticipated in hard rock, the Engineer should consider conventional tunneling. Moreover, means and methods are the responsibility of the Contractor.

Spoil removal for soft-ground micro tunneling machines is typically by slurry using smaller slurry conveyance pipes and pumps as required. Another method is by auger similar to the horizontal boring auger, only a bentonite slurry is also injected at the cutter head and conveyed by the augers to a holding tank (volume equal to one-shove) beneath the thrust jacks in the pit.

Spoil removal and rotation of cutter head is accomplished by an auger for hard rock mini-TBMs (less than about 4.5 feet).

3. *Slurry Rotary Drilling (SRD)*

This method of horizontal boring is similar to the auger method in that it is typically executed using boring and receiving pits and is intended for straight line boring. However, a drill bit and tubing are used rather than a cutting head and auger. Drilling action is accomplished by rotating and pushing the drill tubing. A drilling fluid is also used which can be water, air, or bentonite slurry. The drilling fluid keeps the rotating bit clean and aids in spoil removal. Drilling fluid is delivered through the drill tubing and spoils return to the boring pit through the bore hole. In unconsolidated, noncohesive soils, bentonite slurry aids in preventing bore hole collapse and much of the slurry cuttings remain in the bore hole. Pilot holes are typically drilled first, then reaming bits are employed to enlarge the bore for the desired carrier pipe diameter. The drill bits are not directionally controlled and intermediate access pits are sometimes employed to ensure proper alignment of the bore path. Since the bit is unguided, the accuracy of the bore hole depends largely on subsurface conditions. Obstacles can deflect the drill bit off course, and operator experience plays a significant role in the bore's success and accuracy.

This method is most effective for bore holes from 2 to 12 inches in diameter; however, 48-inch bores have been successfully completed in stable soil conditions. Pipe installation is independent of the boring operation and thus any pipe material that is suitable for jacking or pulling can be installed. Installing pipe spans in the range of 40 to 75 linear feet is most common with this method. As pipe spans increase, so does the chance of unacceptably aligned bore holes due to the unguided nature of this method.

4. *Directional Drilling*

Many innovative features from the oil drilling industry have been applied to horizontal earth boring and have advantages over SRD. The terms horizontal directional drilling and directional boring apply to a wide range of techniques and applications. Two key features of directional drilling differentiate it from SRD. The first is that a drill motor powered by pressurized cutting fluid operates the drill bit rather than a rotating drill string. The second is that the drill bit is steerable and thus can be maneuvered around obstacles or to correct the bore path. These characteristics give

directional drilling superior capabilities and wider applicability over SRD. Thus, it is the more common method of the two employed.

The steering ability of directional drilling results from the chisel shape of drill bits used which deflects it in the direction oriented. When the bit rotates, it progresses straight. Controlling rotating and push allows for drill bit steering. Drill string position is accomplished with a guidance system mounted in the drill bit assembly, and by magnetically tracking it from the ground surface above the bore. For hard rocks and boulders, a rotary percussion cutterhead can be used.

Once a pilot hole is excavated, larger diameter bores are created by pulling back a large diameter cutter with the drill string (back reaming). The hole may be back reamed in a succession of increasingly larger diameters to achieve the desired final diameter. Special back reamers are available for hard rock or gravels. On the final back reaming, the finished desired pipe is pulled through. The use of directional drilling is particularly advantageous for river crossings.

Large percentages of gravels, cobbles, and boulders make drilling difficult and expensive. Steering accuracy is also an important consideration.

5. *Compaction/Pipe Ramming*

Impact moles or pipe ramming techniques, as the names imply, use a pneumatic system which punches through soil by a percussive action. The driving head is typically cone shaped using a stepped cutting head or a series of open steel tubes which punch through the ground, and is subsequently blown through, flushed free or emptied by reamers.

Another technique is to drive the pipe or casing directly without a cutting head. If the line is 6 inches in diameter or greater, the head is driven with an open face, with a band installed around the leading edge for reinforcement. This also reduces the friction from the following pipe. In some cases, water or bentonite slurry can be applied to the outside of the pipe for lubrication.

Diameters obtainable by pipe ramming vary from less than 2 inches to as much as 4.6 feet. Smaller diameter bores (less than 7 inches) are common in the United States while Europe and Japan have had great success with larger diameter impact moles.

Larger diameter pipe ramming can accommodate cobbles and boulders since there is no equipment inside the casing for obstruction of these obstacles. Pipe ramming techniques used to install a smaller diameter pipe may not offer the same amount of flexibility in excavation.

Pipe ramming is worth considering because it is reported to save time and money in equipment and labor time compared with pipe jacking or other microtunneling techniques.

6. *Percussive Drilling*

Combining percussion action with rotary drilling has proven to be an effective means of drilling through hard rock and has been applied in some trenchless methods. Applying a down-the-hole (DTH) percussive drill in conjunction with a track-type auger set up has been used to horizontally bore through hard rock. The largest DTH bit available is 43 inches in diameter and is reported to have been applied in lengths in excess of 1000 feet.

DTH hole percussive bits are pneumatically powered for percussion energy, and rotation and thrust are supplied by the drill rig. Hole cuttings are removed by the air supplied to the bit and are guided back to the bore pit in the annulus between the drilling shaft and the casing. Drilling hammer accuracy improves with harder ground conditions. This method is non-steerable and thus initial setup and alignment are critical to boring to the receiving pits. Large diameter bores are typically accomplished by drilling a small pilot hole and then opening the hole with larger bits in subsequent passes. The limitations of this method are the environmental impact during initial startup due to the percussive impact at the surface and dust control from cuttings blown out by the compressor throughout the operations.

D. Jacking Pit

Minimum size jacking pits depend on the size of the pipe being installed. For the 20-inch to 50-inch diameter range, the minimum width for jacking pits range from about 8 feet to 15 feet, and the minimum length will vary from about 20 to 40 feet, depending on equipment and pipe length. Minimum size receiving pits will vary from about 6-foot to 10-foot diameter.

With directional drilling, a jacking pit is not necessarily required. With any trenchless method, however, a small staging area is required adjacent to the work area and is typically a minimum of 5,000 square feet.

Although the Contractor is responsible for these items, the Engineer and its geotechnical sub-consultants should provide geotechnical criteria that enable the Contractor to design the shoring and foundation for its equipment. Also, the Engineer should consider the Contractor's staging requirements and need for jacking and receiving pits when planning special crossings.

12.2.5 MATERIAL SELECTION

With all these trenchless scenarios, a carrier pipe or conductor casing is jacked or pulled for installation. Typical pipe is reinforced concrete pipe, plastic pipe, corrugated metal pipe, or sheet steel pipe in 10-foot to 20-foot sections. Crossings under county or state highways may require a steel or other type of conductor casing like reinforced concrete, or plastic. The carrier pipe is installed on saddles (by rollers, cradles, or slurry) which are later backfilled with cementitious materials such as grout or cellular concrete. Smaller diameter pipes are not usually grouted.

Alternative one-pass liners with a sacrificial steel liner cast with an internal steel liner have also been manufactured in the past. Other one-pass linings for potable water pipes are available. These specially coated linings have a sacrificial layer in addition to normal corrosion protection. They are patented and offer a flush bell with an interlocking joint that seals pressures to greater than 300 psi.

Directionally drilled one-pass lining installations use welded steel pipe, also with a sacrificial coating for installation.

Trenchless constructed pipes may have special transition pipelines or vaults required on either side of the bored subsurface crossing.

12.2.6 REFERENCE

- A. Should the reader have any suggestions or questions concerning the material in this section, contact one of the member agencies listed.

- B. The publications listed below form a part of this section to the extent referenced and are referred to in the text by the basic designation only. Reference shall be made to the latest edition of said publications unless otherwise called for. The following list of publications, as directly referenced within the body of this document, has been provided for the user's convenience. It is the responsibility of the user of these documents to make reference to and/or utilize industry standards not otherwise directly referenced within this document.

Substantial material (e.g., manuals, guidelines, videos, and references and associations) has been published about trenchless construction. The American Society of Civil Engineers has a draft "Standard Construction Guidelines for Microtunneling" (November 1998) that is under committee review. The following are a few sources provided to the Design Engineer as a primer and introduction to trenchless construction references.

- Boyce, G.M, and Cross, T.R., 1997, A 10-year review of microtunneling in North America, in J.E. Carlson and T.H. Budd, eds., Proceedings of the Rapid Excavation and Tunneling Conference, Society of Mining Engineers, Las Vegas, NV, June, 22-25.
- Hancher, D.E., White, T.D., Iseley, D.T., 1989, Construction specifications for highway projects requiring horizontal earth boring and/or pipe jacking techniques, Joint Highway Research Project No: C-36-672, File 9-11-26, Conducted for Indiana Department of Highways for Purdue University.
- Iseley, D.T., 1990, Trenchless excavation construction: microtunneling the United States experience, in R. Sinha, ed., Proceedings of the International Symposium on Unique Underground Structures, Colorado School of Mines and U.S. Bureau of Reclamation, Denver, Vol. 2, Chap 92, June.
- TRB (Transportation Research Board), 1997, Synthesis of Highway Practice, 242, Trenchless Installation of Conduits beneath roadways, National Cooperative Highway Research Program, Iseley D.T., and S.B. Gokhale, eds., National Academy Press, 76p.

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- North American Society for Trenchless Technology
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END OF SECTION