SECTION 3.0

Conceptual Design of Well Facilities

This section presents conceptual designs for new Zone 7 well facilities. New Zone 7 wells may be used daily or to meet peaking and/or emergency demands that affect final design choices. Conceptual designs address civil, mechanical, electrical, and instrumentation and control I&C issues, as well as with siting considerations and issues related to potential grouping of wells into common treatment systems. This section also reviews disinfectant treatment system options and provides construction cost estimates for wells, well facilities, and transmission connections for a variety of design options. This chapter reflects work originally presented to Zone 7 in Draft Technical Memorandum *Conceptual Wellfield System Design and Cost Estimate* (CH2M HILL, 2002).

3.1 Alternative Well Locations and Facility Types

3.1.1 Alternative Well Locations

Future well facilities for Zone 7 will be incorporated into different types of urban and semi-urban areas. Zone 7 needs flexible well facilities designs that will be acceptable to the public in these different environments and maintain reasonable costs. A review of the current and future land uses within Zone 7 suggests that most future wells will be located in a mostly urban environment. These urban environments can be divided into three distinct areas, which include:

- **Residential Areas.** The predominant use of land in these areas include residential housing, apartments, condominiums, and shopping centers. In these areas, future well facilities will likely be located on small lots or rights-of-way adjacent to the current land uses.
- **Parks and Open Space Areas.** The predominant use of land in these areas is as open space with public access for recreational use. In these areas, future well facilities will likely be located in corner areas of the park or other more remote locations on the available property.
- **Industrial and Other Areas.** The predominant use of land in these areas consist of factories, manufacturing, and warehouses. In these areas, future well facilities will be located on small parcels of land that may be available adjacent to the current land uses. These include rights-of-way adjacent to roads, small lots, and other available parcels.

Potential well facility impacts to the surrounding area include: aesthetic considerations, such as overall appearance of the facility; potential noise impacts from equipment operations and maintenance; equipment and material deliveries, which include truck traffic; and chemical deliveries and storage. Some of these impacts, such as the aesthetics of the facility and the noise impacts, are controllable and can be substantially reduced through proper design. Other potential impacts, such as equipment and material deliveries, can be partially reduced by selecting processes that minimize impacts.

Considering the potential impacts discussed above, the three types of well facility locations were combined into two groups: 1) residential, park, and open spaces and 2) industrial and other areas. These two groups are separated based upon similarity of potential impacts. For example, in a residential or park area, the aesthetics of the facility building and exposed equipment are more important than they would be in an industrial setting. In addition, chemical delivery and storage may be more tolerable in an industrial setting as compared to a residential or park setting. The conceptual designs for these to location types are detailed later in this section.

3.1.2 Alternative Well Facility Types and Operational Groups

Some of the new well facilities may be integrated into the Zone 7 supply system to help meet demand on a daily basis, while other new wells may only be used for drought and other periodic water shortage emergency needs. These two types of wells are herein termed "base" and "auxiliary" wells, respectively. Base wells would be used quite frequently, while auxiliary wells would remain mostly in standby mode. These two types of wells have different design considerations and may be outfitted differently. However, even auxiliary wells will need to be "exercised" periodically to maintain well performance and must undergo water quality sampling approximately once a month or quarter, as required by the DHS.

Groundwater pumped from the wells will require some level of treatment prior to being pumped into the distribution system. Existing Zone 7 wells use disinfection by chlorine and ammonia to form a chloramine residual. Future treatment may include the addition of fluoride. Both base and auxiliary wells may be grouped into systems that serve a common treatment system, or they may be outfitted with individual treatment systems. In order to keep the treatment systems manageable in size, the maximum number of grouped wells that might serve any single treatment system generally will be three and may include a demineralization facility. The number of wells serving a treatment system will depend on both the hydrogeology at the location (primarily well yield) and the supply needed to meet local water demand. The following two general configurations of wells and treatment systems may be used (also see Figure 3.1-1):

- **Adjacent Treatment**. This configuration comprises one well with adjacent treatment facilities with up to two additional auxiliary or base wells, located separately, but pumping to the common treatment facility.

- **Separate Treatment**. This configuration comprises one to three wells pumping to a common treatment facility located separately from the well sites. For wells without on-site treatment, a raw water pipeline will be required to convey water from the wells to a treatment system. Raw water pipelines will be located within public rights-of-way and should be sized for velocities of 3 to 5 feet per second (ft/s).

As discussed earlier, two general land-use categories guide the selection of the aesthetic design components of each well and treatment location: 1) residential, park, and open space and 2) industrial areas. The impact of these designations on the site design will resolve around visual appearance and noise. A third issue that impacts design is risk associated with truck traffic and chemical deliveries and storage. These risks can also be managed through operator training and standard operating and safety procedures.

This third issue of risk can be considered in the facility component selection, but these considerations are site-specific. For example, if a high-capacity auxiliary well is located in a residential neighborhood, based on economics, the desired chlorine system would be bulk deliveries of sodium hypochlorite solution. This is because a salt-based, on-site chlorine generation system is expensive, especially for a system that is used infrequently. However, an on-site generation system using salt may be more desirable from a safety viewpoint, as it avoids frequent truck deliveries of the sodium hypochlorite and large tanks of the concentrated solution are not stored on site. A compromise in this situation may be that the liquid chlorine storage could be sized to store more product, thereby requiring fewer deliveries, thus reducing the truck traffic to the site. This would require larger tanks, and the maximum recommended storage for the concentrated hypochlorite solution is 30 days, to minimize degradation. Lower concentrated solutions can be stored for longer periods.

In summary, two types of well designations will be used, and these designations will guide the selection of the well site equipment at that site. Base wells will be used on a daily basis with other existing wells and supplies; whereas, auxiliary wells generally will remain in standby mode and used only to meet emergency needs. Wells may be grouped and piped to a common treatment system. One to three wells might serve a given treatment system. Treatment systems might be sited separately or adjacent to wells. Treatment system equipment selection will depend on the type of wells supplying the location. All sites include aesthetic issues that are strongly related to surrounding land use: residential, park, and open space versus industrial. The types of well sites and treatment sites that are considered are represented in Table 3.1-1. Different well and treatment types will then be combined into one of two operational groups, depending upon if the treatment system is located adjacent to a well or on a separate site.

3.1.3 Existing Distribution System

New wells and well fields will require conveyance piping to treatment facilities and the existing water distribution system. Operating pressures in the existing distribution system typically range from approximately 100 to 125 pounds per square inch (psi). New pipes will range from 10-inch to 36-inch-diameter, depending on the well flow rates. The pipe materials used typically will be ductile iron or welded steel, cement mortar-lined, and coated.

3.2 General Well Facility Design Criteria

Future Zone 7 wells may be located throughout the service area. The wells may be operated independently or be grouped with discharge to a common treatment system. The following subsections discuss required pumping systems, piping, valving, and discharge controls.

3.2.1 Well Pumps and Motors

Water must be pumped from the well, through the treatment system, and into the distribution system. It is currently assumed that the well pump will meet all these requirements. The pumping rates for new wells are expected to be in the range of 1,000 gpm to 4,000 gpm. The head developed by the well pumps must deliver the pumped water into the distribution system at the water delivery pressure.

The type of pumps used for the new wells may be either vertical turbine or submersible pumps. Vertical turbine pumps are the preferred pumps because of access to the electrical motor, generally higher pump efficiencies, and overall lower cost. However, high-horsepower vertical motors generate noise, and it will be necessary to reduce the noise levels. This could be achieved through a combination of noise-insulated well buildings and the use of carefully selected equipment or by using submersible pumps.

The noise standards recommended for the entire project area are:

- L_{max} (maximum noise level, not to be exceeded during any 1-hour period): 60 decibels, A-rated (dBA).
- L_{50} (noise level not to be exceeded for a cumulative period of 30 minutes or more in any 1-hour period): 45 dBA.
- Cumulative (15 minutes in any 1-hour period): 50 dBA.

The desired maximum pump and motor speed is 1,800 revolutions per minute, which provides a good balance between equipment life and the overall pump size required to place in the well. Assuming a water delivery pressure of up to approximately 120 psi and a depth-to-pumping water level of approximately 300 feet, the well pump motors will require horsepower (hp) ratings in the general range of 200 hp to 800 hp. This will require pump diameters from a minimum of 10 inches for the 1,000 gpm flows to as large as 18 inches for the 4,000 gpm flows. The submersible pump motors for the horsepowers required range from a minimum of 10-inch-diameter for the 200 hp units to as large as 18-inch-diameter for the 800 hp units. These sizes need to be considered carefully when selecting the final well casing sizes.

3.2.2 Well Discharge Piping

The well discharge piping serves two functions: 1) the piping must deliver the groundwater from the well to the treatment system, and 2) the piping must enable pumping water to waste during well startup and in the event of system over pressurization. A typical piping configuration is shown in Figure 3.2-1.

Starting the well pumps and discharging through the well piping will begin by pumping the wells to waste between 5 minutes to over 30 minutes. In the piping configuration shown in Figure 3.2-1, this is performed by opening the pump control valve (PCV) fully and then starting the pump. When a well is not in operation, the PCV is in the open position. Opening of the PCV should be incorporated into the pump start sequence and should be controlled by an on-site programmable logic controller (PLC) with a set point determined by operator (typical). With the PCV open and the pump operating, the piping check valve is held closed by downstream pressure, and the water discharges through waste piping to a storm drain or other discharge point. After a timed period, the PCV needs to slowly close. This will cause pressure to build on the upstream side of the piping check valve and cause it to slowly open. Once the PCV is fully closed, all the water discharged by the pump will be directed through the discharge piping and travel to the treatment system. Treated water feeds directly to the distribution system.

Shutting down the pump should follow the same procedure in reverse. The PCV slowly opens and discharges the pumped water to the storm drain. This action slowly closes the piping check valve and prevents a surge in the system from closing the valve too quickly. Once the check valve is fully closed and seated, the pump can be shut off.

An over-pressure safety feature must also be incorporated into the discharge piping. This feature should provide protection to the piping and pump in case of high pressure in the discharge piping. Damaging high pressure can be caused in the discharge piping if a downstream valve in the piping is accidentally closed during pump operation, or if the pump is started against a closed valve. In theses cases, or others, a mechanical method to relieve this pressure must be installed on the piping. As shown in Figure 3.2-1, the preferred method is a pressure relief valve that discharges to the waste piping. It is important to install the pressure relief valve so no other valves can accidentally block the pressure relief operation.

The features listed below should be incorporated into the discharge piping. Where possible, these features are shown on Figure 3.2-1.

- The timer that controls the length of waste discharge should have a manual-set option through a hand dial in the local control panel.
- An air/vacuum valve should be installed on the discharge piping to vent air during pump startup. Direct discharge/vent to floor drain.
- Flow meter should have a local readout and a 4 to 20 milliampere (mA) output signal.
- Discharge to waste must incorporate a positive backflow device, preferably an air gap.
- Pressure indication must have with a 4 to 20 mA output signal on the discharge piping.
- System should have pressure switch that shuts down the pump in case of high line pressure and subsequent a pressure relief valve operation.
- Piping should include sample taps to obtain water quality samples on raw water pipe for pump discharge and in between the sodium hypochlorite and the ammonia injectors.
- Piping should be sized to a maximum velocity of 5 ft/sec to reduce noise (10-inch to 18-inch).
- Pump pedestal should be of adequate height above the floor to prevent external water from entering well.
- System should have vertical turbine pump that pack drain piping to the floor drain to the sewer.
- Piping and valves should be of adequate height above the floor to allow service to flanges, etc.

3.3 General Site Considerations

Site considerations for well and treatment system locations revolve around three main issues: 1) ease of access for routine visits including monitoring, construction, and maintenance; 2) equipment exposure to the elements; and 3) security. The selection of components to address these considerations for each site is guided by both functionality and the site land-use designation (residential or industrial).

3.3.1 Civil Facilities

Access to the sites requires the ability for both passenger vehicles to access and park and for large trucks to deliver chemicals (treatment site) and to service the well. This will require the vehicles into the site to have minimum turning radii of 55 feet. Additionally, each site should ideally have two entrances/exits so large trucks can enter and exit the site without turning around or backing up. The site should also include space for parking up to three passenger vehicles or pickup trucks.

It is also important for site layouts to have entrance gates set back from the road so trucks can pull in off the main road prior to opening the gate. This reduces traffic congestion when trucks or smaller vehicles need access to the sites. The site roadways with these features are shown on Figures 3.2-1, 3.3-1, and 3.3-2.

It is important to note that the ideal site layout may differ from the actual site layout. This will be due to availability of land parcels and their ultimate size and shape. For the well-only sites, smaller parcels of land could be used, if the truck access requirements to the site were relaxed. This may be the case in industrial areas, where well sites may comprise only the well and well house in a road right-of-way. In this case, the site layout still needs to allow access to the well for service; however, access for infrequent large truck visits may require the use of adjacent roadways or other public land. Building setbacks must also conform to local codes, as applicable.

Most well and treatment sites require fencing to provide site security and a barrier for unauthorized personnel from entering. The fencing may take different forms depending on the location of the site but, at a minimum, should be a 6- to 8-foot-high, chain-link fence that may contain decorative slats in certain areas or barbed wire in others. Concrete masonry block walls may also be used to match surrounding facilities. Fencing must be in accordance with local requirements in terms of setbacks and heights. In open space or public park areas, fencing may not be included to minimize impacts to these areas or loss of open space. At these locations, the buildings must provide adequate security. Also, the areas adjacent to the building must allow for truck access for chemical deliveries and maintenance.

Site grading will be provided in accordance with local requirements. Storm drains will be required for discharging the well water during startup and shutdown of the well, as previously described. Catch basins and manholes will also be provided for storm drain collection and connection to the existing system. The storm drains will be sized at a minimum to handle the total well capacity. Sewer connections may be provided where bathroom facilities are included, typically only where chemicals and continuous sample monitoring are used. Potable water connections will also be required where chemicals are used for emergency showers and eye washes and for service sinks.

Typically, sites will be paved with asphalt concrete or concrete to allow for truck access and parking for maintenance personnel. Landscaping will also be provided in accordance with local code requirements. Landscape areas will have with 6-inch concrete curbs. At treatment sites that are designated for base well use and at base well sites that contain smaller electrical motors, a parking space with easy access to power connections and manual transfer switches will be provided for a portable backup generator. At all other sites, power connections and manual transfer switches will be provided for portable generators; however, a designated generator parking location may not be provided.

3.3.2 Electrical and I&C Facilities

The District typically uses 4,160-volt power supply for wells with capacities of 2,000 gpm and higher. All other wells use 480-volt power. Electrical service to the well sites will be provided by concrete pad-mounted transformers owned by the power company. Pacific Gas & Electric (PG&E) requires a 10-foot minimum clearance on all sides of the transformer. Removable guard posts are also provided for protection.

Future wells will include provisions for connection of portable emergency generators with manual transfer switches. For 4,160-volt service, large trailer-mounted generators will be rented as needed. For 480-volt service, District-owned, trailer-mounted generators are used. Locations are provided for the portable generators in the vehicle parking areas as shown in Figures 3.1-1, 3.2-1, and 3.3-1.

Electrical control panels will be located in a separate electrical room within the building. Controls for sodium hypochlorite and ammonia feed systems will be located separate from the storage tanks or in corrosion-resistant housings.

In general, all electrical equipment will be designed in accordance with the National Electric Code and local codes and will be UL-rated or equivalent. Well facilities shall be considered primary facilities for seismic design considerations and reliability. UPS systems are required for the backup of control system, alarms, radios, etc. with a minimum 2-hour supply. Control will interface with the District's existing supervisory control and data acquisition (SCADA) system, with radio communications for telemetry. The control system will be monitored with a PLC or remote terminal unit at each site. All electrical devices, switches, etc., shall be identified in accordance with District standards. Facilities will be designed for sustained temperature ratings between 25 and 105 degrees Fahrenheit.

Instrumentation will be provided in accordance with District requirements and standards. At a minimum, signals are required to monitor flow to waste activities, production flow rate and total volume, well water level, piping pressure, water quality, and various alarms. Pumps and equipment will be provided with local power disconnects (480-volt motors only) and local/on/off/remote switches. The pump waste control valves also include solenoids and position signals for automatic operation. Chemical feed systems will include leak-detection equipment of secondary containment systems. For security, motion detectors or intrusion switches will also be provided for the building. Telephone service will also be provided.

Outdoor site lighting will be provided in accordance with Illumination Engineering Society Standards and local codes. Outdoor lighting shall be low-pressure sodium type and controlled with local switches. Emergency lighting for emergency system repairs will be provided in accordance with Zone 7 standards.

3.4 General Description of Treatment Facilities

Zone 7 currently uses chloramination for disinfection to meet drinking water standards and to limit formation of disinfection byproducts. The chemical feed systems for chloramination include sodium hypochlorite and aqueous ammonia. As discussed above, additional provisions for future fluoridation facilities will be provided at some of the treatment facilities.

Treatment systems were evaluated for a range of flows received from small individual wells to large operational groups. It was assumed that the smallest well capacity would be 1,000 gpm. If this well were to be a single well in an operational group, the smallest-sized treatment system would require a capacity to treat 1,000 gpm. It was also assumed that the largest single well capacity would be 4,000 gpm. Considering an upper limit on the size of a treatment facility, it was assumed that no more than one large well and two small wells would be included in an operational group. Therefore, the largest treatment facility required would be 6,000 gpm. Any larger treatment facilities will require a larger footprint than currently planned. Well capacity, chlorine dosage, and demand are discussed on Table 3.4-1.

Following development of an area and the installation of wells, the final treatment facility size will be determined and its dimensions will be within the bounds of those presented here. In general, treatment facilities will be designed per all applicable federal, state and local codes for toxic materials. These include the National Fire Protection Association 820, Standard for Fire Protection in Wastewater Treatment and Collection Facilities, OSHA, local hazardous materials fire codes, and District confined-space requirements.

3.4.1 Sodium Hypochlorite

Sodium hypochlorite can be supplied in bulk deliveries, typically as a 12.5-percent solution, or generated on site using catalytic electrolysis of a brine solution for a 0.8-percent solution of hypochlorite. On-site generation is preferred for large capacity systems or in areas where large bulk shipments and storage of the chemical are undesirable. However, the equipment for on-site generation has high capital and operation and maintenance (O&M) costs. Thus, for the auxiliary well systems where the wells will be used infrequently, bulk deliveries of hypochlorite may typically be more practical. The following general assumptions are used for the sodium hypochlorite system configurations presented:

The disinfection systems will be capable of treating the maximum flow with the dosages indicated below.

Bulk sodium hypochlorite and salt storage facilities were sized for a 30-day storage time between deliveries and an average flow equal to one-half of the rated flow. Therefore, the wells will normally operate half of the time. If the wells are operated continuously, then the time between deliveries shortens to 15 days.

Additional facilities common to all the chemical feed systems include secondary containment of hazardous chemicals, eyewash and shower stations, ventilation systems, related safety equipment, and standby power for treatment systems.

Buildings will be provided to house process equipment, sodium hypochlorite storage tanks for 12.5-percent solutions, and instrumentation and controls.

3.4.1.1 Alternative 1 – Bulk Delivery and Storage

For bulk deliveries, sodium hypochlorite is typically supplied as a 12.5-percent solution. The solution degrades over time, losing some of its disinfection strength and forming chlorate ions in solution. The rate of degradation is impacted by the solution concentration, heat, light, and chemical impurities. Storage systems are typically sized for a 30-day supply or less. Lower concentration solutions have a slower rate of degradation and can be stored for longer periods, if required. To minimize degradation, the chemical should also be stored out of direct sunlight, and a high quality solution should be purchased.

Sodium hypochlorite is available in bulk truck deliveries up to 4,500 gallons or semi-bulk and transferred to a storage tank as needed. Chemical metering pumps would be used to feed the hypochlorite to the point of application. Secondary containment for the storage area and truck unloading area would be provided.

The chemical demands, storage tank capacity and pump sizes are summarized in Table 3.4-2. The facilities are given for treatment systems sized for peak flows of 1,000 gpm and 6,000 gpm, (1.44 mgd and 8.64 mgd) operating 50 percent of the time.

3.4.1.2 Alternative 2 – On-site Generation

Sodium hypochlorite is generated on site using catalytic electrolysis of a high-purity (food grade) saltwater or brine solution. Approximately 3.5 pounds of salt are required to produce 1 pound of available chlorine. Salt is mixed with water in a saturation tank to a desired concentration. The solution is then fed through the generators to produce sodium hypochlorite as needed. The sodium hypochlorite is stored in a small product tank. The process waste product, hydrogen gas, is dewatered and disposed of by venting outdoors.

Facilities include a salt saturation tank, water-softening equipment, chlorine generator, sodium hypochlorite storage tank, metering pumps, instrumentation, controls, and miscellaneous appurtenances. Secondary containment will be provided for the hypochlorite solution and salt storage tanks and piping.

Soft water, with a maximum hardness of 25 mg/L as calcium carbonate, should be used for mixing the brine solution. The water must also be free of trace organics and metals that would cause electrode fouling or scaling in the generators.

The electrolytic cells must be cleaned regularly with an acid solution, which produces a concentrated waste acid byproduct. Larger generators often include an acid-cleaning system. Typically, the cells require cleaning every 2,000 to 4,000 hours of service. The cleaning frequency is dependent on the salt purity and water quality. In addition, the electrolytic cells require replacement about every 4 years, depending on the hours of operation. Acid solution will be delivered, as required, to avoid long-term storage.

Chemical demands and equipment sizing for typical treatment systems with peak capacities operating 50 percent of the time are summarized in Table 3.4-3.

3.4.1.3 Evaluation of Treatment Alternatives

In order to evaluate the applicability of the two systems for sodium hypochlorite, preliminary estimates of capital cost, O&M costs, and present worth were prepared. The estimates for the two alternatives are for purposes of comparison only, and do not reflect the actual engineer's estimate of construction cost. Annual O&M estimates comprise chemical, equipment, labor, and power costs, as summarized in Table 3.4-4.

Estimated costs for the complete systems described in this section were also prepared. These are combined with the treatment costs and presented in a subsequent section. A summary of the preliminary estimates of capital, O&M costs, and present-worth costs for each sodium hypochlorite feed system alternative is presented in Table 3.4-5. These costs are based on preliminary and general assumptions for comparative purposes only, and do not reflect the total cost of the chemical treatment system. These costs do not reflect cost for items or facilities common between the alternatives such as site work, building, utilities, engineering design, etc. The actual final costs are anticipated to vary. Preliminary design estimates typically provide an order-of-magnitude cost with an expected accuracy of +50 percent to -30 percent of the actual cost of construction. Based on this expected level of accuracy, the final alternative may not be selected solely on cost considerations.

Capital, O&M costs, and present-worth costs are lower for bulk-delivery systems for both sizes of sodium hypochlorite feed systems. Thus, bulk delivery systems are more economical. The costs for on-site generation are about double of that for bulk delivery systems.

3.4.1.4 Recommended Sodium Hypochlorite Feed System

As noted above, on-site generation is recommended for large-capacity systems in residential, commercial, and open space areas where large bulk shipments and storage of the chemical are undesirable. Bulk delivery systems are recommended for all other locations. Since the solution degrades over time, for small well systems where the wells will be used infrequently, the chemical should used completely or diluted if stored for more than 1 month.

3.4.2 Aqueous Ammonia

Aqueous ammonia is supplied commercially at a 19-percent concentration. Feed systems should be designed for 3 to 5 pounds of chlorine per pound of ammonia, based on the design demand. Required facilities include an aqueous ammonia storage tank, a pressure relief valve with a scrubber tank to prevent discharge of ammonia gasses, metering pumps, instrumentation, and controls. A minimum of two ammonia injectors will be provided. This allows the system to remain in operation while one injector is out of service for cleaning. A cartridge water softener will also be provided if water quality is hard. For treatment system designed for 1,000 and 6,000 gpm, the ammonia system requirements are summarized in Table 3.4-6.

3.4.3 Fluoridation – Future Facilities

Space should be included for future fluoridation facilities. The chemical feed system for fluoridation typically uses chemical injection using fluosilicic acid solution (H_2SiF_6). Metering pumps feed directly from a bulk storage tank or drums to the feed point. The system would be based on a flow-paced control, with adjustments based on residual concentrations. Where the feed concentration is too low to accurately meter, a day tank and transfer pumps would be included to allow the concentrated acid to be diluted prior to metering. Fluoride system requirements are summarized in Table 3.4-7.

3.5 Specific Description of Site Alternatives

Based on discussions above, eight general site alternatives were identified. All of these alternatives are similar and share many functionality characteristics. However, each has unique characteristics for its location and function that need to be addressed. The following presents each site alternative and lists its unique characteristics based on the previous discussions.

3.5.1 Auxiliary Well/ Industrial

Auxiliary wells will be idle much of the time. The basic layout is shown on Figure 3.2-1. These types of wells in industrial settings will share the basic layout of all wells but will have:

- Metal or non-decorative block building.
- Chain-link site perimeter fencing.
- Vertical turbine well pumps.
- Backup power connections and manual switch transfer. Optional designated space for generator parking.
- Site may include full access for trucks as shown on Figure 3.2-1, or be as small as the size of the building and air gap building footprint.

3.5.2 Auxiliary Well/ Residential

Auxiliary wells in residential settings will share the basic layout of all wells but will have the characteristics listed below. The basic layout is shown on Figure 3.2-1.

- Decorative block building.
- Chain-link site perimeter fencing with slat fill or concrete masonry block wall.
- Vertical turbine well pumps if site is large enough to mitigate noise with building and distance.
- Submersible well pumps if site is too small to mitigate noise with building and distance.
- Backup power connections and manual switch transfer. Optional designated space for generator parking.
- Site may include full access for trucks as shown on Figure 3.2-1, or be as small as the size of the building and air gap structure footprint.

3.5.3 Base Well/Industrial

Base wells will frequently be used daily to meet routine water demands. The basic layout is shown on Figure 3.2-1. This type of well in an industrial setting will share the basic layout of all wells but will have:

- Metal or non-decorative block building.
- Chain-link site perimeter fencing.
- Vertical turbine well pumps.
- Electrical service from "Essential Service" grid.
- Backup power connections and manual switch transfer.
- Designated space for generator parking for smaller horsepower motors.

3.5.4 Base Well/Residential

Base wells in a residential setting will share the basic layout of all wells but will have the following characteristics. The basic layout is shown on Figure 3.2-1.

- Decorative block building.
- Chain-link site perimeter fencing with slat fill or concrete masonry block wall.
- Vertical turbine well pumps if site is large enough to mitigate noise with building and distance.
- Submersible well pumps if site is too small to mitigate noise with building and distance.
- Electrical Service from "Essential Service" grid.
- Backup power connections and manual switch transfer.
- Designated space for generator parking for smaller horsepower motors.
- Air gap building.

3.5.5 Treatment, All Auxiliary Wells, Industrial

Treatment systems for auxiliary wells in industrial areas will be operated monthly, at the most, to exercise the well and obtain water quality samples. These types of treatment systems will use liquid sodium hypochlorite supplied in bulk deliveries for disinfection. In addition, provisions will be included for use of 55-gallon drum deliveries supplied with drum pumps.

The life of sodium hypochlorite solution is much longer at lower doses. Because all feeder well treatment systems typically will be used infrequently, a diluted solution of sodium hypochlorite strength equal to approximately 0.8 percent is recommended for routine use. The lower-strength solution is expected to last several months and, combined with higher-flow chemical feed pumps, can effectively disinfect flows during routine sampling or short-duration pumping times. If the feeder wells are expected to be used for longer durations, higher-strength solution should be brought to the treatment site, and the chemical feed pumps should be adjusted for the higher-strength chemical. The solution should be periodically tested to confirm its strength if stored for any length. The treatment systems for feeder wells in industrial sites are expected to have the following characteristics. The basic layouts are shown in Figures 3.3-1 and 3.3-2.

- Metal or non-decorative block building.
- Chain-link site perimeter fencing.
- No backup power.
- Liquid sodium hypochlorite and ammonia chemical feed system capable of handling both high-strength and low-strength solutions.
- Backup power connections and manual switch transfer.
- Optional designated space for generator parking.

3.5.6 Treatment, One or More Base Wells, Industrial

Treatment systems serving one or more base wells will provide daily flow treatment. These treatment systems will be located in areas that may be frequented by large trucks for the many industrial activities nearby. Therefore, this type of treatment system will use the more economical liquid sodium hypochlorite for disinfection. The treatment systems serving one or more base wells in industrial sites are expected to have:

- Metal or non-decorative block building.
- Chain-link site perimeter fencing.
- Liquid sodium hypochlorite and ammonia disinfection system.
- Backup power connections and manual switch transfer.
- Designated space for generator parking.

3.5.7 Treatment, All Auxiliary Wells, Residential

Treatment systems for auxiliary wells in residential areas will be operated monthly, at the most, to exercise the well and obtain water quality samples. These types of treatment systems will use the more economical bulk delivery of liquid sodium hypochlorite for disinfection. The life of sodium hypochlorite solution is much longer at lower doses. Because the all feeder well treatment systems typically will be used infrequently, a diluted solution of sodium hypochlorite strength equal to approximately 0.8 percent is recommended for routine use. The lower-strength solution is expected to last several months and, combined with higher-flow chemical feed pumps, can effectively disinfect flows during routine sampling or short-duration pumping times.

If feeder wells are expected to be used for longer durations, higher-strength solution should be brought to the treatment site, and the chemical feed pumps should be adjusted for the higher-strength chemical. The treatment systems for all feeder wells in residential sites are expected to have:

- Decorative block building.
- Chain-link site perimeter fencing with slat fill or concrete masonry block wall.
- Backup power connections and manual switch transfer.

- Optional designated space for generator parking.
- Liquid sodium hypochlorite and ammonia chemical feed system capable of handling both high-strength and low-strength solutions.

3.5.8 Treatment, One or More Base Wells, Residential

On-site chemical storage may be undesirable for treatment systems serving one or more base wells in a residential setting. Treatment systems in these areas might use a salt-based chlorine generator for disinfection. The treatment systems serving one or more base wells in residential sites are expected to have:

- Decorative block building.
- Chain-link site perimeter fencing with slat fill or concrete masonry block wall.
- Backup power connections and manual switch transfer.
- Designated space for generator parking.
- Salt-based chlorine generator and ammonia disinfection system.

3.6 Budgetary Cost Estimates

3.6.1 Budgetary Unit Prices

Unit prices were developed for various well and treatment system components for budgetary estimating purposes, as shown in Table 3.6-1. Well facility components and their associated unit prices are combined, depending on the well capacity, location, type of treatment, etc., for a total budgetary price of a complete well system. These range from a small single-well system with no on-site treatment facilities to a large well system combined with treatment facilities on the same site.

Wells will be located in two different types of land-use areas: residential or industrial. The unit prices in Table 3.6-1 are based on wells located in residential settings. As noted, cost factors were developed to adjust the costs for industrial settings. These factors take into consideration that industrial settings require less landscaping and use less-expensive building materials than the residential sites. The building and site costs should be reduced by the approximately 25 and 10 percent, respectively, for industrial settings. The following additional assumptions were used to develop the cost estimates:

- Land costs were assumed to be $30,000 per acre.
- Chain-link perimeter fencing was assumed for all sites.
- A 30-percent construction contingency was used for all costs.
- All costs include in percent of construction, 8 percent engineering cost, 5 percent services during construction cost, and 8 percent permitting and legal cost.
- Residential sites are assumed to be sod.

- Industrial sites are assumed to be graded gravel.
- Large well (4,000 gpm) electrical service was assumed to be 4,160-volt.
- Small well electrical service was assumed to be 480-volt.
- Control signals were assumed to be communicated by radio from each individual site to a common existing SCADA control facility.
- Adequate storm sewers exist within 100 feet of each well site.
- Adequate sanitary sewers exist within 100 feet of each treatment site.

3.6.2 Cost Estimate Summary

A summary of the budgetary capital construction costs for a variety of alternative and treatment systems based on the unit costs presented in Table 3.6-2. Other-sized systems and configurations can be estimated from those given based on the unit prices listed.

3.6.3 Budgetary Cost Estimate Example

A budgetary cost estimate is provided in Table 3.6-3 as an example of how to use the unit cost information presented in Table 3.6-1 to determine the total cost for a given system (capacity, type of treatment system, etc.) summarized in Table 3.6-2. For this example, a 1,000-gpm well is selected to be located in a residential area with an on-site sodium hypochlorite generation system for disinfection. As shown below, the total budgetary cost is estimated at $1,740,900.

TABLE 3.1-1
General Well Types

Site Types and Treatment Groups			
Industrial Setting		**Residential, Open Space, or Park Setting**	
Auxiliary Well Industrial	Base Well Industrial	Auxiliary Well Residential	Base Well Residential
Treatment, Feeder, Industrial	Treatment, Base, Industrial	Treatment, Feeder, Residential	Treatment, Base, Residential

TABLE 3.4-1
Well Capacity, Chlorine Dosage and Demand

Item	Quantity	
Treatment system peak capacity,	**Small Well**	**Large Well**
gpm	1,000	6,000
mgd	1.44	8.64
Treatment system average operating capacity,		
gpm	500	3,000
mgd	0.72	4.32
Maximum chlorine dosage, mg/L	1.5	1.5
Average Chlorine Demand, lb/day	9	54

TABLE 3.4-2
Sodium Hypochlorite – Bulk Deliveries

Item	Description/Quantity	
Chemical	Sodium hypochlorite, NaOCl, 12.5% solution	
Treatment system peak capacity for 30-day chemical storage, mgd	1.44	8.64
Treatment system average operating capacity for 30-day chemical storage, mgd	0.72	4.32
Hypochlorite solution demand, lb/day	151	908
Volumetric demand, gal/day	16.5	98.9
Storage capacity, gal	550	3,200
Metering pump quantity, each (one standby)	2	2
Metering pump capacity, gph	2.8	8.2

TABLE 3.4-3
Sodium Hypochlorite – On-site Generation

Item	Description/Quantity	
Chemical	Sodium hypochlorite, NaOCl, 0.8% solution	
Peak treatment system capacity, mgd	1.44	8.64
Average treatment system capacity, mgd	0.72	4.32
Hypochlorite solution demand, lb/day	2,360	14,200
Volumetric demand, gal/day	280	1,700
Brine feed concentration, mg/L	28,000	28,000
Salt demand, lbs/lb chlorine	3.5	3.5
Salt demand, lbs/day	32	190
Salt storage capacity, lbs	1,000	4,800
Power requirement, kW-hr/lb chlorine generated	2.5	2.5
Hypochlorite storage capacity, gal (2 day demand)	600	3,600
Metering pump quantity, each (one standby)	3	3
Metering pump capacity, gph	12	70

TABLE 3.4-4
Assumptions for Preliminary Cost Comparison

Item	Quantity
Power Cost	$0.18/kW-hr
Chemical Costs	
Bulk sodium hypochlorite, 12.5% solution	$0.75/gal
Salt	$0.07/lb.
Replacement equipment for on-site generation	$1,500/5 years large capacity system $500/5 years small capacity system
Average labor rate	$65 per hour
Labor hours (during operation)	
Bulk sodium hypochlorite	10 hours/week
On-site generation	20 hours/week
Annualized cost period	20 years
Interest rate	3 percent

TABLE 3.4-5
Preliminary Cost Comparison of Sodium Hypochlorite Alternatives (including ammonia feed system)

Alternative	Capital Cost	Annual O&M Cost	Present Worth
6,000 GPM Capacity			
Bulk Delivery	$251,300	$41,200	$823,400
On-Site Generation	$524,800	$68,900	$1,513,100
1,000 GPM Capacity			
Bulk Delivery	$200,300	$35,000	$691,000
On-Site Generation	$338,800	$67,800	$1,318,700

TABLE 3.4-6
Ammonia Feed System

Item	Description/Quantity	
Chemical	**Aqueous Ammonia, NH_3, 19% solution**	
Peak treatment system capacity, mgd	1.44	8.64
Average treatment system capacity, 50% duty, mgd	0.72	4.32
Ratio chlorine to ammonia, lb:lb	3:1	3:1
Ammonia solution demand, lb/day	16	95
Ammonia solution demand, gal/day	2.0	12.2
Storage capacity, gal	100	400
Metering pump quantity, each (one standby)	2	2
Metering pump capacity, gph	0.18	1.2

TABLE 3.4-7
Fluoride Feed System

Item	Description/Quantity	
Chemical	**Fluosilicic Acid, 22% solution**	
Peak treatment system capacity, mgd	1.44	8.64
Average treatment system capacity, mgd	0.72	4.32
Dosage, mg/L	1.0	1.0
Solution demand, lb/day	35	207
Solution demand, gal/day	3.3	19.6
Storage capacity, gal	150	650
Metering pumps quantity, each (includes standby)	2	2
Metering pump capacity, gph	0.3	1.6

TABLE 3.6-1
Budgetary Unit Prices for Well/Treatment Facility Master Planning

Well/Treatment Facility Component	Estimated Unit Cost
Well Drilling	$50/in dia/ft
1,000 gpm, 16” well casing	$320,000
2,000 gpm, 18” well casing	$360,000
3,000 gpm, 20” well casing	$400,000
4,000 gpm, 24” well casing	$480,000
Well Pump & Mechanical Equipment	
1,000 gpm, 10” Vertical Turbine Pump, 200 Hp	$100,000
2,000 gpm, 12” Vertical Turbine Pump, 400 Hp	$133,000
3,000 gpm, 14” Vertical Turbine Pump, 600 Hp	$166,000
4,000 gpm, 18” Vertical Turbine Pump, 750 Hp	$200,000
Wellhead Pipe, Valves & Fittings (On-site Piping)	
1,000 gpm	$75,000
2,000 gpm	$100,000
3,000 gpm	$125,000
4,000 gpm	$150,000
Chemical Treatment System Equipment	
1,000 gpm Bulk Hypochlorite & Ammonia System	$22,825
4,000 gpm Bulk Hypochlorite & Ammonia System	$27,813
6,000 gpm Bulk Hypochlorite & Ammonia System	$32,800
1,000 gpm On-site Chlorine Generation & Ammonia System	$59,100
4,000 gpm On-site Chlorine Generation & Ammonia System	$86,525
6,000 gpm On-site Chlorine Generation & Ammonia System	$113,950
Buildings, Residential Area, $150/sf	
Small Well Only	$150,000
Large Well Only	$195,000
Small Treatment System Only	$135,000
Large Treatment System Only	$150,000
Small Well and Treatment Building	$255,000
Large Well and Treatment Building	$300,000
Cost Factor for Industrial Area ($100/sf)	-25%
Civil Site Work and Landscaping, Residential Area	
Small Well Site	$15,300
Large Well Site	$45,000
Cost Factor for Industrial Area	-10%
Electrical	
Percent of Mechanical and Chemical Treatment Equipment	40%
Instrumentation and Controls	
Control System	$60,000
Equipment Instrumentation, Percent of Mechanical and Chemical Treatment Equipment	12%
Water Main, 4 ft. cover, AC Replacement	
1,000 gpm, 10” Pipe	$80/ft.
2,000 gpm, 12” Pipe	$96/ft.
3,000 – 4,000 gpm, 18” Pipe	$144/ft.
6,000 gpm, 24” Pipe	$192/ft.

TABLE 3.6-1
Budgetary Unit Prices for Well/Treatment Facility Master Planning

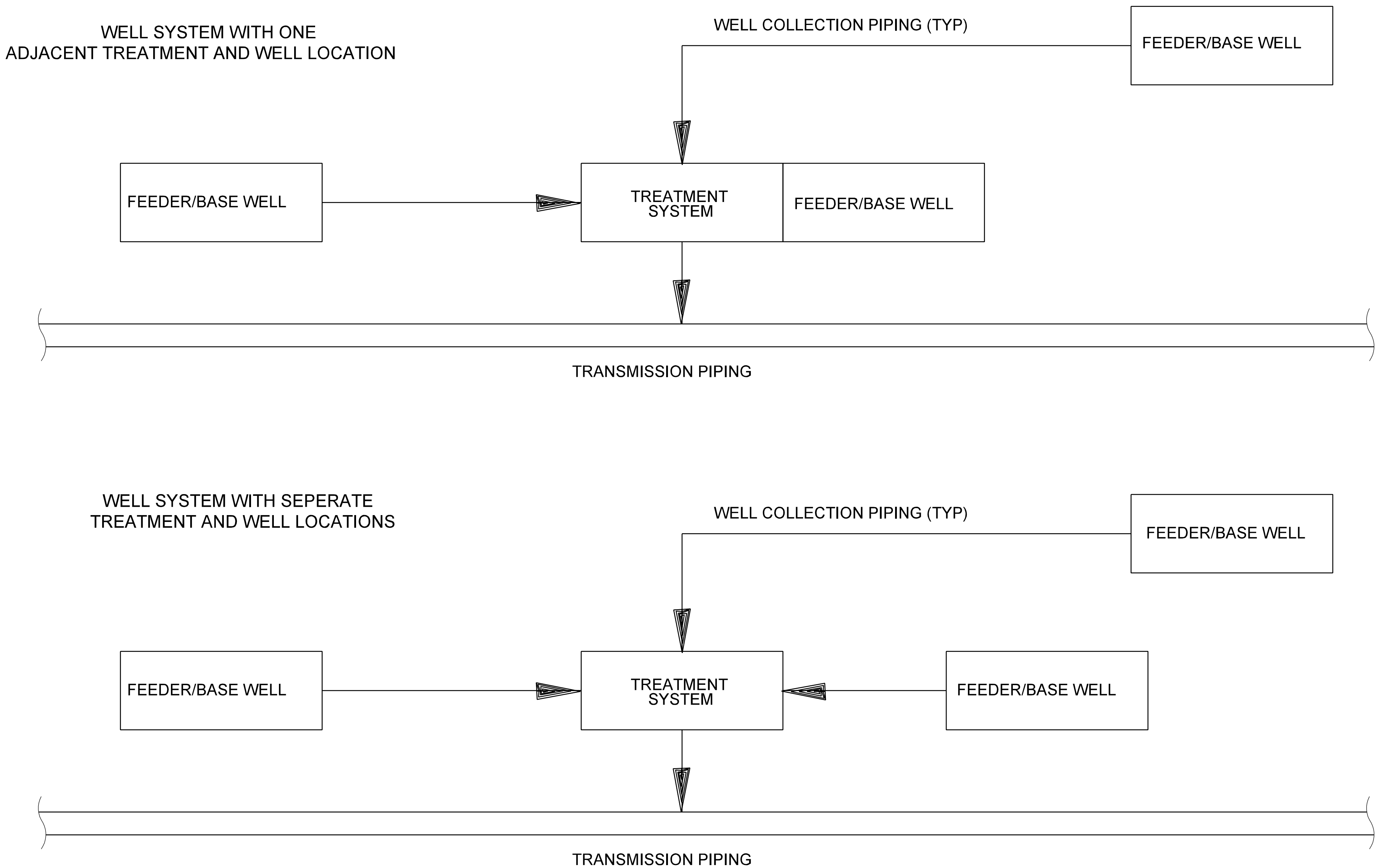
Well/Treatment Facility Component	Estimated Unit Cost
General Conditions	10%
Construction Contingency	30%
Engineering and Legal	
Design Engineering	8%
Engineering Services During Construction	5%
Permitting and Legal	8%

TABLE 3.6-2
Preliminary Capital Cost Comparison of Sodium Hypochlorite Alternatives

Alternative	1,000 gpm Capacity	4,000 gpm Well and 6,000 gpm Treatment Capacity
Residential Well	$1,403,800	$2,270,200
Residential Well with Treatment – Bulk Delivery	$1,645,500	$2,538,100
Residential Well with Treatment – Onsite Generation	$1,740,900	$2,751,500
Residential Treatment – Bulk Delivery (without Well)	$423,900	$527,500
Residential Treatment – Onsite Generation (without Well)	$519,300	$740,900
Industrial Well	$1,336,300	$2,178,000
Industrial Well with Treatment – Bulk Delivery	$1,532,600	$2,400,500
Industrial Well with Treatment – Onsite Generation	$1,628,000	$2,614,000
Industrial Treatment – Bulk Delivery (without Well)	$362,900	$454,800
Industrial Treatment – Onsite Generation (without Well)	$458,300	$668,200

TABLE 3.6-3
Budgetary Capital Cost – Sample Calculation
1000 gpm Well, Residential Area with On-Site Hypochlorite Treatment System

Description of Item	Cost
1. Well Drilling, 1,000 gpm, 16” Well Casing	$320,000
2. Well Pump & Mechanical Equipment, 10” VT Pump	$100,000
3. Wellhead Pipe, Valves, & Fittings/Onsite Piping, 1,000 gpm	$75,000
4. Chemical Treatment System Equipment, 1,000 gpm, On-Site Gen. System	$59,100
5. Buildings, Small Well and Treatment, Residential	$255,000
6. Civil Site Work, Small Well	15,300
7. Electrical (40% of Items 2, 3 & 4, or 0.40 x $234,100)	$93,640
8. Instrumentation and Controls, Control System	$60,000
9. Instrumentation and Controls (12% of Items 2, 3 & 4, or 0.12 x $234,100)	$28,092
Subtotal	**$1,006,132**
10. General Conditions (10%)	$100,613
Subtotal	**$1,106,745**
11. Construction Contingency (30%)	$332,024
Subtotal	**$1,438,769**
12. Design Engineering (8%)	$115,102
13. Engineering Services During Construction (5%)	$71,938
14. Permitting and Legal (8%)	$115,102
Total	**$1,740,900**



NOTES:
1. A MINIMUM OF ONE WELL AND ONE TREATMENT SYSTEM CAN COMPRISE AN OPERATIONAL GROUP
2. UP TO THREE WELLS AND ONE TREATMENT SYSTEM CAN COMPRISE AN OPERATIONAL GROUP
3. THE TREATMENT SYSTEM CAN BE ADJACENT TO A WELL OR SEPERATE AS SHOWN

FIGURE 3.1-1
OPERATIONAL GROUP CONFIGURATIONS
ZONE 7 - WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

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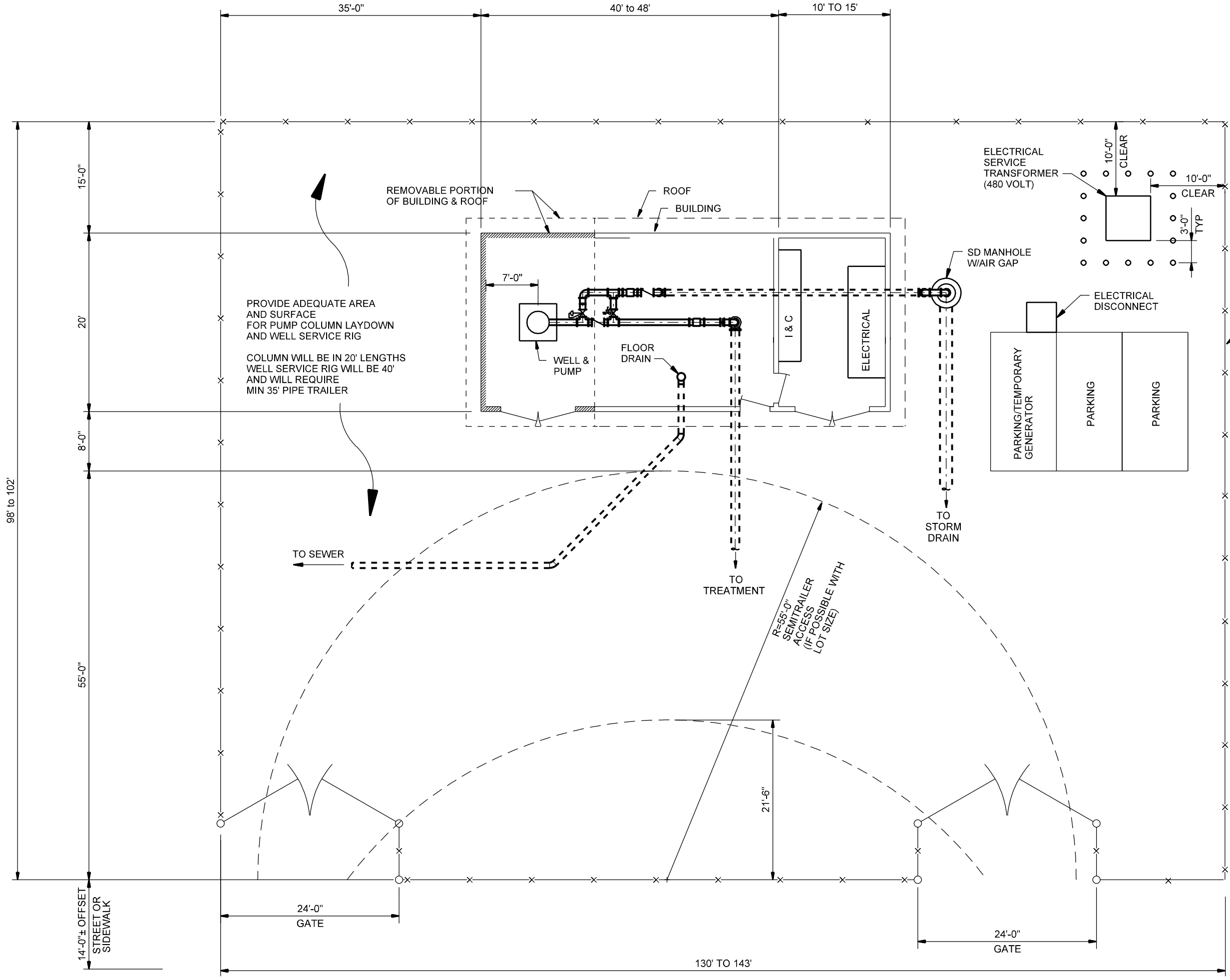
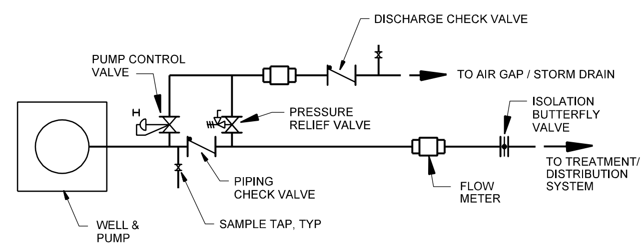
163304.WM.06_W102003001SFO_Z7 FIGURE 3.1-1_10/13/03_ccc

NOTES:

1. BUILDING SETBACKS IN RESIDENTIAL AREAS MUST FOLLOW LOCAL CODES AND MAY VARY FROM THAT SHOWN
2. THE SITE IMPROVEMENTS MUST BE ARRANGED TO CONFORM TO THE ACTUAL SITE SIZE. ALL FEATURES SHOWN MAY NOT BE POSSIBLE DEPENDING ON ACTUAL SITE SIZE.
3. DRAWING REPRESENTS BOTH BASE AND FEEDER WELLS IN ALL LAND USE AREAS. BASE AND FEEDER WELL DIFFERENCES ARE DESCRIBED IN THE TEXT.
4. PIPING ROOM REQUIRES 40' WIDTH FOR 10" PIPING, 48' WIDTH FOR 18" PIPING.
5. ELECTRICAL ROOM REQUIRES 15' WIDTH FOR 4160 VOLT SERVICE, 10' WIDTH FOR 480 VOLT SERVICE.
6. TRANSFORMER SHOWN FOR 480 VOLT SERVICE.



SITE PLAN
NTS



PIPING SCHEMATIC
NTS

FIGURE 3.2-1
TYPICAL WELL FACILITY SITE PLAN
ZONE 7 - WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

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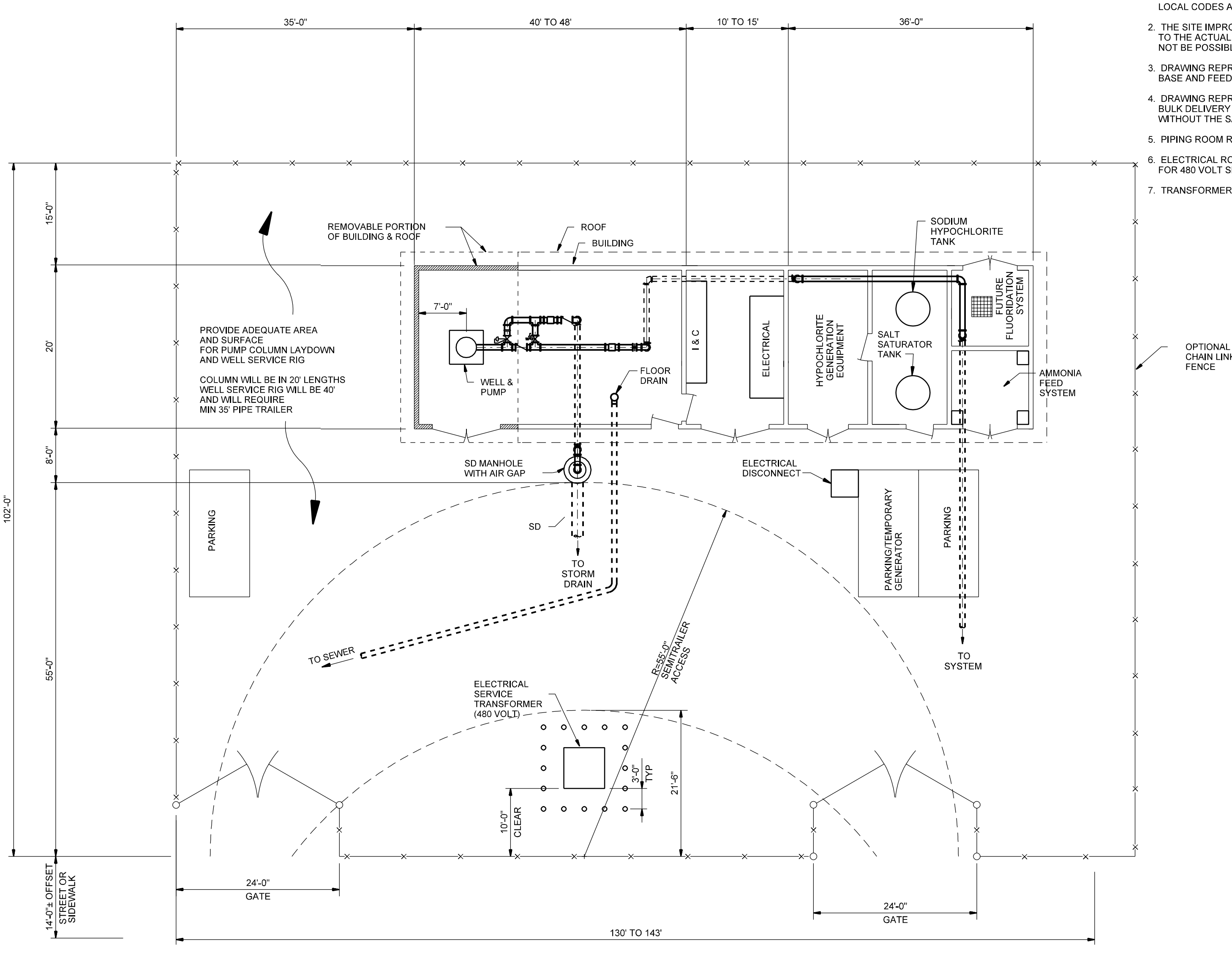
163304.WM.06_W102003001SFO_Z7 FIGURE 3.2-1_10/13/03_ccc

NOTES:

1. BUILDING SETBACKS IN RESIDENTIAL AREAS MUST FOLLOW LOCAL CODES AND MAY VARY FROM THAT SHOWN
2. THE SITE IMPROVEMENTS MUST BE ARRANGED TO CONFORM TO THE ACTUAL SITE SIZE. ALL FEATURES SHOWN MAY NOT BE POSSIBLE DEPENDING ON ACTUAL SITE SIZE.
3. DRAWING REPRESENTS BOTH BASE AND FEEDER WELLS IN ALL LAND USE AREAS. BASE AND FEEDER WELL DIFFERENCES ARE DESCRIBED IN THE TEXT.
4. DRAWING REPRESENTS ONSITE HYPOCHLORITE GENERATION USING SALT. BULK DELIVERY CHLORINE SYSTEM WILL USE SAME BUILDING SIZE WITHOUT THE SALT SATURATOR TANK.
5. PIPING ROOM REQUIRES 40' WIDTH FOR 10" PIPING, 48' WIDTH FOR 18" PIPING.
6. ELECTRICAL ROOM REQUIRES 15' WIDTH FOR 4160 VOLT SERVICE, 10' WIDTH FOR 480 VOLT SERVICE.
7. TRANSFORMER SHOWN FOR 480 VOLT SERVICE.



SITE PLAN

NTS

FIGURE 3.3-1
WELL FACILITY WITH ON-SITE TREATMENT
ZONE 7 - WELL MASTER PLAN

ZONE 7 WATER AGENCY
WELL WATER PLAN

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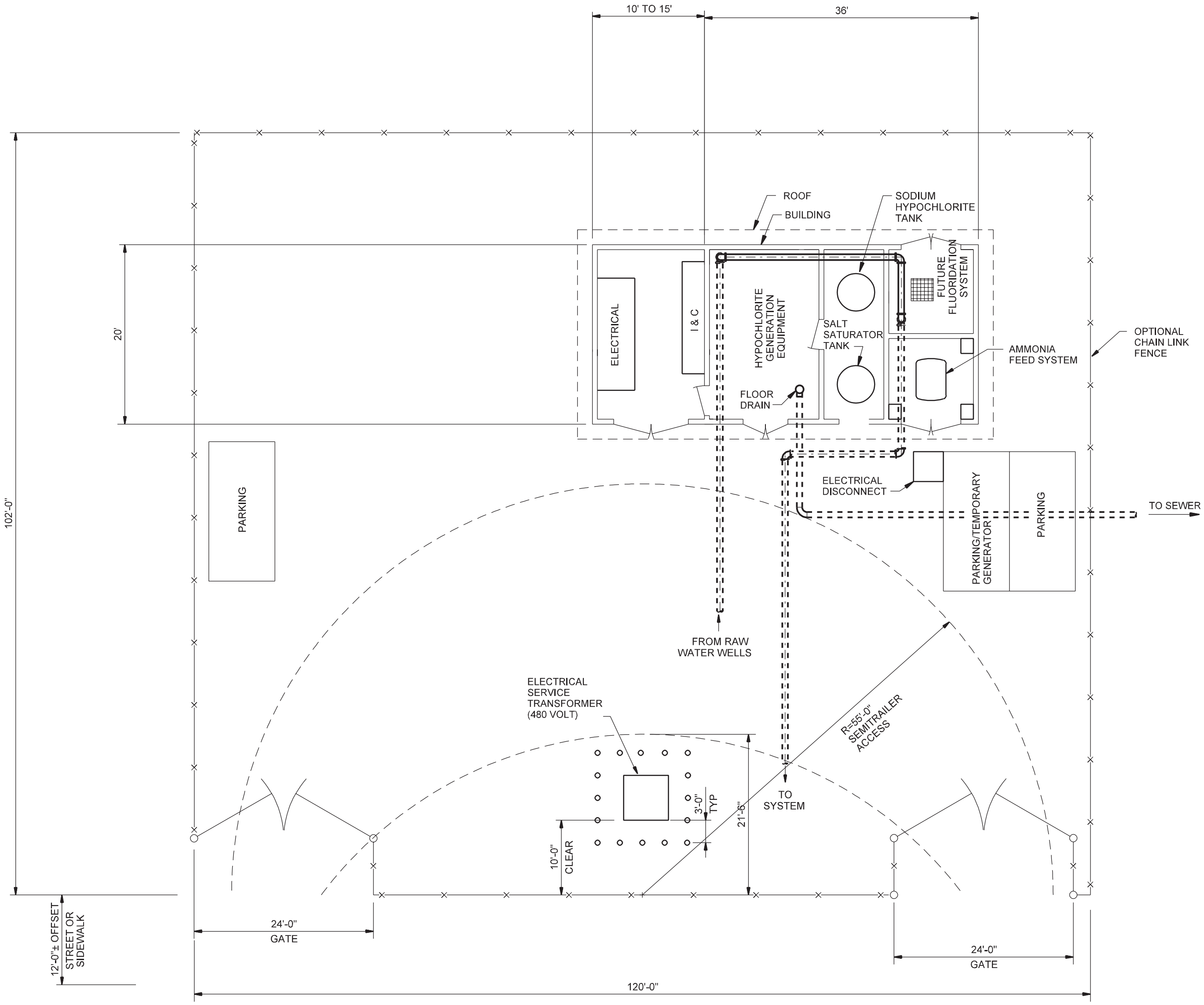
163304.WM.06_W102003001SFO_Z7 FIGURE 3.3-1_10/13/03_ccc



NOTES:

1. BUILDING SETBACKS IN RESIDENTIAL AREAS MUST FOLLOW LOCAL CODES AND MAY VARY FROM THAT SHOWN
2. THE SITE IMPROVEMENTS MUST BE ARRANGED TO CONFORM TO THE ACTUAL SITE SIZE. ALL FEATURES SHOWN MAY NOT BE POSSIBLE DEPENDING ON ACTUAL SITE SIZE.
3. DRAWING REPRESENTS ALL LAND USE AREAS. DIFFERENCES ARE DESCRIBED IN THE TEXT.
4. DRAWING REPRESENTS ONSITE HYPOCHLORITE GENERATION USING SALT. BULK DELIVERY CHLORINE SYSTEM WILL USE SAME BUILDING SIZE WITHOUT THE SALT SATURATOR TANK.
5. ELECTRICAL ROOM REQUIRES 15' WIDTH FOR 4160 VOLT SERVICE, 10' WIDTH FOR 480 VOLT SERVICE.
6. TRANSFORMER SHOWN FOR 480 VOLT SERVICE.

SITE PLAN
NTS

FIGURE 3.3-2
TYPICAL WELL FACILITY TREATMENT SYSTEM
ZONE 7 - WELL MASTER PLAN
ZONE 7 WATER AGENCY
WELL WATER PLAN

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163304.WM.06_W102003001SFO_Z7 FIGURE 3.3-2_4/19/04_mai