CHAPTER 2.1
GROUND WATER EXTRACTION WELLS

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2.1-1. GENERAL. Ground water extraction wells are often an integral part of a pump and treat system. The extraction wells remove contaminated ground water or create a hydrologic barrier to the movement of a plume of contaminated ground water. Each well extracts water at rates that can vary from a few gallons per minute up to hundreds of gallons per minute. Other fluids, such as non-aqueous phase liquids, may also be removed using extraction wells. The water from an extraction well system usually is pumped to a treatment plant where the contaminants are removed. After the water has been treated, it may be discharged back into the subsurface, to a sewer system, or to a lake or stream. Subsurface discharge can be accomplished by means of one or more recharge wells. These wells are designed to recharge ground water, to provide some measure of hydrologic control on the migration of the contaminated ground water, or to create a flushing of contaminants toward adjacent extraction wells.

a. Scope. This section describes the installation of ground water extraction and recharge wells. Monitoring wells and piezometers are also installed as part of ground water extraction systems and they are discussed to a limited extent in this section. For the purposes of this document, the term piezometer will refer to a device that is used to measure the ground water elevation of a particular hydrologic unit (geologic material that has distinct hydrologic parameters), whereas a monitoring well will be used to obtain a representative water sample in addition to water elevation data. See EM-1110-1-4000, and ASTM D 5092 for more detailed information on monitoring wells.

b. Equipment.

(1) Well Drilling Equipment.

(a) Determine that the drill rig has been inspected in accordance with the provisions of EM-385-1-1 (Chap. 16).

(b) Confirm that the contractor is maintaining records of tests and inspections on site.

(c) Confirm the rig is free of fluid leaks and has been decontaminated prior to moving onto the drilling location. ASTM Standards D 5088 and D 5608 address decontamination of field equipment.

(d) Confirm that the drill rig is capable of performing the approved drilling method. Additional guidance on drilling methods can be found in EPA/625/6-87/016.

(e) Ensure that the driller has all of the sampling equipment for the required geotechnical and chemical samples (split spoons, stainless steel split spoons, shelby tubes, etc.). Additional guidance on sampling methods can be found in EM 1110-1-1906 and EPA/625/R-93/003a.

(f) Ensure that the rig is equipped to carry out Standard Penetration Tests per ASTM D-1586.

(2) Personnel.

(a) Ensure that the driller is licensed in the State to perform the required work.

(b) Confirm that all persons working in the exclusion zone meet OSHA requirements for training and medical surveillance and that they have read and signed the SSHP. They also must be wearing appropriate protective clothing as described in the SSHP.

c. Preconstruction Submittals. The contractor should provide preconstruction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Drilling and Well Installation Plan which describes:

- the drilling method and equipment;
- well installation procedures;
- soil/rock logging procedures and forms;
- soil sampling and sample handling procedures;
- drill cuttings/fluid handling plan;
- well development procedures;
- well testing procedures and equipment;
- well permitting information (copies of all permits must be maintained on site);
- procedures to obtain digging permits/utility clearances; and
- decontamination procedures.

The plan needs to outline the responsibilities and authorities for each of the above activities.

(a) Verify that the drilling subcontractor has read the well installation specifications prior to installation of the wells.

(b) Qualifications for the driller should be submitted if licenced drillers are required in that state. Verify that the qualifications meet the specifications and any state requirements. The qualifications, including education and experience, of the geologist or engineer responsible for logging the materials encountered in drilling should also be submitted for information.

(2) Submittals or catalog information on:

- well screen and casing;
- cement and/or bentonite well sealant;
- precast well head vaults (if applicable);
- piping;
- pump(s) and associated equipment;

- gauges and controls; and
- electrical components.

(3) Gradation test results for filter pack material and pipe bedding/backfill, if required.

d. Construction Submittals. The contractor should provide construction submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Boring logs for extraction, injection, or monitoring wells.

(2) Proposed well locations or well screen placement may be a submittal if well construction was left to the contractor based on conditions encountered. Contact the design district if uncertainty exists about the adequacy of the proposal.

(3) Well construction diagrams for each well installed.

(4) Water yield test results for individual extraction (or recharge) wells. Water yields are determined by performing specific capacity tests and are used to verify design assumptions. Results of these tests may need to be submitted to the designer for review and approval.

(5) Chemical sampling results from the initial well sampling.

(6) Water level measurements and contour maps as required. This information may need to be submitted to the designer for review and approval.

(7) Geophysical logs such as gamma, neutron, resistivity, etc., if required.

(8) Well development records including parameter measurements and any required photos.

(9) Well testing records such as specific capacity tests.

(10) Well registration records with local/state authorities if the contractor has been assigned this responsibility.

e. Start-up Submittals. The contractor should provide start-up submittals as required by the specifications. The following is a list of typical submittal requirements.

(1) Completed Start-Up Checklist. This checklist is used to ensure that the equipment and controls will perform safely and as expected.

(2) Start-up Monitoring Plan. This plan identifies procedures for initial start-up of the system including step-by-step procedures for valve settings, circuit checks, energization, and monitoring.

2.1-2. PRODUCTS.

a. Water. Verify that the source of any water used in the drilling/development process is approved in the specifications or chemical testing has been performed to verify it is of adequate quality. Note, use of water from sources with free chlorine may

result in contamination of the well with trihalomethanes. This may be a problem depending on the contaminants present in the ground water.

b. Below-Ground Equipment.

(1) Screen.

(a) Verify that well screen slot type, slot aperture, and material (composition and wall thickness) are consistent with specifications and the filter pack being used.

(b) New well screen should be used for all wells. It should be cleaned and wrapped at the factory. On-site, the screen should be stored in a clean, safe location where it will not be damaged by equipment. If the screen is not wrapped or is otherwise suspect, require the screen to be steam cleaned and protected until installation.

(2) Casing.

(a) Verify that well casing diameter, schedule, and material type meet specified requirements.

(b) Assure that joints can be made water-tight.

(c) Well casing should be new and wrapped at the factory. On-site, it should be stored in a clean, safe location where it will not be damaged by other equipment.

(3) Filter Pack.

(a) Check that the grain size of the filter pack is compatible with the formation and the slot size of the well screen is appropriate for the filter pack gradation selected. The filter pack should also meet all specifications for cleanliness, roundness etc.

(b) If no filter pack gradation is given, check that the filter pack is a uniform sand or gravel of gradation large enough to prevent entry of the pack through the screen slots. Uniform means it has a uniformity coefficient of 2.5 or less. The uniformity coefficient is the sieve aperture passing 60 percent (D60) of the material divided by the sieve aperture passing 10 percent (D10) of the material.

(c) Determine if a sieve analysis of material from the formation is required and ensure the test is carried out in accordance with the specifications.

(4) Well Seal. There is a wide variety of requirements for well seals among the various regulatory agencies. Therefore, the inspector must review the contract documents and regulations since each project will be different.

(a) Sodium-type bentonite must be used and should be provided in the form required by specifications.

(b) Pellets or granules should be used for bentonite seals.

(c) Cement must meet specified requirements for type and must be mixed with the appropriate amount of water.

(d) In the absence of a specified mix, allow use of 6-8 gallons

of water to one 94-lb bag of cement.

(e) Bentonite powder may be mixed with the cement to reduce shrinkage.

(f) If not specified, allow 3-5 percent mixture of bentonite in the cement by weight.

(g) The bentonite powder should be mixed with the water before adding the cement to assure adequate mixing.

(5) Well vaults.

(a) Verify consistent diameters of vault penetrations with associated casing, piping, or utility conduits.

(b) Vault covers must be appropriate for traffic conditions if flush-mounted.

(c) Ensure the ground surface slopes away per specified requirements.

(d) Assure that adequate means of opening large vault covers are provided.

(e) Ensure proper labeling and painting of vault covers as required by the specifications.

(f) Ensure that covers and locking mechanisms perform according to specified requirements.

(g) Ensure that there is proper labeling of all valves, switches, etc.

(h) Ensure that all confined space requirements are clearly labeled, if required.

(6) Piping.

(a) Piping must meet requirements for schedule, diameter, and joints.

(b) Ensure that the piping is adequately supported.

2.1-3. EXECUTION.

a. Drilling.

(1) Confirm that the necessary notifications/drilling permits have been obtained from the State, County or appropriate agency before any drilling commences.

(2) Confirm that any required easements, leases, rights-of-way, etc. have been obtained.

(3) Confirm that the Public Affairs Office has been notified, when required, and that the contractor(s) know who to notify in case of public inquiries.

(4) Check that all utility clearances have been received for the subsurface work and that there are no overhead hazards that will

interfere with raising or lowering the drill mast.

(5) Determine that drilling locations are correct. If it is impossible to install a well in a specified location, determine the best alternate location that meets the requirements of the design. If there are any questions about a possible alternate location, contact the design district to confirm a new location.

(6) Confirm that safe drilling procedures are used and that an exclusion zone is well defined around the drill rig. Also verify that required safety equipment is present and that it is calibrated and operated in accordance with the requirements of the SSHP.

(7) If required, confirm that all drill cuttings and or liquids are screened, drummed, labeled and stored in accordance with the work plan. Ensure that any sampling of the drums is done in accordance with the sampling plan. On non-CERCLA sites, a RCRA hazardous waste determination should be made for all containerized wastes to establish whether they may be subject to accumulation time limitations and/or subject to special management requirements.

(8) Ensure that the field geologist records all well installation details on the well installation diagram, especially the volume of fluids added to the holes and the number of bags of filter sand, cement, bentonite, etc.

(9) Verify that samples are collected at the prescribed levels and that the geologist is logging the hole according to USACE guidelines. Additional guidance on logging requirements can be found in EM 1110-1-4000 and EM 1110-1-1804.

(10) Verify that the well is at the proper depth or geologic interval before allowing the screen to be installed.

(11) Determine if slot size criteria for the screen are outlined in the specifications. If not, the contractor will have to perform the appropriate grain size tests and calculations should be made to determine the appropriate screen slot size.

(12) Determine that the diameter of the hole is within the range stated in the specifications.

(13) Ensure that the well location is surveyed and documented. Wells are typically surveyed to the nearest 1 foot horizontally and .01 foot vertically.

(14) Ensure that the driller has made arrangements for emergency response and transport and that emergency numbers are posted on site.

b. Installation.

(1) Determine that all materials to be installed in the well are the correct diameter, length, size and grade as indicated in the specifications. Materials should be clearly labeled and in their original packaging or the labels should be fixed on the materials (e.g. PVC pipe).

(2) ensure that well materials are wrapped and sterile. If not, they must be decontaminated with a steam cleaner and wrapped to prevent contamination. Workers handling the unwrapped screen should wear clean (latex) gloves. The objective of not touching the screen

is to minimize the possibility of biological fouling occurring in the well.

(3) Ensure that the borehole is protected from foreign objects or surface water run in if the borehole is left open at any time.

(4) Confirm that the well is in the center of the hole and that centralizers are properly installed if required by the specifications.

(5) Determine that all of the materials to be added to the annular space are present in adequate amounts and that they meet the requirements of the specifications.

(6) All materials to be added to the annular space (filter pack sand, bentonite, grout, etc.) should be tremied in from bottom to top and at a flow rate which prevents bridging. The tremie pipe should be lowered carefully into the annulus to the bottom of the hole and the material poured or pumped down the pipe. As the space fills the tremie pipe should be gradually withdrawn from the hole.

(7) Ensure that the well casing has a temporary cover on it once it is installed to prevent foreign materials from falling into the well.

(8) Make sure that the installers frequently measure the levels of annular fill materials with a weighted tape. This ensures uniformity of placement around the circumference of the annular space and that the proper thickness of materials is maintained.

(9) After all materials are placed in the annular space, a test should be carried out to verify the plumbness and alignment of the wells. This requires the contractor to lower a ten foot long, steam-cleaned, weighted slug of inert material (often PVC filled with sand) the full length of the well to demonstrate the plumbness of the well so that pumps and other equipment can be lowered into the well.

(10) Ensure that the completed well conforms to all state/local installation requirements.

c. Predevelopment. After the filter pack is in place it is not uncommon in a mud-rotary drilled hole to pump out or circulate clean water into the hole to remove as much of the drilling mud as possible before it "sets up" in the hole. This process needs to be fully documented as to the amounts of fluids removed and/or added on the well installation diagram.

d. Development.

(1) Ensure that development does not proceed until after the prescribed waiting period (usually 48 hours after the annulus has been grouted).

(2) Ensure that all required instruments are in working order before development begins and that they have been calibrated in accordance with the requirements in the specifications. Example instruments include pH meter, thermometer, specific conductance, total dissolved solids (TDS), Eh or other meters which measure oxidation-reduction potential, dissolved oxygen (DO) and turbidimeter.

(3) Confirm that the development proceeds until the parameters

stabilize.

(4) Confirm that the requirements for turbidity are met using a calibrated turbidimeter.

(5) Check that the development method to be used conforms with the method outlined in the specifications.

(6) No additives other than water should be placed in the well unless they are specifically called for in the specifications. If additives are to be used, ensure that the chemicals are clearly labeled.

(7) Check any apparent digressions from the language of the specifications with a project geologist for concurrence and document the conversation.

e. Installation of Equipment.

(1) Ensure that the pumps that go in the hole correspond with the specifications and submittals.

(2) Verify that the pumps are installed at the designed level in the well.

f. Wells Containing Light Non-Aqueous Phase Liquids (LNAPL).

(1) Review the drawings to determine whether one or two pumps are to be installed in the hole.

(2) Ensure that the installer measures the depth to water and product in the well.

(3) Confirm that the pump(s) are installed at the depth(s) required in the specifications. This is usually referenced to depths above or below the water/product interface.

g. Manhole or Doghouse.

(1) Ensure that these structures comply with the plans and specifications.

(2) Check that all equipment and piping are properly installed and that all equipment, valves and meters are accessible and readable.

(3) Ensure that the structures have a functioning, locking mechanism and that the required keys, etc. are provided.

(4) Manholes, etc. may be classified as confined spaces and require appropriate safety measures outlined in the SSHP. If the structure is a confined space, ensure that the required confined space labeling is present.

h. Abandoning Wells. In the event that there are problems or deficiencies with installed wells, ensure that the well is abandoned by the contractor according to the specifications and state regulations. This may involve grouting the hole, removing casing or cutting it off below the ground surface, surveying (if required) and notification of the appropriate regulatory authority. ASTM D 5299 provides additional guidance on abandoning wells.

i. Ground Water Monitoring Wells. Monitoring wells follow the same general principles for installation as outlined for extraction wells. Requirements for the installation of monitoring wells are addressed in EM 1110-1-4000 and ASTM D-5092. Whereas the primary goal of an extraction well is to produce a specified pumping rate for ground water, the goal of a monitoring well is to produce a representative sample of ground water from the aquifer. Monitoring wells differ from extraction wells in three main aspects: diameter, development criteria, and surface completion.

(1) Installation.

(a) Confirm the well materials are the correct size and schedule.

(b) Generally monitoring wells are two inches in diameter. However, in some cases where free product is present, four inch diameter wells may be required.

(c) Confirm whether the surface completion is flush mounted or a nominal stickup.

(d) Confirm that flush mounted vaults meet requirements of size and strength for traffic loads.

(e) Confirm that the concrete pad meets specifications and slopes away from the well.

(f) Confirm that protective bollards are installed if required by the specifications. The bollards should not be installed in the concrete pad.

(g) If protective locking casing is installed, assure that it allows access to the monitoring well.

(2) Development. ASTM D 5521 provides additional guidance on well development.

(a) Confirm that development proceeds until the specified parameters stabilize.

(b) Confirm that requirements for turbidity are met using a calibrated turbidimeter.

(c) Ensure that the specified amount of water is removed during development. This may include an amount equivalent to that added (or lost) by drillers during drilling and installation.

(d) Check that the development method to be used conforms with the method outlined in the specifications.