# Design Checklist for EWB-USA Chapters Working on Drilled Well

**TAC Review for Phase 2 – Borehole development and aquifer evaluation**

The following checklist provides a list of specific information that must be incorporated into your team’s 525-Pre-Impementation Report for a water supply project that involves drilling a well. The project timeline for drilling a well can vary depending on the site location, community objectives, and the overall program goals. In general, the process can be divided into four distinct phases:

* Phase 1 – Assessment
* Phase 2 – Borehole development and aquifer evaluation (Implementation #1)
* Phase 3 – Pumping and distribution system (Implementation #2)
* Phase 4 – Monitoring and evaluation

This checklist is intended to meet the minimum requirements for TAC review of the 525 Pre-Implementation Report that is submitted for Phase 2 – Borehole development and aquifer evaluation. Additional components required for a comprehensive water distribution system (e.g. pump, storage tank, and distribution pipe network) are not covered in this checklist. It is typically assumed that data collected after the well is drilled (described in Section 3) is required to properly design the remaining components.

The direct involvement, including travel to oversee well construction and testing by an experienced person, is a very critical element in the success of a well construction project. For additional clarification and instruction on each item, refer to the commentary that follows the checklist. This list represents the minimum requirements specific to well drilling. Your specific project may require additional detail not listed here.

If your project will include an electric pump, you will need to address issues of power supply to the pump. A pipeline from the well to the storage tank and the water distribution system will be needed for those aspects of the overall project, but those items are not unique to a project that includes construction of a well. This document is focused only on the well drilling portion of the work, which is typically implemented as the first phase of the overall implementation.

Drilling a well for an EWB project will generally have a lot of unknown factors. It is possible that this will be the first well drilled in the local area. The chapter should investigate the presence, history of performance and condition of wells in nearby communities. Geologic conditions may vary greatly from what was expected. The initial drilling should be viewed as construction of a test well to determine how much water will be available from the well and the general water quality. In most cases the test well will then become the production well. The information obtained during the well testing will be essential to planning the remainder of the water system.

Well construction is first step in the planning and construction of a water system. Planning and design of the remainder of the water system can only proceed after testing has determined the quantity and quality of water available from the well. Chapters should contact the reviewing EWB-USA Project Engineer for exceptions from the recommended phasing.

For more complete instructions on design requirements that apply to all EWB-USA projects, please refer to the 525 – Pre-Implementation Report Instructions. It is intended that these two instructional documents be used together as your team prepares your design documentation.

**Checklist**

1. **Design Details**
   1. **Design Criteria, Standards, and Permits**
   2. **Problem Definition**
   3. **Intended Use**
   4. **Site Selection**
      1. **Access**
      2. **Power supply**
      3. **Hydrogeology**
      4. **Setback requirements**
      5. **Location relative to points of use**
      6. **Property Ownership**
2. **Well Design and Specifications**
   1. **Conceptual Plan**
   2. **Depth, diameter**
   3. **Target aquifer**
   4. **Casing (PVC or steel)**
   5. **Well screen, slots, perforations**
   6. **Sand filter/gravel pack**
   7. **Surface seal**
3. **Well Completion and Testing**
   1. **Well screen development**
   2. **Drawdown, yield, and recovery**
   3. **Water quality; Specific conductivity, iron, arsenic, pH, and coliform bacteria**
   4. **Well drilling log and well construction report from contractor**
4. **Driller Qualifications**
   1. **License**
   2. **Local reputation/experience**
   3. **Permits**
   4. **Submittals**
5. **Construction Planning** 
   1. **Turnkey operation or other subcontractors**

**Checklist Commentary**

1. **Design Details**
   1. **Design Criteria, Standards, and Permits.** Identify criteria to be used in the design of the well such as local and national permits or construction standards if available, World Health Organization, or other standards or guidelines. Provide justification for any variance from these standards. Verify what local/national permits are required to drill a borehole or construct a well

Teams are also expected to refer to other EWB-USA water resources guidance documents, including the 3-part Water-Supply Webinar that is pre-recorded and available on the my.EWB-USA website. <http://contractsolutionsgroup.com/ProgramFiles/EWB/catalog.htm>

There are also links to several references for constructing wells in developing countries at the EWB website <http://my.ewb-usa.org/project-resources/technical-resources>. A comprehensive resource entitled “Water Supply Well Guidelines” is available at the following site: http://www.seidc.com/pdf/WATER\_SUPPLY\_WELL\_GUIDELINES-third\_edition.PDF\_CP1.pdf”

* 1. **Problem Definition.** Provide a clear, concise description of the exact problem that construction of a well is intended to solve.

Example: A residential and day student high school is connected to an unreliable community water system and would like to have access to drinking water during those times that the community system is not operating.

Example: A medical clinic has access to a surface water source that provides an adequate quantity but is of poor quality. The source of the poor-quality water is a 20 minute walk from the clinic necessitating a significant effort in hauling water to the clinic.

* 1. **Intended Use.** Clearly describe how water from the well will be used.

Example: The proposed system is intended to provide 100% of the drinking water for 400 day students and drinking and cooking water for 20 boarding students at a high school for all months except January, June and July.

Example: The proposed system will provide 100% of the water needed for drinking and hand washing for a medical clinic during the dry season months of May – August.

Provide a narrative description of the demand to be supplied by the system to achieve this goal.

* Define the unit demand (liters per person per day) for the system.
* Provide references for the unit demand value used. The chapter must include information from a survey of the community regarding the amount of water currently used, types of water uses, distance or time traveled for water and water quality. Please also refer to the guidance sheet on estimating average daily water demand available on the my.EWB-USA website under EWB-USA Guidelines.
* Define total demand for the system on an appropriate time step. This may be daily or monthly depending on the system design.
  1. **Site Selection. D**escribe the criteria used to identify the most appropriate well location and alternate site(s).
     1. **Access.** What is the distance from the from the drilling contractors home base? What are the road conditions? Is the road passable all year, or must the drilling be accomplished during certain seasons? Will the well site be accessible year round after construction to facilitate pump installation and servicing?
     2. **Power supply.** What is the source of power for the pump if the well will be equipped with other than a hand pump? Are the electrical line, transformer, etc. already in place, what voltage and phase electrical is available? Has the team investigated the requirements for providing electrical service to the well/pump? What controls are planned to turn the pump on and off, and protect the pump from variations in line voltage, lightning, or phase failure?
     3. **Hydrogeology.**. Describe the anticipated hydrogeologic conditions. Present results from hydrogeological study. Will drilling be mostly through sediments (describe if sand or clay and any known depths) or consolidated rock? What is the target aquifer? What is the source of recharge for groundwater in the aquifer? Will pumping potentially affect other wells/springs? (NOTE: by describing known depths of sand or clay we can infer something about the potential risk from surface contamination. For example, if there are several meters of clay between land surface and the aquifer we wouldn’t be too concerned about a latrine 15+ meters away. But if there are only a few meters of sand between land surface and the water table then we might be very concerned about a latrine or other potential contaminant source that is within 50 meters or maybe farther.
     4. **Setback requirements.** Identify potential contaminant sources (latrines, livestock pens, etc.) and provide adequate setback distance to the well site. Wells should be located upgradient of potential contaminant sources as much as possible.
     5. **Location relative to points of use.** If a water distribution system is already present, describe the location of storage tank(s) and the overall layout of the distribution system in relation to the well site.
     6. **Property Ownership.** Property should either be in public ownership or otherwise committed in writing to community use prior to constructing the well. A successful well greatly increases the value of a land parcel and it might be more difficult to negotiate an agreement with the landowner after a well has been constructed.

1. **Well Design and Specifications**
   1. **Conceptual Plan.** A conceptual plan of the entire system should be included so that it is clear how the well will be used in the future. A site plan should be included (drawn at an appropriate scale) showing the well site, access roads, electrical service, planned location of future storage tank and water distribution system, topography, property lines, and potential contaminant sources.
   2. **Depth, diameter.** What is the anticipated total depth of the well? What is the thickness or depth of the various geologic strata that are expected to be encountered during drilling? The diameter of the borehole will be dependent on the type and size of pump that will be installed and whether it will be necessary to install a sand filter or gravel pack. Allow a minimum of two inches for the sand filter/gravel pack and surface seal, e.g., if the outside diameter of the casing is 4.75 inches, the borehole should be at least 8.75 inches diameter.
   3. **Target aquifer.** Describe the local hydrogeology and identify the anticipated source of groundwater, e.g., fractured bedrock, karstic limestone, unconsolidated sand and gravel sediments. What evidence is available to indicate this might be a source of water?
   4. **Casing (PVC or steel).** The well casing can be steel or PVC. Each has its advantages/disadvantages. To a large extent, the choice of materials will depend on the type of material that is available locally and what the contractor is most comfortable working with, provided that the materials selected are resistant to corrosion in the aquifer and have adequate strength to resist collapse of the borehole.
   5. **Casing centralizers.** The need for casing centralizers is dependent on the hydrogeologic conditions encountered by the well, and particularly by geology of the screened interval of the well. If a sand/gravel filter is to be installed to prevent sediments from passing through the well screen, then casing centralizers are imperative. Casing centralizers will allow uniform placement of sand filter/gravel pack material around the well screen or perforations and to insure an adequate thickness of the surface seal between the casing and borehole. Casing centralizers need to be placed only at the bottom and top of the well screen. They are not needed in those sections of a borehole where there is no well screen. If the well is to be constructed without a sand/gravel filter, then centralizers are not necessary. An example where centralizers are not needed might be a well drilled in limestone or fractured bedrock where it is not necessary to filter fine-grained sediments from entering the well.
   6. **Well screen, slots, perforations.** Describe the type of openings that will allow water to flow into the well. The openings should be compatible with the type of geologic material. For example, torch-cut perforations in steel casing are not compatible with an unconsolidated sand aquifer as there will be nothing to prevent the sand from entering the well. Conversely, stainless-steel Johnson-type well screen isn’t necessary in a limestone aquifer.
   7. **Sand filter/gravel pack.** In some situations, it might be necessary to install a graded sand filter in the annular space between the well screen and the borehole wall to prevent fine-grained sediments from entering the well. Coarse gravel is sometimes installed in the annular space to serve as a conductor to collect water over a long reach of the borehole and provide a pathway for the water to flow to the screened area of the well casing.
   8. **Surface seal.** The annular space between the outside of the well casing and the borehole wall must be sealed with an impermeable material (cement, clay, etc) near the surface to prevent downward migration of contaminants from the surface to the aquifer. Generally the upper 10-20 feet of the annular space in the well are sealed. Required depth of the surface seal varies by state and country. Check to determine the local requirements for your area. If there are no local requirements, specify a minimum of 3 meters or to the water table, whichever is greater.
2. **Well Completion and Testing.** Testing should be conducted at the completion of the well construction to determine the quantity and quality of water from the well. Chapters should submit their plans for completing the following tasks once the well has been drilled. This information will serve as the foundation for Phase 3 – Pumping and Distribution System. Results from these tests must be included in the 525 for Phase 3.
   1. **Well screen development.** The method of well screen development is dependent on the aquifer material. At a minimum, the well should be cycled off/on over the course of several hours, and water quality (turbidity) should be monitored until it is clear (less than 3 NTU if turbidimeter available, otherwise clear to sight in a white cup).
   2. **Drawdown, yield, and recovery.** The pumping test should exceed the anticipated normal pumping rate for the well and the duration of the pumping should be longer than would typically occur during normal operations to provide some assurance that the well will not be operating at its marginal capacity when it is placed into production mode. Measuring the rate of water level recovery is important in evaluating whether the well will be a reliable supply day after day.
   3. **Water quality core testing requirements: specific conductivity, nitrate, fluoride, iron, arsenic, color, odor, turbidity, pH, and thermo-tolerant coliform bacteria.** Specific conductivity is easy to measure with a handheld instrument and provides a general indicator of the total dissolved solids in the water. pH is an important parameter because it will dictate the type of pumping equipment to be installed in the well and throughout the distribution system. (Low pH water is corrosive to metal.). A water sample should be collected near the end of the test pumping period to test for coliform bacteria. All of the drilling fluids should have been flushed from the well by that time and the water collected should be representative of water from the aquifer

These elements are the minimum microbial and physical parameters needed to evaluate whether the water is suitable for direct human consumption without further treatment. If a particular region has a history of other adverse contaminants additional tests will be required. Some other common contaminants that might require testing if known to be present in the area include ammonia, pesticides, and metals (e.g. lead, copper and manganese).

* 1. **Well drilling log and well construction report from contractor.** Include description of well cuttings from regular intervals during the drilling process, top and bottom of geologic formations or strata, depth to water table, depth at which water was encountered and estimate of water production from various zones, borehole diameter and depth, casing diameter and depth, screened interval, type of screen, gravel pack, surface seal, etc.

1. **Driller Qualifications.** Hiring a reliable, qualified driller is probably the most important determinant in the success of a well drilling project.
   1. **License.** A license is not an assurance that a driller will do a good job, but it does indicate that the driller has a minimal level of competency. Many developing countries may not have licensing programs for well drillers.
   2. **Local reputation/experience.** Local experience and positive recommendations from previous customers is probably the best indicator of a driller’s potential to successfully complete the project.
   3. **Permits.** Require the drilling contractor to obtain the required permits prior to giving a notice to proceed with drilling.
   4. **Submittals:** The drilling contractor should submit copies of catalogue cut-sheets of all materials proposed to be used for approval by REIC (responsible engineer in charge). Contractor to provide copies of logs of drilling operations, well development pumping and test data, and to provide acceptance of the completed well by permitting authorities prior to final payment. Copies of all documents prepared by the driller and received from the permitting authority must be delivered to the chapter.
2. **Driller’s Contract.** 
   1. All well drilling projects should have a written contract signed prior to initiating work or making any payment. The contract should clearly state the price and quantity for each item, e.g., price per foot of drilling, price per foot for well casing, etc.
   2. No payment should be made until the drilling contractor has arrived at the site with all of the equipment and materials necessary to construct the well and conduct the testing as described in the contract.
3. **Construction Planning.** Have all materials staged at the site before drilling begins. This includes casing, screen, sand filter material, gravel pack, bentonite or grout for the surface seal, test pump, generator (if needed for the test pump), well cap, etc. Verify that the materials on site meet the minimum specifications/submittals.
   1. **Turnkey operation or other subcontractors.** It is often preferable to have the drilling contractor complete all of the work through having a working pump in the well at the end of the project. Bringing in numerous subcontractors for finishing work will lead to delays in completing the project. It is important to have a very clear contract for a “turnkey” operation, including a schedule of payments at various milestones before completion of a project that produces potable water. In developing countries, such “turn-key” operations should consider options for operation and maintenance for up to three years to provide the community with someone to call if the system stops working and to provide training so the community can take over O&M in the future.