USACE St. Louis District Levee Safety Program

Standard Operating Procedure: Inspection, Maintenance and Mechanical Rehabilitation of Relief Wells

Updated 3 March 2023

Part I. INTRODUCTION

1.1 General

The following Standard Operating Procedure (SOP) provides guidance for the inspection, maintenance, and mechanical rehabilitation of relief wells. The technical guidance is based on current technologies and best practices recognized by the U.S. Army Corps of Engineers. Recommended methodologies for the inspection, maintenance and rehabilitation of relief wells are subject to change over time. This document supplements guidance provided in levee Operations and Maintenance Manuals which provides the legal requirements for nonfederal sponsors of Federal civil works projects.

1.2 Reporting of Data

Reporting of data associated with these activities should be sent to US Army Corps of Engineers, CEMVS-EC, Levee Safety, 1222 Spruce Street, St. Louis, MO 63103 or emailed to the District Levee Safety Program Manager.

1.3 Description of Relief Wells

Relief wells are in place to provide underseepage relief during high-water events. They accomplish this by tapping into the substratum and providing pressure relief in a controlled manner with low flow resistance, preventing uncontrolled piping and erosion of the foundation soils.

Well construction is essentially the same from the ground surface to the total depth. Wells are constructed with a riser pipe (solid pipe) and screened sections. Screened sections are sometimes interspersed with blanks to block out the finer material layers unacceptable for screening. The well construction material types that are typically installed in St. Louis District are creosote-impregnated wood stave, PVC, mild-steel, and stainless-steel.

Wells installed by USACE between 1950-1970 are generally constructed of creosote-impregnated wood stave risers and screens. Wells constructed by USACE in the 1970s thru the 1980s typically have either PVC or mild-steel as their construction materials. Finally, wells constructed by USACE in the 1990s to present, utilized stainless-steel risers and screened sections as the construction material. It is important to know which type of material was used in the construction of the wells to select the correct pumping test method and mechanical rehabilitation to use, should it become necessary.

Relief wells shall be maintained in accordance with the levee system Operations and Maintenance (O&M) Manual. This includes regular inspection and soundings to identify damages, debris accumulation or obstructions and pumping tests to determine the specific capacity of the well (gpm/drawdown). Loss of specific capacity indicates loss of open area in the well and gravel pack. This loss increases the pressure gradient during high water events potentially leading to uncontrolled piping and erosion in the foundation soils. Results of these activities may indicate a need for mechanical rehabilitation of the well.

PART II. INSPECTION

Relief wells should be kept free of sand, silt, organic matter, or any other material that will retard free flow. Particular attention should be directed to inspecting the condition of the neoprene or rubber gaskets on the underside of the check valves and on top of the wood-stave tenon, depending upon construction materials. Deterioration, damage, or loss of these gaskets could result in the damage to the well due to infiltration of muddy or contaminated water.

Inspection shall be completed on an annual basis or at the frequency identified in the levee system Operations and Maintenance Manual. The inspection of the relief well shall include a report of the general exterior condition of the relief well, noting any problems with discharge flow away from the well, and any damage or missing parts to the outlet works, tees, manholes and any remediation of these problems. A photo of the exterior of the well, with a placard showing the levee name, relief well number, and approximate station, or state-plane coordinates, should be included in the inspection. An example inspection report is included as Attachment 1 to this SOP.

PART III. PUMPING TEST

Relief wells shall be tested by pumping to determine the specific capacity ratio of the well (gpm/drawdown) on a five year basis or at the frequency identified in the system Operations and Maintenance Manual. Pumping tests should be performed by permitted contractors or levee sponsor personnel with experience in testing and maintenance of relief wells.

Relief well pumping tests should occur at the design flow rate of each relief well. In St. Louis District, historically the typical design flow rate was 500 gpm. Recent relief well design flows are based on underseepage analysis and may vary from well to well. In some cases, the design flow rate may be greater than or less than 500 gpm. It is important the pumping tests occur at the design flow rate in order to understand the current condition as a measure of the relief well's efficiency, and therefore ability to adequately reduce underseepage in accordance with its design intent. However, because pumping test requirements span the complete life of an individual well, sponsors may prefer to have consistency in pumping test flow rates to manage long term maintenance costs througout their inventory. In this situation, sponsors may "rebaseline" relief wells at a 500 gpm flowrate by completing the first pump test at its original design flow rate within 5 years of installation and then following up with a 500 gpm test. All future pump test may then be completed at the 500 gpm for comparison of specific capacities.

Measurement of adjacent well draw-downs during pumping tests is not required, though this practice is recommended. The draw-down measurements can assist in determing the radius of influence of an individual well and help to better define the distance between wells that should be avoided when performing consecutive testings. The theoretical radius of influence given by Sichardt (1930) is:

$$R = C' d \sqrt{k_h}$$

Studies of relief wells in the Metro East region have indicated the radius of influence can extend over 1,000 feet from a pumped well.

Detailed procedures are described below.

3.1 General

Prior to any pumping or other down well activity, all wood stave wells shall be treated for free standing creosote using a low-flow, closed loop filtration and washing system.

A water level indicator or an alternative, accurate means for determining the water level in the wells to the nearest 0.10-foot shall be utilized. Readings shall be taken prior to, after and for the duration of the pumping test, for the intervals indicated in the O&M manual, or other guidance provided by the USACE. The use of a weighted tape shall not be regarded as sufficiently accurate for such measurement. The initial groundwater level should be sufficient enough to perform the pumping test while maintaining a water level at least 1-foot above the top of the well screen. No pumping test or other down hole activities that could impact water levels shall be performed concurrently on any other relief well within a 500-foot radius of the well being tested.

The depth of each well shall be measured and recorded prior to and following each pump test If at any time the total depth measurement indicates that there is debris in the well, of less than 20 % of the screen length, it shall be removed by bailing or airlifting, to within 2 feet of the installed depth. If there is more than 20% of the screen length covered by debris in the well, the data shall be recorded and no further work performed. This data should be reported to the St. Louis District.

3.2 Personal Protection and Safety

As a minimum, personnel handling the equipment, water lines, hoses, pumps and supplies shall wear latex or rubber gloves, eye protection and sleeve protection. Precautions shall be taken prior to entering any confined space with oxygen-depleted environments. Regulations for OSHA 29CFR1910 and U.S. Army Corps of Engineers Safety Manual, EM 385-1-1 entitled ‘Safety and Health Requirements Manual’, which are applicable to this work, shall be observed and complied with.

3.3 Equipment

3.3.1 *Riser Pipe Extensions*

Riser pipe extensions, also known as standpipes, may have been issued to levee sponsors for specific relief wells if those wells are expected to flow under river elevations below flood stage. The risers will be installed in accordance with the system Operations and Maintenance Manual to prevent natural relief well flow during pumping tests and allow accurate results to be achieved.

3.3.2 *Pumps*

Only deep well submersible pumps shall be used for this pumping test. Pump set-up shall include all equipment necessary to power the pump and direct discharge away from the well and prevent ponding at the well for the duration of the test. The pumps shall be capable of producing the design flow of the relief wells at a minimum. Pumps shall be capable of producing the required flow from the wells with static water levels as low as 25-foot below ground surface and maintaining uninterrupted flow for up to 2 hours.

3.3.3 *Flow Meters*

A flow meter shall be used to determine flow rates during relief well pumping tests. Flow meters shall be of standard rotating propeller design, compatible with the pumps and water lines, or

approved alternative. All flow meters shall be calibrated prior to the commencement of work, and any time the levee sponsor or contractor has reason to suspect inaccuracy. The accuracy for rotating propeller design meters should be within 2% of measured flow.

3.3.4 *Rossum Sand Tester*

A Rossum Sand Content Tester shall be utilized to evaluate and record the amount of sand and/or material being pumped from the well, in parts per million. The sample shall be collected in the discharge line while the water is in turbulent flow. The sample shall be collected according to the manufacturer's directions. The flow rate through the tester shall be checked during each run. If the flow rate is not as specified by the manufacturer, the test shall be repeated. There shall be a minimum of three readings per two-hour pump test.

3.4 Procedure

Following the bottom cleanout, the depth of each well shall be measured and recorded prior to and following each pumping test. The submersible pump shall be installed and the testing initiated by pumping continuously for 2 hours. The pumping rate shall be a constant discharge approximately equal to the design flow rate. The flow rate shall be reduced if drawdown in the well approaches the top of the screen section. Pumping rate shall be held constant and testing continued until drawdown is stabilized, but at no time shall the water level be closer than 1-foot from the top of the well screen during pumping.

The pumping rate may be adjusted as needed to meet the drawdown and screen exposure requirements. If the target pumping rate cannot be achieved, reduce the rate to 75% of the target or the maximum that can be sustained for a 30-minute test. If the 75% target gpm or the maximum that can be sustained for a 30-minute test cannot be met, the pump test shall be terminated, and data recorded and submitted to the St. Louis District.

When practical, all discharge shall be directed over the top of the levee and the pipe shall be terminated in a saxophone discharge. Minimum 4 mil thickness plastic shall be placed under the terminus to prevent erosion of the levee slope. Where discharge over the top of the levee cannot be achieved, the flow shall be directed to an appropriate area in which the sponsors has right of way or maintains flowage easements and in accordance with applicable environmental regulations.

Wells which show a loss of specific capacity of more than 80% of original, shall have a mechanical rehabilitation procedure performed as an attempt to restore the specific capacity to 80-100% of original.

3.5 Reporting

The relief well inspection, pumping test, cleanout and sand infiltration test data shall be reported on the forms following this SOP and a summary tabulation of results of the work shall be provided to the St. Louis District - See Paragraph 1.2, above.

PART IV. MECHANICAL REHABILITATION OPTIONS

4.1 General

Well rehabilitation is periodically required during the life of a well, as groundwater contains bacteria and minerals which cause well plugging. Screens, gravel pack and formations may become blocked, reducing the capacity and efficiency of the well. There are several options for mechanical rehabilitation of the wells, which may breakup, or loosen biofouling or mineral incrustation, thereby improving the capacity and efficiency of the well. Mechanical rehabilitation can be an aggressive procedure and should only be undertaken by experienced personnel. Any single or combination of mechanical rehabilitation methods may be used to treat wells.

Periodically during mechanical rehabilitation, total depth measurements shall be taken. No less than 3 measurements should be taken per rehabilitation cycle. The time and total depth measurement shall be recorded and reported. This is to confirm that the well screen has not been breached or damaged and to ensure the filter pack or aquifer is not impacting the total depth of the well. If at any time there is concern that damage to the well has occurred, all work shall cease, all data shall be recorded, and the St. Louis District shall be notified immediately.

Following any mechanical rehabilitation, a total depth measurement should be taken. Any debris brought into the well by this action, should be removed by airlifting or bailing. In addition, a post-rehab pump test should be completed to gauge the effectiveness of the mechanical rehabilitation. The post-rehabilitation pump test shall conform to the requirements as specified in Part 3, above.

Wells which show a loss of specific capacity of more than 80% of original, and that do not respond to mechanical rehabilitation procedure performed, shall be scheduled for replacement, and shall be monitored to ensure well screen and filter pack remains in place until such time that it can be replaced. Wells scheduled for replacement shall be included in the report cited in Section 4.5.

4.2 Pump Surging

Pump surging is an easy rehabilitation option to attempt. The pump is already in the well from the initial pump test and no additional equipment is necessary. Pump surging consists of pumping at varying rates from maximum to minimum to create the greatest amount of water surge in the well. Maximum should be no more than the maximum flow attempted during the initial pump test on that particular well, as specified in Part 3 above. Pump surging can be applied for up to 2 hours in a well.

4.3 Brushing

Brushing of the interior of the well from the riser thru the screened sections is often employed as a ‘pre’ treatment to mechanical rehabilitation. Brushing consists of attaching a stiff poly or nylon brush to drill pipe or surge block and brushing the interior of the well. It is recommended that brushing be accomplished in small sections, to ensure thorough cleaning of the interior of the well. On 8-inch diameter, wood stave wells, it is recommended that the brush diameter be no more than 7-inches. There are other diameters available for larger diameter wells, or for more aggressive brushing in mild-steel and stainless wells. Brushing can be employed prior to any of the other mechanical rehabilitation methods.

4.4 Surge Block

The surge block method works similarly to the pump surge method but applies the surging action to a particular section of well screen at a time. This method is typically combined with brushing of the interior of the well with a stiff nylon brush, usually attached to the bottom of the surge block.

The surge block shall be operated by equipment capable of varying speeds over the full depth of the wells. The equipment shall be capable of traversing and maintaining the velocity of surge block travel in the wells at a rate between 1 to 1-1/2 feet per second in both down and up direction.

The following description for a surge block is appropriate for 8-inch diameter, wood stave wells: the surge block shall consist of two-groups of neoprene rubber circular disks spaced 4 feet apart and held in place by washers and spacers. Each group of disks shall consist of a 1-inch thick, 7-inch diameter rubber disk, with a 1-inch thick, 5-inch diameter rubber disk on either side. This combination of rubber disks shall be fixed between rigid washers 2-1/2- to 3-1/2-inches in diameter. The entire assembly shall be rigidly fastened to the end of a drill stem or pipe of sufficient mass to cause it to fall free on the downward stroke. The disks shall be replaced whenever they become worn, or after every fourth well that has been surged with a given set of rubber disks. A solid surge block shall not be used.

Determine the depths to the screen section to be treated, typically between 5 and 10 feet in length. The surge block shall be allowed to free fall through the screened section being treated. At no time shall the surge block be allowed to free-fall and strike the bottom of the well. The surge block shall then be raised to its original position. Repeat for a period of 30 minutes and for each treated section of screen.

4.5 Reporting

The mechanical rehabilitation, and pre- and post- pumping test shall be reported on the forms included as Attachment 3 of this SOP and a summary tabulation of results of the work shall be provided to the St. Louis District - See Paragraph 1.2 above.

Attachment 1

_____Levee System

RELIEF WELL INSTPECTION DATA SHEET

RELIEF WELL NO. _____ STATION_____ OFFSET_____

If no station/offest given, provide gps lat/long reading. Photograph number: _____

AS BUILT DEPTH_____	MEASURED DEPTH_____

RELIEF WELL TYPE (CIRCLE ONE)	M(manhole) D (vertical discharge) T (tee discharge)

RELIEF WELL OUTLET CONDITIONS:	(remarks)
Missing/Damaged bolts ____ of ____	
Missing/Damaged washers ____ of ____	

GENERAL CONDITIONS:	(remarks)
Easily accessible Y N	
Good condition Y N	
Good rust protection Y N	
Good drainage around the well Y N	

CONDITION OF VERTICAL DISCHARGE				CHECK APPLICABLE BLOCK **(√)**		
ITEM	N/A	Good	Fair	Poor	Missing	comment
Lid						
Screen						
Standpipe						
Checkvalve						
Checkvalve gasket						

CONDITION OF HORIZONTAL (TEE) DISCHARGE				CHECK APPLICABLE BLOCK **(√)**		
ITEM	N/A	Good	Fair	Poor	Missing	comment
Lid						
Flapgate						
T-stub						

REMARKS	

(DATE)	(INSPECTOR)

Attachment 2

RELIEF WELL PUMPING TEST REPORT

LEVEE SYESTEM: _____ **DATE:** _____

RELIEF WELL NO.: _____

LOCATION (STA. OR SPCS)

AS-BUILT INFO: **TOP OF RISER (EL):** _____ **Total Depth of Well (FT)** _____

TOP OF SCREEN (EL): _____ **TOP OF SCREEN (FT bgs_:** _____

BOTTOM OF WELL (EL): **BOTTOM OF WELL (FT bgs:**

OBSERVATION INFO:

INITIAL WATER LEVEL: _____ **STATIC water level**

MEASUREMENT TAKEN AT: **Typically top of riser**

Remarks: _____

Time		water level	draw-down	Sanding Rate ml/L	Time		water level	draw-down	Sanding Rate ml/L	Discharge Rate		
Since Test Began	Time of Day (Ex: 9:30 am)				Since Test Began	Time of Day				Time	flow-meter	Discharge rate
0 Sec			0		13							
15					14							
30					15							
45					20							
60 Sec / 1 Min					25							
75					30							
90					35							
105					40							
120 Sec / 2 Min					45							
2.5 Min					50							
3					60 Min / 1 Hr							
3.5					70							
4					80							
4.5					90 Min / 1.5 Hr							
5					100 Min							
6					120 Min/2 Hr							
7					150 Min/2.5 Hr							
8					180 Min/3 Hr							
9					210 Min/3.5 Hr							
10					240 Min/4 Hr							
11					270 Min/4.5 Hr							
12					300 Min/5 Hr							

Legend:

Water Level and Drawdown in decimal Feet **Required Rossum reading;** all others are optional **bgs: below ground surface**

Discharge Rate in gpm

Sanding Rate in ml/L

Attachment 3
MECHANICAL REHABILITATION DATA

Levee System: _____				Well #: _____		Date: _____
Location (STA):	As Built depth to top of screen:				As-Built inside depth of well:	
Surge / Int. Pump	Cycle Number	Depth of Screen Inteval	Start Time	Finish Time	Depth to Well Bottom	Comments