WORKING COPY

VERIF. DATE: _____

INTIALS: _____

CP2-ES-0024/FR3

Monitoring Well Maintenance Implementation Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

DOE CONTRACTOR PERSONNEL ONLY

Monitoring Well Maintenance Implementation Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—May 2025

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Task Order DE-EM0004895

DOE CONTRACTOR PERSONNEL ONLY

THIS PAGE INTENTIONALLY LEFT BLANK

APPROVALS

Monitoring Well Maintenance Implementation Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

CP2-ES-0024/FR3

May 2025

BRETT SMOTHERS (Affiliate) Digitally signed by BRETT SMOTHERS (Affiliate) Date: 2025.05.15 15:08:33 -05'00'

Brett Smothers/Date
Environmental Monitoring Manager

KATRINA HALL (Affiliate) Digitally signed by KATRINA HALL (Affiliate) Date: 2025.05.15 15:15:56 -05'00'

Katrina Hall/Date
Environmental Stewardship Manager

DOE Approval Letter: N/A Date: N/A

Effective Date: 5/20/2025

Required Review Date: 5/20/2028

Nuclear Safety Documentation: N/A per CP3-NS-2001, Step 6.1.1

THIS PAGE INTENTIONALLY LEFT BLANK

REVISION/CHANGE LOG				
Revision/ Change Letter	**Description of Changes**	**Pages Affected**	**Date of Revision/ Change**	**Approved By (signature on file)**
R1	New document (PAD-PROJ-0025/R1)	All	April 2011	Signature on file
R0	Change to CP2	All	April 2016	Signature on file
R1	Executed necessary bluesheet revisions due to Contract transition, including but not limited to, updated Prime Contractor, personnel/staff, roles and responsibilities.	All	April 2017	Curt Walker
R2	Updated personnel/staff, monitoring well counts, rehabilitation methods, and references.	All	August 2019	Lisa Crabtree
R3	Updated personnel/staff, monitoring well counts, roles and responsibilities, and references.	All	May 2025	Brett Smothers

THIS PAGE INTENTIONALLY LEFT BLANK

CONTENTS

FIGURE v

TABLES v

ACRONYMS vii

EXECUTIVE SUMMARY ix

1. INTRODUCTION 1
   1.1 PURPOSE 1
   1.2 STRATEGY 1
   1.3 BACKGROUND 2

2. MAINTENANCE MONITORING 3
   2.1 VISUAL INSPECTIONS 3
   2.2 PHYSICOCHEMICAL WATER QUALITY 5
   2.3 MONITORING WELL PERFORMANCE 6
   2.4 DOWN-HOLE VIDEO INSPECTION 7

3. MONITORING WELL REHABILITATION AND MAINTENANCE 9
   3.1 PUMP REMOVAL 10
   3.2 MECHANICAL REDEVELOPMENT 10
   3.3 CHEMICAL TREATMENT 10
   3.4 PHYSICAL MAINTENANCE 11

4. DECONTAMINATION 13

5. REFERENCES 15

THIS PAGE INTENTIONALLY LEFT BLANK

FIGURE

1. MW Maintenance Flowchart..... 4

TABLES

1. Summary of Physicochemical Parameters Relevant to MW Maintenance..... 5
2. Causes of Poor MW Performance..... 6
3. MW Rehabilitation Methods..... 9

THIS PAGE INTENTIONALLY LEFT BLANK

ACRONYMS

AKGWA	Assembled Kentucky Groundwater Database
BART™	Biological Activity Reaction Test
EMP	environmental monitoring plan
FRNP	Four Rivers Nuclear Partnership, LLC
KAR	*Kentucky Administrative Regulations*
MW	monitoring well
PZ	piezometer
SRB	sulfate-reducing bacteria

THIS PAGE INTENTIONALLY LEFT BLANK

EXECUTIVE SUMMARY

The purpose of this monitoring well (MW) maintenance implementation plan is to protect and maintain the integrity of the MW network at the Paducah Site in order to obtain representative groundwater samples. At the time of the issuance of this plan, there are 434 MWs and piezometers (PZs) that have a "current" status in the environmental monitoring program. Routine, visual inspection criteria assessing the physical condition for all of these MWs are included in this plan. The MW maintenance program for the Paducah Site MWs is outlined in this implementation plan. Note: Adding or abandoning MWs or PZs does not necessarily justify an update to this plan.

Previous down-hole investigations at the Paducah Site (BJC 2000a; BJC 2000b; BJC 2001) indicated that common MW maintenance problems include biofouling and corrosion. This resulted in the implementation of the MW maintenance program and subsequent rehabilitation of individual MWs. Additionally, because the MWs are of varying age, construction, and condition, the routine visual inspections are designed to identify whether security, integrity, or other problems exist and deficiencies can be corrected through the maintenance program.

This inspection and maintenance plan combines regular assessment of each MW's physical condition, geochemical trends, and performance history to identify physical or chemical-related problems with the MW. This maintenance implementation plan outlines MW evaluation methods including visual inspections (including down-hole equipment/pump system examination), evaluation of physicochemical data, MW performance assessments, and down-hole video inspections if warranted.

A variety of mechanical and chemical MW rehabilitation techniques can be used on the MWs depending on the severity of the problem. Methods include brushing, redevelopment by surging and/or pumping, and, in MWs with severe biofouling, chemical treatment. Prior to the implementation of chemical treatments, the U.S. Department of Energy will seek approval by the Kentucky Department for Environmental Protection with regard to a job-specific work plan. Permitted MWs should be given priority for maintenance when problems are identified.

THIS PAGE INTENTIONALLY LEFT BLANK

1. INTRODUCTION

1.1 PURPOSE

Groundwater monitoring wells (MWs) and piezometers (PZs) often degrade in quality with age. Effective stewardship, a program of routine inspections of the physical condition of each MW, and a review of the MW's performance and geochemical trends ensure that representative water-quality monitoring and hydrologic data are being obtained from the MW network at the Paducah Site.[1] The purpose of this maintenance implementation plan is to protect and maintain the integrity of the MW network through the following:

- Inspecting the physical condition of MWs;
- Reviewing performance and geochemical trending data;
- Identifying maintenance needs that, if implemented, can extend the life of the MW; and
- Identifying MWs that require rehabilitation.

Appendix B of the current CP2-ES-0006, *Environmental Monitoring Plan* (EMP) provides a list of all site MWs, including their status and monitoring frequency. This maintenance plan, in conjunction with the EMP, allows the groundwater program to focus available resources on MWs that provide the most useful data.

1.2 STRATEGY

MWs are best maintained by a preventative maintenance program involving routine inspection and monitoring of the MW's performance along with preventative maintenance and treatment, as necessary. Because the Paducah Site uses a low-flow sampling procedure, proper MW maintenance is important. The objective of this plan is to develop an inspection and maintenance approach that identifies and corrects MW problems.

The maintenance schedule will be determined annually based on a review of and consideration of each MW's sampling status, the physicochemical parameters (physical and/or chemical groundwater properties) indicative of biofouling or encrustation, physical integrity, and visual examinations (as recorded during sampling and annual inspections).

Approval for MW activities in facilities and locations managed by Four Rivers Nuclear Partnership, LLC, (FRNP) will be obtained through the Facility Manager.

Approval for MW activities in facilities and locations not managed by FRNP (e.g., Mid-America Conversion Services, LLC, cylinder yards, West Kentucky Wildlife Management Area, Tennessee Valley Authority property, or residential wells) will be obtained through procedure CP3-SI-0001, *Site Interface Agreement,* or other agreements (e.g., license agreements).

[1] For the purposes of this plan, the reference to "MW" also includes piezometers.

1.3 BACKGROUND

As of April 2025, there have been 580 MWs installed or drilled at the Paducah Site. These MWs were installed in conjunction with various groundwater quality monitoring programs, Resource Conservation and Recovery Act hazardous waste permit, solid waste permit, remedial investigations, plume characterization, and aquifer testing projects. Of these, 146 have been plugged and abandoned in accordance with 401 *KAR* 6:350, *Monitoring well construction practices and standards*. A total of 434 MWs have been assigned a "current" status designation according to the EMP. Forty-two of the 434 MWs are solid waste landfill compliance MWs at the C-746-S, -T, and -U landfills, and nine are for the C-404 Low-level Radioactive Waste Burial Area. Maintenance and rehabilitation of those MWs are performed following notification of appropriate state agencies as specified in the respective groundwater monitoring plans and permits.

A regular program of MW rehabilitation began in 2002 (BJC 2002). This program was initiated following three down-hole video investigations at the Paducah Site (BJC 2000a; BJC 2000b; BJC 2001), which revealed evidence of corrosion (minor to severe) in stainless-steel casings and biofouling in the screens of 75 MWs. The results of these corrosion studies at the Paducah Site (BJC 2000a; Underwood 2000a; Underwood 2000b) indicate that corrosion in MWs at the Paducah Site primarily is caused by electrochemical phenomena (galvanic electrolysis) and enhanced by microbial induced corrosion, in this case, sulfate-reducing bacteria (SRB). The galvanic activity is localized between the stainless steel well casing (anode) and the iron isolation casing (cathode). To a lesser degree, SRB also are attacking the well casing exterior below the isolation casing, usually along the weaker stainless-steel weld seams. The use of polyvinyl chloride (PVC) well casing in new MWs, unless in a known volatile organic compound source area with a concentration of > 60,000 mg/L will prevent future corrosion problems (EPA 1995).

2. MAINTENANCE MONITORING

Maintenance monitoring involves the collection and evaluation of physical, hydraulic, and water quality factors for the purpose of detecting deteriorating conditions in a MW. Maintenance monitoring helps identify problems early so that preventative maintenance can be scheduled. The maintenance monitoring program involves visual inspection of MW components, including down-hole equipment/pump system; evaluating physicochemical water quality data; microbial sampling and analysis, if warranted; assessing MW performance indicators; and down-hole video inspections, as needed. The results of these inspections are used to determine if a maintenance action is needed (Figure 1). Maintenance monitoring activities planned are summarized here.

2.1 VISUAL INSPECTIONS

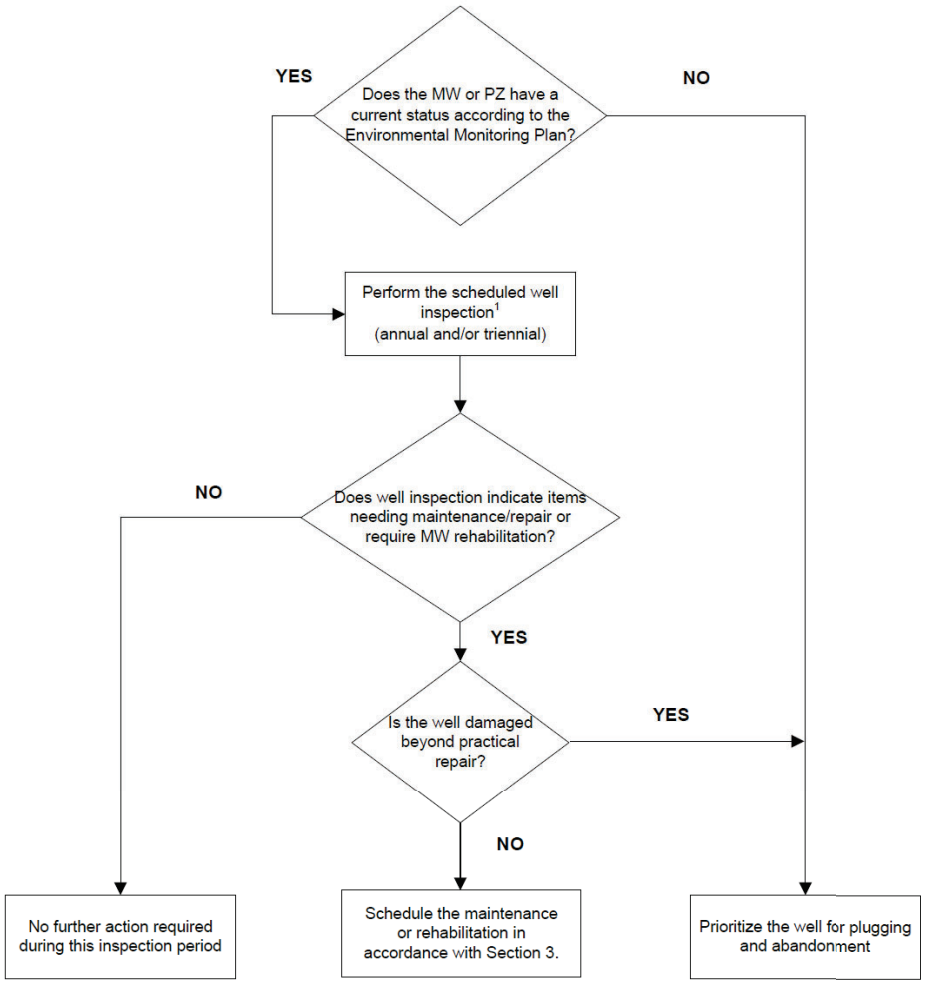
Visual inspections of the Paducah Site MWs are performed on a routine schedule as part of the preventative maintenance plan. The "PGDP Monitoring Well Inspection Checklist," CP4-ES-0074-F01, is completed to document the inspection and the physical condition of the MWs. All MWs with a "current" status designation in the EMP will be inspected on an annual basis and MW depth measurements performed on a triennial basis. Additionally, during routine sampling events, sampling personnel inspect the MW and record any deficiencies. MWs associated with C-404 Low-level Radioactive Waste Burial Area have the pumps removed annually for inspection, if possible, according to procedure *Monitoring Well Inspection and Maintenance*, CP4-ES-0074. Some MWs may not be able to have the pump assembly removed for reasons such as obstructions, bent inner casing, etc. In these cases, field personnel document the pump could not be removed on the inspection checklist, CP4-ES-0074-F01.

Priority maintenance items include MW security (e.g., locks, secure caps.) and MW integrity issues that could lead to surface infiltration (e.g., leaking MW cover lids, loose annular seal, cracked pads). When pumps and discharge lines are removed (such as for routine maintenance and repair), they are inspected for signs of corrosion, biofouling, and encrustation. Equipment showing evidence of this will be photographed and observations recorded. All equipment will be refurbished and rebuilt, if necessary.

The annual MW visual inspections include an evaluation of the condition of the following:

- Paducah Site MW identification labeling [in addition, the Assembled Kentucky Groundwater Database (AKGWA) label should be present];
- Condition of inner and outer casing, MW covering, protective posts, and concrete pad;
- MW security;
- Condition of sampling equipment; and
- MW access including condition of gravel pad, entrance road, and drainage culverts.

During triennial inspections of all MWs and during annual inspections of C-404 Low-level Radioactive Waste Burial Area MWs, the total depth of the MW is measured after removing the pump assembly. Depth measurements are the only direct method of measuring any change in the down-hole physical condition of a MW by comparing these measurements to a reference depth. Differences between the measured depth and the reference depth may indicate the following:



[1] Includes visual inspection, evaluation of physiochemical water quality data, assessment of well performance, and down-hole video inspection (as needed).

[1] Includes visual inspection, evaluation of physiochemical water quality data, assessment of well performance, and down-hole video inspection (as needed).

Figure 1. MW Maintenance Flowchart

- Accumulations of sediments or other debris (encrustation by-products) in the bottom of the MW;
- Obstructions in the MW, possibly caused by structural failure of the MW due to deterioration in the MW casing or screen; or
- Field measurement errors (e.g., wrong MW, recording errors, incorrect measurement reference point used) or errors in the weighted tape used to measure the depth.

After the inspections have been performed, completed inspection checklists are provided to Environmental Stewardship personnel, who review the checklists and implements maintenance actions as described in Section 3. The inspection data on the checklists is entered into a database to track and sort the maintenance needs of Paducah Site MWs. The database also is designed to identify if a MW is a permitted MW to ensure that the proper notifications are made, as noted in Section 1.3.

Many MWs accumulate sediment at the bottom, which may plug the screened interval if the MW has not been developed properly. This sediment can affect the performance of the MW and the quality of chemical analyses. MWs that have accumulated enough sediment to obscure the lower portion of the screen will be scheduled for maintenance/rehabilitation. When field personnel make the total depth measurement, they should indicate if the depth measurement was hard or soft. A measurement is considered soft when it is difficult to detect whether the indicator probe/measuring tape has touched the bottom of the MW (this is often an indicator of possible sediment or bacterial slime buildup at the bottom of the MW and often is noted by the presence of sediments on the weighted tape). A measurement is considered hard when it is easy to detect whether the indicator probe/measuring tape has touched the bottom of the MW. A hard measurement indicates that the MW is relatively clear of sediment or slime.

2.2 PHYSICOCHEMICAL WATER QUALITY

The purpose of physicochemical monitoring is to detect changes in parameters that may reflect MW deterioration or indicate the cause of MW deterioration. Table 1 is a summary of physicochemical parameters relevant in MW maintenance (Smith 1995; ASTM 2024). Not all of the parameters herein are analyzed for in every MW sampled at the Paducah Site, but the hydrogen-ion concentration (pH), redox potential (Eh), dissolved oxygen, specific conductance, and turbidity are field parameters that are collected with every sampling event. The remaining parameters [total organic carbon, iron (Fe), manganese (Mn), sulfur (S), and sulfate (SO_4)] can be used for physicochemical monitoring in MWs where the data are collected or obtained by a special sampling event if deterioration of the MW is expected. Rather than provide specific criteria or trigger levels for these parameters, the objective is to detect changes or abrupt fluctuations that would be considered confirmatory of field observations. Fluctuations in physicochemical parameters, such as increases or decreases in Eh, pH, conductivity, Fe, Mn, and S concentrations, are indicative of the MW environment (Smith 1995). Redox potential is very important to the make-up of the microflora in the MW and aquifer and also to the fate of Fe, Mn, and S, which produce mineral forms of precipitates. Parameters relevant to formation of encrustations [e.g., calcium $(Ca)^{2+}$ ion] will be evaluated where data are available. Total organic carbon content will be evaluated because it is an empirical indicator of biofouling potential. Particle counting and turbidity are significant site-specific parameters denoting the origin of minerals and/or precipitates. Increases in turbidity and particle counts indicate suspended solids content that may result from silting or biofouling (Smith 1995). Such solids data are useful in specifying remedial treatments (e.g., if only silt is present, the MW may simply require bailing and/or redevelopment).

Table 1. Summary of Physicochemical Parameters Relevant to MW Maintenance

Parameter	Diagnosis
Eh (redox potential)	Indicator of probable metallic ion states and microbial activity. Usually measured as bulk Eh, which is a composite of microenvironments.
pH	Indicator of acidity/basicity and likelihood of corrosion and/or mineral encrustation. Combined with Eh to determine likely metallic mineral states present, and with conductivity and alkalinity, to assess inorganic salts occurrence.
Specific Conductance	Indicator of total dissolved solids content and a component of corrosivity assessment. Changes also are caused by microbial activity.
Turbidity/Total Suspended Solids	Indicator of suspended particles content, suitable for assessment of relative changes indicating changes in particulates or biofouling.
Total Organic Carbon	Empirical indicator of the potential for biofouling.
Fe (total, Fe^{2+}/Fe^{3+}, minerals, and complexes)	Indicator of clogging potential, presence of biofouling, Eh shifts.
Mn (total, Mn^{2+}/Mn^{4+}, Mn minerals and complexes)	Indicator of clogging potential, presence of biofouling, Eh shifts.
S (total, S^{2-}/S^0/SO_4, S minerals and complexes)	Indicator of clogging potential, presence of biofouling, Eh shifts.

Source: Smith 1995

Performing an annual review on analytical data relative to key physicochemical changes is necessary in the overall preventive maintenance program. Analytical data are reviewed on all landfill permitted MWs (i.e., C-746-S, -T, -U landfills, C-404 Low-level Radioactive Waste Burial Area) under various schedules. The assessment reviews also will evaluate any noticeable changes relating to biofouling. Historical data are indispensable in a preventive maintenance program. Time-series plots revealing parameter changes in analytical data (Table 1), along with visual examinations of sample characteristics (e.g., bacterial slime) are useful in analyzing current or potential well conditions. Prioritizing MWs for maintenance is subjective; however, a review of the historical data should reveal developing problems. The use of historical data, when combined with physicochemical monitoring, is the best approach to maintenance prioritization.

If physiochemical data give a strong indication of potential biofouling, a test for microbial populations is recommended. Currently, the most practical approach to detect nonfilamentous, metabolically active biofouling microflora in water wells is the Biological Activity Reaction Test (BART™) method. The BART™ test kits are inexpensive, are relatively easy to use, and increasingly are accepted as the standard biofouling monitoring method in the water well industry.

2.3 MONITORING WELL PERFORMANCE

During routine MW sampling activities, factors relating to MW performance are recorded. These factors will be evaluated along with other information to determine the need for maintenance. Table 2 summarizes a variety of performance problems and causes that are considered typical of MWs in general.

Table 2. Causes of Poor MW Performance

Performance Problems	Possible Cause
Sand/Silt Pumping*	Inadequate screen and filter-pack selection or installation, incomplete development, screen corrosion or parting, collapse of filter pack due to excessive vertical velocity, and washout. Rock wells: presence of sand or silt in fractures intercepted by well-completed in open hole, incomplete casing bottom seat. Causes pump and equipment wear and plugging.
Silt/Clay Infiltration	Generally inadequate seal around the well casing or casing bottom, infiltration through filter pack, or "mud seams" in rock, inadequate development, or overdevelopment in tills, or material so fine that formation cannot be monitored without accepting some turbidity. Causes reduced performance, filter plugging, and interference with samples.
Pumping Water Level Decline	Outside influences such as area or regional water level declines or well interference or plugging or encrustation of the borehole, screen, or gravel pack. Sometimes a regional decline will be exaggerated at a well due to plugging.
Lower (or Insufficient) Yield*	Dewatering or caving in of a major fracture or other water-bearing zone, pump wear or malfunction, encrustation, plugging, or corrosion and perforation of column pipe, increased total dynamic head in water delivery or treatment system.
Complete Loss of Production	Most typically pump failure (mechanical or electrical), but also possibly catastrophic loss of well production due to dewatering, plugging, and collapse.
Chemical Encrustation	Deposition of saturated dissolved solids, usually high Ca, Mg, carbonate and SO_4 salts or iron oxides. Causes reduced specific capacity and well efficiency, interference with sample analyses. Actually rare except for deep wells in highly mineralized groundwater, as in the western U.S.
Biofouling Plugging*	Microbial oxidation and precipitation of Fe, Mn, and S with associated growth and slime production. Often associated with simultaneous chemical encrustation and corrosion. Associated problems: well "filter effect" samples and pumped water are not necessarily representative of the aquifer. Usually includes "iron bacteria." Causes reduced specific capacity and efficiency, reduced yield, interference with sample quality, and even complete well production loss. Often works simultaneously with other problems such as silting.
Pump/Well Corrosion*	Natural aggressive water quality, including hydrogen sulfide, sodium chloride-type waters, biofouling, and electrolysis due to stray currents. Aggravated by poor material selection in pump or column pipe, casing, and screen. May result in secondary system symptoms.
Well Structural Failure	Tectonic ground shifting, ground subsidence, failure of unsupported casing in caves or due to poor grout support, casing or screen corrosion and collapse, casing insufficient for in-ground conditions, local site operations, collapse of unstable rock borehole.

*Performance problems considered the most typical at the Paducah Site.
Source: Smith 1995

2.4 DOWN-HOLE VIDEO INSPECTION

Inspection with a down-hole video camera is not a routine part of maintenance monitoring, but this procedure may be conducted if down-hole problems are detected (e.g., if a newly installed MW is not functioning as expected). A down-hole video survey provides a direct view of conditions within MWs. The video can be used to document the occurrence of MW damage and deterioration over time. A progression of videos in any particular MW, if available, provides a direct way to watch changing conditions in the MW (e.g., progressing screen corrosion or biofouling development).

THIS PAGE INTENTIONALLY LEFT BLANK

3. MONITORING WELL REHABILITATION AND MAINTENANCE

Lack of a maintenance program can lead to MW performance deficiencies (physical problems) or sample quality degradation (chemical problems). These problems are inherent to MWs because they often are left idle for long periods of time between sampling events. Typical solutions for these problems that would be applied to water supply wells may not be appropriate for MWs because of the need to minimize their impact on the conditions that the MWs were installed to evaluate. In other words, methods of MW rehabilitation should not, more than transiently, change the chemistry of the groundwater being monitored (ASTM 2024).

Methods to rehabilitate a MW may include redevelopment to remove fine-grained materials and other materials that may be clogging the MW screen. Rehabilitation can be accomplished using surge blocks, pumping, water jetting, or a combination of methods. In severe cases, chemical rehabilitation may be used for redevelopment for biofouling. A summary of rehabilitation methods is listed in Table 3.

Table 3. MW Rehabilitation Methods

Method	Description
Brushing	A hard-bristle brush is used in an up-and-down motion on the well screen. The brush should fit snuggly inside the well and be made of hard plastic or other material that will not abrade, gouge, or otherwise damage the well casing and screen.
Bailing	Solids are bailed from the bottom of the well using a suction bailer.
Pumping	A small-diameter pump is used to over pump the well to remove solids; can also be used with surging over 1–2 ft intervals of the screened zone.
Jetting	A jetting tool is used to clean the screen interval with a high-velocity stream of water.
Surge Blocks	A beveled edge cylindrical unit. As the unit is introduced and moves downward in the well, the internal membrane flexes away from the block in order to permit the one-way flow of fluid upward. The membrane closes against the cylinder to prevent the flow of water as the block moves upward.
Biofouling Chemical Treatment	A bioacid dispersant and acid treatment is introduced into the well screen and agitated to remove biological induced accumulations. Chemical treatment must be approved by the Kentucky Division of Waste Management in advance.

Maintenance for the permitted MWs is performed following notification of appropriate state agencies as required by their respective groundwater monitoring plans and permits. The Environmental Monitoring Manager is responsible to schedule all maintenance and ensure the appropriate notifications have been made.

The physical maintenance actions will be addressed as prescribed in Section 3.4, and will be conducted in accordance with *Monitoring Well And Associated Infrastructure Installation,* CP4-ES-0069, and *Monitoring Well Inspection and Maintenance*, CP4-ES-0074.

MW rehabilitation methods (e.g., mechanical and chemical treatments) will be addressed as prescribed in Sections 3.2 and 3.3 and will be conducted in accordance with *Monitoring Well Brushing and Over Pumping*, CP4-ES-0075. Other mechanical methods will require approval from the Environmental Monitoring Manager and a task-specific work plan. Chemical methods of rehabilitation require the Environmental Stewardship Manager, in consultation with selected Environmental Remediation program staff, to evaluate chemical usage. Use of chemicals will require a task-specific work plan, which must include measures to ensure that the chemicals are recovered in their entirety and that other potential consequences of chemical usage are evaluated. Prior to the implementation of such a task-specific work plan, approval by the Kentucky Department for Environmental Protection would be required.

3.1 PUMP REMOVAL

The first step for MW rehabilitation involves removing the pump and the associated discharge line (tubing) and inspecting them for evidence of mechanical failure, biofouling, encrustation, or corrosion. Equipment showing evidence of these will be photographed. All pumps will be refurbished and rebuilt, if necessary, before reinstalling. The pump and tubing will be decontaminated as necessary before reinstalling. This system is considered a dedicated system to its MW location and will not be used as a replacement in any other MWs.

3.2 MECHANICAL REDEVELOPMENT

Following removal of the pump and discharge line, it is best to brush the interior of the MW to remove any biofilm, scale, or encrustation. Brushes are selected for size, stiffness, and materials (inert and compatible with MW casing and screen). The diameter of the brush should be slightly larger than the inside diameter of the MW to ensure a snug fit. It should be made of hard plastic or other material that will not abrade, gouge, or otherwise damage the MW casing or screen (suitable brushes include the WireHog® polybrush and the Cotey Chemical Corporation® Model J200 brush, although other brushes with nonmetal bristles may be used for MWs that have PVC casings or screens). MWs that have stainless-steel risers and stainless-steel screens may use brushes with metal bristles, if the bristles will not abrade, gouge, or otherwise damage the MW casing or screen and the bristles are inert and compatible with the casing and screen. Brushing simply involves running a hard bristle brush up and down the length of the MW screen to remove sediment and biofilm encrusted on the MW casing and screen. If biofouling is present, the brushing action also should be performed on the inside of the MW casing up to the static water level in the MW. The up and down movement of the brush produces a surging effect that enhances the redevelopment process. After the MW casing is brushed, any biofilm, along with any scale and encrustation, shall be allowed to settle to the bottom of the MW.

Following brushing, the MW should be redeveloped using a small diameter pump to remove the material that has settled at the bottom of the MW. During pumping, surging of the screened interval also may aid in material removal. The pumping should continue until no further silt or other loosened material is observed in the pumped water. The pump must be decontaminated between uses in MWs to prevent cross-contamination. Any waste derived from mechanical redevelopment will be properly managed through final disposition. A video inspection may be performed following redevelopment to determine if the process was successful in removing encrustation from the screen.

3.3 CHEMICAL TREATMENT

If analytical data or MW performance indicates no improvement after the use of mechanical techniques, chemical redevelopment techniques may be employed. Caution must be used in evaluating the use of any method that introduces a chemical to the subsurface. Harsh or corrosive chemicals can damage MW materials, and they can significantly alter the groundwater chemistry near the MW for prolonged periods. Chemical treatment is typically not recommended in MWs and should be considered a last resort due to possible impacts or side effects from the chemicals. Chemicals typically used for MW rehabilitation include acids, biocides, oxidizers, and other additives. The specific chemical, or chemical mixture, used depends on the type of MW problem to be addressed. Acids often are recommended for rehabilitation (e.g., glacial acetic acid, glycolic acid, other organic acids such as oxalic and citric acid) (USACE 2000).

Full rehabilitation using a chemical treatment method often is conducted only if severe biofouling and/or microbial plugging have occurred such that mechanical redevelopment alone is not sufficient. This method

combines conventional mechanical treatments (brushing, jetting, surging, and pumping) with chemical application.

Care will be taken to follow all applicable regulations pertaining to the handling of treatment chemicals. Volumes of all chemicals injected will be recorded. It is anticipated that a majority of the chemicals will be recovered during the required subsequent redevelopment. During the removal phase, groundwater will be extracted until the water has low turbidity and the pH stabilizes to within a 10% variance of the pretreatment pH.

3.4 PHYSICAL MAINTENANCE

All of the Paducah Site MWs are inspected to evaluate their physical condition by utilizing the inspection guidance described in Section 2.1 of this plan. The inspections are designed to provide a comprehensive evaluation of the physical condition of the MWs. Environmental Stewardship schedules the MWs that require maintenance by prioritizing, as described below, and completing a maintenance work request. Maintenance of the MWs is either self-performed or subcontracted depending on the nature of the maintenance action. Some maintenance is required to be performed by a Kentucky-Certified Monitoring Well Driller.

The type of maintenance that is required is prioritized to keep the most critical needs performed (e.g., security and integrity issues).

(1) MW security (such as missing locks or lockable caps, broken hasps on aboveground MWs, missing/stripped bolts on flush mount MWs)

(2) MW integrity (cracked pads that can lead to surface infiltration, torn/ripped gaskets on flush mount MW covers, annular seal problems)

(3) Pads below surrounding grade or not sloping away from the MW

(4) Damaged inner casing

(5) Clogged or insufficient weep holes

(6) Problem with sampling equipment

(7) Missing or no clear measuring reference point

(8) Obstructions in a MW

(9) Sediment accumulation in bottom of MW

(10) Accessibility and cosmetic

(a) Access road repairs
(b) Bollard damage
(c) Pads covered with gravel/soil/debris
(d) Missing or illegible MW identification numbers and/or Kentucky AKGWA tags
(e) Refurbishment of outer casing and/or bollards

The priority items above are designed to be a guide to address the most serious issues and descend to a lower priority so that the MWs are not compromised and data quality will be maintained. These items are a guide to help set priorities; however, consideration also should be given to the underlying goal of the MWs providing representative groundwater data.

Consideration for priority based on use of the MW shall be as follows.

(1) Permitted MWs (i.e., C-746-S, T, and U landfill MWs, C-404 Low-level Radioactive Waste Burial Area MWs)

(2) MWs used for environmental sampling

(3) MWs used for water level only

Another factor that may influence maintenance priority considerations is the location of the MW. MWs located within the U.S. Department of Energy security area are considered more secure than MWs that are located outside the secure area, but are still within the main entry portal of the Paducah Site. MWs located along public roads or within the West Kentucky Wildlife Management Area are at a higher risk because they are easily accessible.

Maintenance also may include abandoning MWs that no longer serve the original purpose or have been damaged or deteriorated to a point where maintenance is not practical. Abandonment also is considered when there is an obstruction in a MW that may, in the future, cause the MW to not provide representative groundwater data (e.g., pump is stuck and pump fails). MW abandonment is a task that would require the services of a Kentucky-Certified Monitoring Well Driller. For permitted MWs, abandonment would be performed in accordance with their respective groundwater monitoring plans and permits.

4. DECONTAMINATION

All equipment and tools used for MW maintenance shall be decontaminated prior to use. Decontamination activities will be conducted under contractor-approved procedures. After decontamination, equipment shall be allowed to dry. It then will be wrapped or covered with clean plastic sheeting or aluminum foil if it is to be stored for more than a few hours. Long-term storage shall occur in clean areas. To prevent cross-contamination, equipment will be decontaminated between each MW such that clean equipment will be used at each MW undergoing maintenance. Additionally, brushes must be decontaminated between uses in MWs to prevent cross-contamination.

Smaller equipment and sampling equipment, such as pumps and tubing, will be decontaminated following procedure, CP4-ES-2702, *Decontamination of Sampling Equipment and Devices*. Initially, soapy water will be pumped through the tubing and pump to flush out residual purge water. A brush or wipe will be used to scrub the exterior of the pump and tubing. After rinsing the external surfaces, tap water will be pumped through the pump and tubing followed by analyte-free water. Equipment also may be cleaned with high-pressure steam or hot water. Steam cleaning and/or hot water washing, which is included in CP4-ES-2702, is recommended for brushes used in scrubbing the MW screen and casing. Tubing may be replaced if deemed necessary.

THIS PAGE INTENTIONALLY LEFT BLANK

5. REFERENCES

ASTM (American Society for Testing and Materials) 2024. *Standard Guide for Maintenance and Rehabilitation of Groundwater Monitoring Wells*, ASTM D 5978M-16/D5978M-16 ,American Society for Testing and Materials International, West Conshohocken, PA.

BJC (Bechtel Jacobs Company LLC) 2000a. *C-746-S&T and C-746-U Landfills Monitoring Wells Camera Inspection, Paducah, Kentucky*, BJC/PAD-186, Bechtel Jacobs Company LLC, Paducah, KY, May.

BJC 2000b. *C-746-K Landfill, C-404 Burial Ground, Northeast Plume Monitoring Wells, and Northwest Monitoring Wells, (North and South Fields) Camera Inspections at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-204, Bechtel Jacobs Company LLC, Paducah, KY, August.

BJC 2001. *Results of the Monitoring Well Corrosion Study, Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-239, Bechtel Jacobs Company LLC, Paducah, KY, February.

BJC 2002. *Monitoring Well Maintenance Implementation Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, BJC/PAD-327, Bechtel Jacobs Company LLC, Paducah, KY, February.

CP2-ES-0006, *Environmental Monitoring Plan Fiscal Year 2025 Paducah Gaseous Diffusion Plant, Paducah, Kentucky*

CP3-SI-0001, *Site Interface Agreement*

CP4-ES-0069, *Monitoring Well And Associated Infrastructure Installation*

CP4-ES-0074, *Monitoring Well Inspection and Maintenance*

CP4-ES-0074-F01, "PGDP Monitoring Well Inspection Checklist"

CP4-ES-0075, *Monitoring Well Brushing and Over Pumping*

CP4-ES-2702, *Decontamination of Sampling Equipment and Devices*

EPA (U.S. Environmental Protection Agency) 1995, *Nonaqueous Phase Liquids Compatibility with Materials Used in Well Construction, Sampling, and Remediation,* EPA/540-S-95-503, July.

Smith, S. A. 1995. *Monitoring and Remediation Wells: Problem Prevention, Maintenance, and Rehabilitation,* first edition, CRC Press, Boca Raton, FL, May.

Underwood, Dan 2000a. Materials and Chemical Technology, United States Enrichment Corporation, Paducah, KY, letter to Stan Knaus, Lan-Con, Inc., Paducah, KY, March 24.

Underwood, Dan 2000b. Materials and Chemical Technology, United States Enrichment Corporation, Paducah, KY, letter to Stan Knaus, Lan-Con, Inc., Paducah, KY, titled, "Evaluation of Piping Northeast Plume," February 21.

USACE (U.S. Army Corps of Engineers) 2000. Operation and Maintenance of Extraction and Injection Wells at HTRW Sites, EP 1110-1-27, U.S. Army Corps of Engineers, Cincinnati, Ohio, January.