SGW-58291
Revision 0

Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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By Julia Raymer at 9:38 am, Jun 15, 2015

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Terms

COC	contaminant of concern
Cr(VI)	hexavalent chromium
CSM	conceptual site model
DOE	U.S. Department of Energy
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
FS	feasibility study
HEIS	Hanford Environmental Information System
MNA	monitored natural attenuation
OU	operable unit
PSQ	principal study question
QA	quality assurance
QC	quality control
RAO	remedial action objective
RDR/RAWP	remedial design report/remedial action work plan
RI	remedial investigation
ROD	record of decision
RUM	Ringold Formation upper mud
SAP	sampling and analysis plan
TCE	trichloroethene

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Data Quality Objectives for 100-FR-3 Monitored Natural Attenuation

The 100-FR-3 Groundwater Operable Unit (OU) comprises groundwater contaminated by releases from facilities and waste sites associated with past operation of the 100-F Reactor and biological experiments. The U.S. Environmental Protection Agency (EPA) issued the 100-F/IU record of decision (ROD) for 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 in September 2014 (EPA and DOE, 2014, *Record of Decision Hanford 100 Area Superfund Site 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2, and 100-IU-6 Operable Units*). The ROD (EPA and DOE, 2014) specifies monitored natural attenuation (MNA) of groundwater and institutional controls to restrict groundwater use as the final remedial actions. MNA will be implemented for hexavalent chromium (Cr(VI)), nitrate, strontium-90, and trichloroethene (TCE) in 100-FR-3 groundwater. Performance monitoring of these contaminants of concern (COCs) in the groundwater is a component of the MNA remedy. Performance monitoring includes two phases:

1. The remediation monitoring phase occurs while remedial activities (in this case, natural attenuation processes) are being implemented to reach groundwater cleanup levels.

2. The attainment monitoring phase occurs after the remediation phase is complete. Data are collected and evaluated to confirm that the cleanup level for each COC has been met and that groundwater will continue to meet cleanup levels in the future.

A data quality objectives (DQOs) workshop was conducted August 6 and 7, 2014 (when the ROD [EPA and DOE, 2014] was still in draft form), to support design of a groundwater sampling and analysis plan (SAP). Additional work was performed after the workshop, including review and contribution from the U.S. Department of Energy (DOE) SAP panel. This report summarizes the output of the DQO process.

Several EPA documents provide criteria and guidance for MNA. Section 3.1.2 of DOE/RL-2014-44-ADD2, *Remedial Design Report/Remedial Action Work Plan Addendum for 100-F/IU Groundwater* (Groundwater Addendum), and DOE/RL-2014-44, *Integrated Remedial Design Report/Remedial Action Work Plan for 100-F/IU* (Integrated RDR/RAWP), lists applicable documents that were considered in DQO planning. Table 1 cross-references EPA criteria with the principal study questions (PSQs) presented in this DQO document.

1 Step 1: State the Problem

Summary: *The problem statement is created to clearly define the issue that requires new environmental data so that the focus of the study will be clear and unambiguous. Pertinent information from similar studies and assumptions should be organized, reviewed, identified, evaluated, and documented.*

- Give a concise description of the problem.
- Identify planning team.
- Develop conceptual site model (CSM).
- Determine resources.

Output of Step 1: Document the four elements listed in this step.

1.1 100-FR-3 Problem Statements

- There is a need to monitor the performance of the natural attenuation remedy.
- There is a need to demonstrate at the end of the remedial action period that cleanup levels for groundwater have been attained.
- There is a need to confirm that concentrations of antimony, cadmium, and cobalt are below action levels.

Table 1. 100-FR-3 Principal Study Questions as Related to EPA Guidance on Monitored Natural Attenuation

Principal Study Question	EPA Guidance*
PSQ 1a. Are contaminant concentrations and plume area/mass decreasing?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 3:** Identify any potentially toxic and/or mobile transformation products **Step 4:** Verify the plume is not expanding downgradient, laterally or vertically
PSQ 1b. Are rates of decline consistent with expectations?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 3:** Identify any potentially toxic and/or mobile transformation products
PSQ 1c. Are there changes in environmental conditions that may reduce the efficacy of natural attenuation?	**Step 2:** Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes
PSQ 1d. Are there unacceptable impacts to the Columbia River?	**Step 5:** Verify no unacceptable impact to down-gradient receptors
PSQ 1e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the natural attenuation remedy?	**Step 6:** Detect new releases of contaminants to the environment that could impact effectiveness
PSQ 2. Are concentrations of antimony, cadmium, and cobalt below action levels?	Not in EPA guidance; required to resolve previous analytical uncertainty
PSQ 3. Do new geologic and hydrogeologic data confirm the conceptual site model?	**Step 1:** Demonstrate that natural attenuation is occurring according to expectations **Step 2:** Detect changes in environmental conditions that may reduce the efficacy of any of the natural attenuation processes **Step 4:** Verify the plume is not expanding downgradient, laterally or vertically
PSQ 4a. Are concentrations of COCs below cleanup levels?	**Step 8:** Verify attainment of the remediation objectives
PSQ 4b. Will groundwater continue to meet the cleanup level in the future?	
Not an identified PSQ; evaluated within EPA performance monitoring guidance	**Step 7:** Demonstrate the efficacy of institutional controls that were put in place to protect potential receptors

* Source: EPA 600/R-11/204, *An Approach for Evaluating the Progress of Natural Attenuation in Groundwater*.

COC = contaminant of concern

EPA = U.S. Environmental Protection Agency

PSQ = principal study question

1.2 Planning Team

Table 2 lists planning team members and roles.

Table 2. 100-F/IU Planning Team

Name	Organization	Role
Brad Bessinger*	SSPA	MNA and performance monitoring
Phil Burke*	CHPRC	OU Lead
Chris Guzzetti	EPA	EPA Project Manager
Mary Hartman*	CHPRC	OU Project Scientist; DQO Facilitator
Scott McKinley	CH2M HILL	Senior Review
Leland Scantlebury*	CHPRC Intern	Support
Greg Sinton*	DOE/RL	DOE Project Manager
Alex Spiliotopoulos*	SSPA	Groundwater Modeling Support
Heather Sulloway*	CH2M HILL	Performance Monitoring Plan lead
Matt Tonkin*	SSPA	Groundwater Modeling Support
DOE SAP Panel	DOE and others	Review DQO output; later review SAP

* Workshop participant

CHPRC = CH2M HILL Plateau Remediation Company
DOE = U.S. Department of Energy
DOE/RL = DOE Richland Operations Office
DQO = data quality objective
EPA = U.S. Environmental Protection Agency
MNA = monitored natural attenuation
OU = operable unit
SAP = sampling and analysis plan
SSPA = S.S. Papadopulos and Associates, Inc.

1.3 Conceptual Site Model

The CSM is described in the remedial investigation (RI)/feasibility study (FS) (DOE/RL-2010-98, *Remedial Investigation/Feasibility Study for the 100-FR-1, 100-FR-2, 100-FR-3, 100-IU-2 and 100-IU-6 Operable Units*), and supplemented by data in the Hanford Environmental Information System (HEIS). The CSM will be refined with collection of additional data and an updated computer model. Figure 1 illustrates a water table map for the region. Figures 2 through 6 show contaminant plumes.

1.4 Resources

Resources are to be planned outside of the workshop.

2 Step 2: Identify the Goals of the Study

***Summary**: Identify the question(s) that the study will address and alternative actions or outcomes that may result based on the results. Define the decision that will be resolved using the data collected to address the problem.*

- Identify PSQs.
- Consider alternative outcomes.
- For decision problems, develop decision statements. For estimation problems, state what needs to be estimated and key assumptions.

Outputs of Step 2:

- Well-defined PSQs
- A listing of alternative outcomes or actions as a result of addressing PSQs
- For decision problems, a list of decision statements that address the study question
- For estimation problems, a list of estimation statements that address the study question

2.1 100-F/IU Principal Study Questions

1. Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?
    a. Are contaminant concentrations and plume area/mass decreasing?
    b. Are rates of decline consistent with expectations?
    c. Are there changes in environmental conditions that may reduce the efficacy of NA?
    d. Are there unacceptable impacts to the Columbia River?
    e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the MNA remedy?
2. Are concentrations of antimony, cadmium, and cobalt below action levels?
3. Do new geologic and hydrogeologic data confirm the conceptual site model?
4. Have remedial action objective (RAOs) been achieved?
    a. Are concentrations of COCs below cleanup levels?
    b. Will groundwater continue to meet cleanup levels in the future?

2.2 Alternative Outcomes

- Continue monitoring program with no change.
- Modify monitoring program.
- Reconsider another alternative for remediation.

2.3 Decision Statements

1. Determine whether natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater is occurring as expected so that natural attenuation may continue, or if other options should be evaluated.
2. Determine whether antimony, cadmium, and cobalt concentrations are below action levels so that monitoring for these metals may cease, or if risks need to be assessed.
3. Determine whether new geologic and hydrogeologic data confirm the conceptual site model, or if the model needs updating.
4. Determine whether COC concentrations are below cleanup levels and attainment monitoring may proceed, or if MNA should continue.

3 Step 3: Identify Information Inputs

Summary: *The third step of the DQO process is to identify information inputs needed to support the decision statements and to specify which inputs will require environmental measurements.*

- Identify types and sources of information needed to produce estimates or resolve decisions.
- Identify the basis of information that will guide or support choices to be made in later steps of the DQO process.
- Select appropriate sampling and analysis methods for generating the information.

Outputs of Step 3:

- Lists of environmental characteristics that will resolve the decision or estimate and potential sources for the desired information inputs
- Information on the number of variables that will need to be collected
- Type of information needed to meet performance or acceptance criteria
- Information on the performance of appropriate sampling and analysis methods

3.1 Action Levels

Table 3 lists action levels for COCs, trace metals, and degradation products of TCE.

Table 3. 100-FR-3 Action Levels

Contaminant	Category	Cleanup or Action Level	Type
Hexavalent Chromium	COC	10 µg/L at Columbia River	Cleanup level
Trichloroethene	COC	4 µg/L	Cleanup level
Nitrate	COC	45 mg/L as NO_3^-*	Cleanup level
Stronium-90	COC	8 pCi/L	Cleanup level
Antimony	Trace metal	6 µg/L	Action level in RI
Cadmium	Trace metal	0.25 µg/L surface water; 5 µg/L DWS	Action level in RI

Table 3. 100-FR-3 Action Levels

Contaminant	Category	Cleanup or Action Level	Type
Cobalt	Trace metal	4.8 µg/L	Action level in RI
cis-1,2-dichloroethene	Degradation product	16 µg/L	Action level in RI
Vinyl Chloride	Degradation product	0.061 µg/L	Action level in RI

* Nitrate may be expressed as nitrate nitrogen (NO_3-N) or as nitrate (NO_3^-). The cleanup level of 45 mg/L as NO_3^- is derived from the DWS of 10 mg/L as NO_3-N.

COC = contaminant of concern

DWS = drinking water standard

RI = remedial investigation

3.1.1 Other Input

- Groundwater sample data from new and existing wells and aquifer tubes (COCs and supporting parameters)
- Historical chemistry and water level data
- Sample data from riverbank seeps
- Groundwater levels
- River stage
- Geologic information
- Updated geologic interpretations from existing wells

3.2 Sampling and Analysis Methods

- Continue current methods of sampling monitoring wells, aquifer tubes, and seeps (per project procedures).
- Analytical methods will be selected to meet required action levels.

4 Step 4: Define the Boundaries of the Study

Summary: *Define the specific spatial and temporal boundaries that are included in the decision.*

- Define the target population of interest and its relevant spatial boundaries.
- Define what constitutes a sampling unit.
- Specify temporal boundaries and other practical constraints associated with data collection.
- Specify the smallest unit on which decisions or estimates will be made.

Outputs of Step 4:

- Definition of the target population with detailed descriptions of geographic limits (spatial boundaries)
- Detailed descriptions of what constitutes a sampling unit

- Time frame appropriate for collecting data and making the decision or estimate, together with those practical constraints that may interfere with data collection
- Appropriate scale for decision making or estimation

4.1 Target Population and Spatial Boundaries

Unconfined groundwater in the 100-FR-3 OU includes 100-F, region south, and region west (upgradient).

4.2 Temporal Boundaries

- Predicted time to cleanup based on the maximum concentrations calculated by the RI model:
  - Cr(VI) at 10 µg/L cleanup level (state surface water quality standard) – 35 years
  - Cr(VI) at 48 µg/L WAC 173-340, "Model Toxics Control Act—Cleanup," groundwater cleanup level – 20 years
  - Nitrate at 45 mg/L cleanup level – 80 years
  - Strontium-90 at 8 pCi/L cleanup level – 150 years
  - TCE at 4 µg/L cleanup level – 50 years
- Trace metals – Time necessary to collect at least 8 independent samples
- As specified in the RI/FS (DOE/RL-2010-98), monitoring will be performed for an additional 5 years after cleanup level for each COC is initially achieved to confirm remediation goals (see Section 7.1.13)
- Automated water level measurements – operate robust network for at least 5 years, then re-evaluate

4.3 Decision Units

- Spatial:
  - Nitrate plume boundaries at >45 mg/L
  - Nitrate plume high-concentration core at >90 mg/L
  - Cr(VI) plume boundaries at >10 µg/L
  - TCE plume boundaries at >4 µg/L
  - Strontium-90 plume boundaries at >8 pCi/L
  - Selected wells for trace metals (see rationale in Step 7)
- Time: 5-year periods (to facilitate 5-year reviews)

4.4 Practical Constraints

- Resource availability for well installation, sample collection, and laboratory analysis (funding)
- Analytical detection limits
- Cultural and ecological constraints on new well locations
- Seasonal variability of river stage and water table

5 Step 5: Develop the Analytic Approach

Summary: *Integrate the outputs from the previous steps into a statement(s) that describes the logical basis to select amongst the alternative actions. This includes specifying the population parameter (e.g., mean, percentile), determining the action level, and constructing the decision rule. A decision rule is determined for each PSQ. At this point, it is assumed that perfect information is available for decision making.*

- Specify appropriate population parameters for making decisions or estimates.
- For decision problems, choose a workable action level and generate and "If… then… else" decision rule.
- For estimation problems, specify the estimator and estimation procedure.

Outputs of Step 5:

- Identification of the population parameters most relevant for making inferences and conclusions on the target population.
- For decision problems, the "if..., then...else..." theoretical decision rule based upon a chosen action level.
- For estimation problems, the specification of the estimator to be used.

5.1 100-FR-3 Parameters of Interest

- Concentrations/trends for each COC and trace metal (as expressed by statistical parameters)
- Plume area or mass for each COC (changes with time)
- Comparison of observations to modeled conditions

5.2 Decision Rules (If/Then)

Table 4 lists decision rules associated with each PSQ.

Table 4. 100-FR-3 Principal Study Questions and Decision Rules

	Principal Study Question	Decision Rule
1	Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?	If the weight of evidence indicates that natural attenuation is occurring as expected, then continue MNA; otherwise evaluate other options.
2	Are concentrations of antimony, cadmium, and cobalt below action levels?	If monitoring indicates that concentrations are not greater than the action level or practical quantitation limit, then discontinue monitoring; otherwise perform risk assessment.
3	Do new geologic and hydrogeologic data confirm the CSM?	If new geologic and hydrogeologic data confirm the CSM, then retain the model; otherwise update it.
4	Have RAOs been achieved? Are concentrations of COCs below cleanup levels? Will groundwater continue to meet cleanup levels in the future?	If RAO has been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise continue MNA.

COC = contaminant of concern
CSM = conceptual site model
MNA = monitored natural attenuation
NA = natural attenuation
OU = operable unit
RAO = remedial action objective

6 Step 6: Specify Performance or Acceptance Criteria

***Summary**: Define how much uncertainty can be tolerated when making the decision of interest, and establish appropriate performance goals for limiting uncertainty in the data. The guidance document says this is where you "face the reality that you will not have perfect information from which to formulate your conclusions." Discuss severity of consequences of making wrong decisions.*

- For decision problems, specify the decision rule as a statistical hypothesis test, examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors.
- For estimation problems, specify acceptable limits on estimation uncertainty.

Output of Step 6:

- A set of performance or acceptance criteria (i.e., DQOs) that data should achieve in order to minimize the possibility of either making a decision error or failing to keep uncertainty in estimates to within acceptable levels

6.1 100-FR-3 Criteria

Traditional statistical sample designs are not typically identified for groundwater investigations. Sampling design will be judgmental.

Criteria for evaluating the data with respect to the PSQs will employ both statistical and nonstatistical methods. Methods of evaluation will be derived from sources such as OSWER 9283.1-44, *Recommended Approach for Evaluating Completion of Groundwater Restoration Remedial Actions at a Groundwater Monitoring Well*. Details are included in Chapter 6 of the Groundwater Addendum (DOE/RL-2014-44-ADD2). Table 1 relates 100-FR-3 PSQs to EPA's criteria for evaluating MNA.

1. Is natural attenuation of Cr(VI), nitrate, TCE, and strontium-90 in groundwater occurring as expected?
    a. Are contaminant concentrations and plume area/mass decreasing? *Statistical evaluation.*
    b. Are rates of decline consistent with expectations? *Statistical evaluation.*
    c. Are there changes in environmental conditions that may reduce the efficacy of NA? *Nonstatistical evaluation*
    d. Are there unacceptable impacts to the Columbia River? *Statistical and nonstatistical evaluation.*
    e. Is there evidence of new or continuing releases of contaminants to the environment that could impact the effectiveness of the MNA remedy? *Nonstatistical evaluation.*
2. Are concentrations of antimony, cadmium, and cobalt below action levels? *Statistical evaluation.*
3. Do new geologic and hydrogeologic data confirm the conceptual site model? *Nonstatistical evaluation.*
4. Have RAOs been achieved?
    a. Are concentrations of COCs below cleanup levels? *Statistical evaluation.*
    b. Will groundwater continue to meet cleanup levels in the future? *Statistical evaluation.*

6.2 Decision Errors and Mitigating Measures

This section describes possible errors for each of the major decision rules. The sources of errors that lead to those decision errors, and factors to mitigate them, are listed in Table 5.

Decision Rule 1: If the weight of evidence indicates that natural attenuation is occurring as expected, then continue MNA; otherwise evaluate other options.

- Decision Error 1a: MNA is deemed ineffective, and a more aggressive form of remediation is implemented unnecessarily. Consequence: Funding could be diverted from higher-priority projects. Severity: Low to moderate.
- Decision Error 1b: MNA is deemed effective and, in fact, it is not. Consequences: Remediation timeline is longer than predicted. Severity: Low.

Decision Rule 2: If monitoring indicates that concentrations of antimony, cadmium, and cobalt are not above action levels or quantitation limits, then discontinue monitoring; otherwise perform risk assessment.

- Decision Error 2a: Monitoring for metals continues even though they are not above action levels. Consequence: Funding could be diverted from higher-priority projects. Severity: Low to moderate.
- Decision Error 2b: Monitoring for metals is discontinued, but they are in fact above action levels. Consequence: Contamination remains in the aquifer or migrates to receptors. Severity: Low to moderate.

Decision Rule 3: If new geologic and hydrologic data confirm the conceptual site model, then retain the model; otherwise update it.

- Decision Error 3a: Conceptual site model is updated unnecessarily. Consequence: Minor outlay of resources. Severity: Low.
- Decision Error 3b: Conceptual site model is not updated, and results do not reflect the natural system accurately. Severity: Low to moderate.

Decision Rule 4: If RAO has been achieved for an individual COC, then proceed to attainment monitoring for that COC; otherwise continue MNA.

- Decision Error 4a: MNA continues longer than needed. Consequences: Continued monitoring would reveal that goals have been achieved. Severity: Low.
- Decision Error 4b: Attainment monitoring begins prematurely. Consequence: Attainment monitoring would reveal the error, and MNA would continue. Severity: Low.

Table 5. Sources of Error and Mitigating Measures

Source of Error	Mitigating Measures
Variability in concentrations causing inaccurate estimates of attenuation rates (e.g., variability due to seasonal or longer-term changes in water table; plume migration)	Consistent schedule for sampling to increase comparability; more frequent monitoring in wells with variable concentrations
Uncertainty in estimates of plume size (interpolation, extrapolation)	Robust monitoring network, including new monitoring wells to reduce uncertainty in plume interpretations; geostatistical methods to evaluate plume size

Table 5. Sources of Error and Mitigating Measures

Source of Error	Mitigating Measures
Uncertainties in model predictions (limitations of model input)	Improvements to model based on new geologic information and expanded automated water level network
New or unknown sources of contamination	Monitor near former source areas with greater density of wells and higher sampling frequency
Analytical error	Robust quality assurance/quality control program to minimize analytical uncertainties

7 Step 7: Develop the Plan for Obtaining Data

***Summary**: Using results from the previous steps, identify the most resource-effective sampling and analysis design for generating data that are expected to satisfy the DQOs.*

1. Compile all information and outputs generated in Steps 1 through 6.
2. Use this information to identify alternative sampling and analysis designs that are appropriate for your intended use.
3. Select and document a design that will yield data for best achievement of performance or acceptance criteria.

Outputs of Step 7:

- Full documentation of the final sampling and analysis design, along with a discussion of the key assumptions underlying this design
- Details on how the design should be implemented together with contingency plans for unexpected events
- Quality assurance (QA) and quality control (QC) procedures that would be performed to detect and correct problems and so ensure defensible results
- Documentation of these items in a SAP

7.1 100-FR-3 Sampling and Analysis Plan

The team designed a monitoring network, analyte list, and sampling frequencies, summarized in the following subsections. Table 6 lists all of the wells and aquifer tubes considered for sampling, and which (if any) PSQs they address. Plume maps with available well locations are attached as Figures 2 through 6. Figures 7 and 8 show locations of the proposed monitoring networks, including new wells.

7.1.1 Monitoring Network for Water Samples (Table 6)

Monitoring wells were selected within and downgradient of contaminant plumes to monitor attenuation and possible migration (PSQs 1a and 1b). Near-river wells, aquifer tubes, or seeps were selected to monitor potential impacts to the Columbia River (PSQ 1d). Wells were preferred over aquifer tubes or seeps. Aquifer tubes or seeps were only selected where there are no wells between the shoreline and the plume boundary.

Wells within the former operational area were selected to monitor for new releases (PSQ 1e). Section 7.1.2 describes the rationale for selection of wells for trace metals (PSQ 2).

The monitoring network comprises the following:

- 28 existing wells, 8 new wells (phase 1), and up to 6 possible additional wells based on results of phase 1
- 6 existing aquifer tubes
- 1 riverbank seep
- Monitoring networks for the attainment phase (PSQ 4) will be determined closer to the end of remediation monitoring phase for each COC.

7.1.2 Rationale for New Well Locations (Phase 1; Figures 7 and 8)

- C9472: South of TCE – monitor plume shrinkage and migration
- C9474: East of 699-71-30 – sentinel well for nitrate
- C9475: West of 699-71-30 – monitor nitrate plume shrinkage
- C9476: Nitrate near south (in plume) – monitor shrinkage of >90 mg/L contour
- C9477: Nitrate near south (east of plume) – monitor plume shrinkage and sentinel well
- C9478: Nitrate far south (upgradient) – monitor nitrate plume shrinkage
- C9479: Nitrate far south (in plume) – monitor plume shrinkage
- C9480: Nitrate far south (east of plume) – monitor plume shrinkage and sentinel well

Proposed locations may need to be moved based on accessibility or results of ecological/cultural reviews. If a location is moved more than ~100 m (330 ft), DOE and EPA will be consulted for concurrence.

Several other locations were considered for new wells during the DQO workshop. After subsequent reviews by the DOE Panel, the team concluded that the following wells were not needed for decision making and were, therefore, eliminated:

- Southeast of Cr(VI) plume and south of strontium-90 plume to delimit plumes and monitor shrinkage (C9469): Plumes are sufficiently delineated by existing wells.
- Northwest edge of Cr(VI) plume to refine plume interpretation and monitor plume shrinkage (C9470): Plume is sufficiently delineated by existing wells.
- North of TCE in area of 1995 study to refine interpretation and monitor plume shrinkage (C9471): This location is within an area where TCE was elevated in groundwater in 1995. However, groundwater flow to the east and south would have decreased concentrations in this region since then, and continued declines can be assumed.
- West of TCE and nitrate to monitor upgradient conditions and refine interpretation of TCE plume (C9473): This location was outside the boundary of the TCE plume in 1995. Because groundwater flow is to the east and south, it is reasonable to assume that the upgradient area remains clean.
- Southeast of nitrate plume to monitor plume shrinkage and possible migration (C9481): Concentrations in wells within the 45 mg/L contour at the south end of the plume are declining or stable. The plume can be monitored adequately with existing wells.

7.1.3 Rationale for Phase 2 Wells

Locations of additional wells will be determined based on evaluation of monitoring data approximately 2 years after the final phase 1 well installation.

7.1.4 Additional Data from New Wells

- Geologic samples
- Aquifer properties

7.1.5 Use of Old Wells

- Evaluate pre-WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," wells for suitability (e.g., review documentation where available and perform camera surveys, borehole geophysics, and field inspections).
- Rehabilitate wells as appropriate (e.g., grout in lower portions of wells with long perforated intervals that span unconfined and part of the Ringold Formation upper mud [RUM]).
- It is unclear if Well 699-60-32 monitors the unconfined aquifer or the RUM. It will be evaluated and, if it monitors the RUM, nearby Well 699-59-32 may be substituted into the monitoring network.

7.1.6 Water Level Monitoring

- Supports PSQs 1c and 4 (Table 6)
- Automated water level stations in 19 wells
- Automated river gauge
- Manual measurements in 41 wells

7.1.7 Analytes

- COCs specific to each location (Table 6)
- TCE degradation products (vinyl chloride and *cis*-1,2-dichloroethene)
- Trace metals in selected wells (Table 6)
- Field parameters (specific conductance, pH, dissolved oxygen, turbidity, and temperature)

7.1.8 Sampling Frequency

- Frequency intervals listed in Table 6
- Minimum of annual sampling for first 5 years to establish new baseline that (a) reflects conditions after completion of source remediation, (b) determines conditions based on consistent set of wells, and (c) provides more data for input to regression calculations
- New wells quarterly for 1 year to establish baseline and seasonal variability
- Selected wells semiannually (high and low river stage) where changes in water table are likely to affect concentrations
- Frequency reduced after 5 years unless data indicate a need for more frequent monitoring
- Attainment monitoring frequency (see Section 7.1.13)
- Major sampling campaigns scheduled for fall when river stage is low (September or October). Semiannual wells (twice per year) also to be sampled at high river stage (mid-May through mid-July)

7.1.9 Quality Assurance and Quality Control Program

QA/QC will be integrated with the entire Soil and Groundwater Remediation Project.

7.1.10 Rationale for Automated Water Level Network

Obtain a good distribution of wells to create triangles for calculating hydraulic gradients. Assume these stations need to be maintained for first 5 years of monitoring, then re-evaluate.

7.1.11 Rationale for Manual Water Levels

Obtain comprehensive set of water level measurements during low river stage (October, concurrent with sampling), high river stage (June), and moderate stage (March, in conjunction with sitewide measurements).

7.1.12 Rationale for Trace Metal Wells

Select a subset of wells to evaluate antimony, cadmium, and cobalt, based on previous exceedances of action levels (Table 7). These wells will go into the SAP for trace metals analysis, and Decision Rule 2 will apply. The process included the following steps:

1. The process began with well lists from the 100-F spatial/temporal network of the RI/FS (DOE/RL-2010-98). Section 4.3.1.2 of the RI/FS (DOE/RL-2010-98) states that no further groundwater monitoring is required for 100-IU-2 and 100-IU-6.
2. The HEIS database was queried for antimony, cadmium, and cobalt data from January 1, 2007 through August 1, 2014.
3. The data were filtered for values above action levels and not flagged U.
4. Four wells with exceedances (~20 percent of available wells in 100-F Area) were selected for further analysis of trace metals.
5. No wells exceeded more than one analyte, and none had a high frequency of exceedance. Concentrations did not vary greatly. Therefore, wells were selected based on spatial spread.

7.1.13 Attainment Monitoring

After a cleanup level is achieved for a COC, a subset of monitoring wells will be sampled for 5 years to verify that cleanup is complete. The well network will be selected based on the location of contamination at the time. Sampling frequency may be quarterly for two years to detect seasonal variability and may be reduced to annually for the next 3 years. Actual number of wells is not known; assumptions for cost estimation are given in Table 8.

7.1.14 Rationale for Wells and Aquifer Tubes Not Sampled

Additional existing wells and aquifer tubes were considered and excluded from the monitoring network. Table 6 lists rationale for not sampling.

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Sample	Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4		Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
EXISTING WELLS																														
199-F1-2	Unconfined	1992	SS, Screen	115.5	110.9								N																	Not in or downgradient of any plume
199-F5-1	Unconfined	1948	CS, Perf	113.9	105.4	X	X		X			X	Y		X			A	S				A	S				B	B	Possible seasonal variation
199-F5-4	Unconfined[d]	1953	CS, Perf	116.0	94.6	X	X		X	X		X	Y		X	S	S	S		A	S	S	S		A	B	B	B		Possible seasonal variation
199-F5-42	Unconfined	1992	SS, Screen	114.7	108.6	X	X	X				X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-43A	Unconfined	1992	SS, Screen	114.7	108.6	X	X	X		X	X	X	Y		X	A		A	A	A	A		A	A	A	B		B	B	
199-F5-43B	RUM	1992	SS, Screen	76.3	73.3								N																	Monitors RUM; not in scope
199-F5-44	Unconfined	1992	SS, Screen	114.4	108.3	X	X	X				X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-45	Unconfined	1992	SS, Screen	115.3	110.6	X	X		X		X	X	Y		X	A	A	A			A	A	A			B	B	B		
199-F5-46	Unconfined	1992	SS, Screen	114.8	110.2	X	X		X			X	Y		X	S	S	S	S		S	S	S	S		B	B	B	B	Possible seasonal variation
199-F5-47	Unconfined	1992	SS, Screen	115.8	109.7	X	X		X			X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-48	Unconfined	1992	SS, Screen	115.7	111.1	X	X		X	X		X	Y		X	A	A	A		A	A	A	A		A	B	B	B		
199-F5-52	Unconfined	2010	SS, Screen	115.5	109.4	X	X	X	X		X	X	Y	X	X	A		A			A		A			B		B		
199-F5-53	RUM	2010	SS, Screen	96.1	93.1								N																	Monitors RUM; not in scope
199-F5-54	Unconfined	2010	SS, Screen	115.0	108.9	X	X		X			X	Y		X	A		A	A		A		A	A		B		B	B	
199-F5-55	Unconfined	2011	PVC, Screen	114.7	111.7	X	X		X			X	Y		X	A		A	S		A		A	S		B		B	B	Possible seasonal variation
199-F5-56	Unconfined	2011	PVC, Screen	115.3	112.2	X	X		X			X	Y		X	A	A	A	A		A	A	A	A		B	B	B	B	
199-F5-6	Unconfined[d]	1956	CS, Perf	116.4	104.5	X	X	X	X			X	Y		X	S		A	A		S		A	A		B		B	B	Possible seasonal variation
199-F6-1	Unconfined	1992	SS, Screen	114.5	108.6	X	X	X	X		X	X	Y	X	X	A		A	A		A		A	A		B		B	B	
199-F7-1	Unconfined	1956	CS, Perf	117.0	112.4	X	X		X		X	X	Y	X	X		A	A				A	A				B	B		Blank casing below perf'd interval; rehab
199-F7-2	Unconfined	1988	SS, Screen	116.1	111.3	X	X		X		X	X	Y	X	X		A	A				A	A				B	B		
199-F7-3	Unconfined	1992	SS, Screen	115.3	110.7	X	X		X			X	Y		X		A	A				A	A				B	B		
199-F8-2	Unconfined	1960	CS, Perf	123.2	110.1	X	X		X			X	Y		X	A			A		A			A		B			B	
199-F8-3	Unconfined	1992	SS, Screen	115.6	112.5								N																	Redundant with nearby wells
199-F8-4	Unconfined	1992	SS, Screen	114.4	111.3	X	X				X	X	Y	X	X			A					A					B		
199-F8-7	Unconfined	2008	SS, Screen	116.5	113.4	X	X		X	X		X	Y		X		A	A	A	A		A	A	A	A		B	B	B	

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Sample	Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4		Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
699-58-24	Unconfined	1971	CS, Perf	113.7	110.7		X				X		N		X															Far downgradient of nitrate plume; water levels only
699-59-32	Unconfined	1971	CS, Screen	110.5	107.5	X?	X?						?	X?	X?															Redundant with nearby well
699-60-32	RUM?	1971	CS, Screen	107.8	104.7	X	X				X	X	Y	X	X			A					A					B		Evaluate; 59-32 instead?
699-61-37	Unconfined	1971	CS, Screen	114.9	111.9						X		N	X	X															No monitoring objective; water levels only
699-62-31	Unconfined	1972	CS, Screen	109.9	106.9	X	X				X	X	Y		X			A					A					B		In south part nitrate plume
699-62-43F	Unconfined	1959	CS, Perf	125.2	110.6								N																	No monitoring objective
699-63-25A	Unconfined[d]	1949	CS, Perf	112.7	92.0	X	X				X	X	Y		X			A					A					B		Long perf interval; may need rehab
699-64-27	Unconfined	1974	CS, Perf	112.0	104.7	X	X				X	X	Y	X	X			A					A					B		
699-65-22	Unknown	Unknown	Galv, unkn										N																	Redundant with nearby well
699-66-23	Unconfined[d]	1961	CS, Perf	113.5	95.2	X	X	X			X	X	Y	X	X			A					A					B		Long perf interval; may need rehab
699-66-38	Unconfined[d]	1962	CS, Perf	125.1	111.1								N																	Monitors mud; not in scope
699-66-39	Unconfined[d]	1971	CS, Perf	126.7	118.5								N																	Monitors mud; not in scope
699-67-51	Unconfined[d]	1962	CS, Perf	130.4	84.7								N																	No monitoring objective; Host well with piezometers
699-69-38	Unknown	Unknown	ABS, unkn										N																	ABS casing in cement well; no monitoring objective
699-69-45	Unconfined[d]	1961	CS, Perf	125.0	58.0								N																	No monitoring objective; host well with piezometers
699-70-23	Unknown	Unknown	CS, unkn								X		N	X	X															Redundant with nearby well for sampling; water levels only
699-71-30	Unconfined[d]	1957	CS, Perf	115.1	96.5	X	X				X	X	Y	X	X		A	A				A	A				B	B		Long perf interval; may need rehab
699-71-52	Unconfined	1954	CS, Perf	123.9	111.7								N																	No monitoring objective
699-74-44	Unconfined	1957	CS, Perf	131.1	115.9		X				X		N		X															No monitoring objective; water levels only
699-77-36	Unconfined[d]	1957	CS, Perf	116.4	101.2	X	X				X	X	Y	X	X		A	A				A	A				B	B		Long perf interval; may need rehab
699-77-54	Unconfined	1957	CS, Perf	125.8	111.5								N																	No monitoring objective
699-80-43P	Lower Mud/ Basalt Top	1965	CS, Screen	-5.5	-8.5								N																	Monitors mud; not in scope

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Sample	Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4		Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
699-80-43S	Unknown	1965	CS, Screen	117.7	111.6								N																	No monitoring objective; piezometer; uncertain completion
699-81-38	Unconfined	Unknown	Galv, unkn										N																	No monitoring objective; strange and uncertain construction
699-83-47	Unconfined	1957	CS, Perf	122.5	107.3								N																	No monitoring objective
699-84-34B	Basalt	1981	Unknown										N																	Artesian well (basalt); not in scope
699-86-42	Unconfined	Unknown	Galv, unkn	125.9	117.9								N																	No monitoring objective
699-87-42A	Unconfined	Unknown	Galv, unkn	128.0	117.7								N																	No monitoring objective
PHASE 1 NEW WELLS																														
C9472	Unconfined	FY16	SS, Screen			X	X				X	X	Y		X		Q	Q				A	A				B	B		
C9474	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
C9475	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X		Q	Q				A	A				B	B		
C9476	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X		Q	Q				A	A				B	B		
C9477	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
C9478	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X			Q					A					B		
C9479	Unconfined	FY16	SS, Screen			X	X				X	X	Y	X	X			Q					A					B		
C9480	Unconfined	FY16	SS, Screen			X	X	X			X	X	Y	X	X			Q					A					B		
PHASE 2 NEW WELLS (temporary well names)																														
FIU-A	Unconfined	TBD	SS, Screen										Y																	
FIU-B	Unconfined	TBD	SS, Screen										Y																	
FIU-C	Unconfined	TBD	SS, Screen										Y																	
FIU-D	Unconfined	TBD	SS, Screen										Y																	
FIU-E	Unconfined	TBD	SS, Screen										Y																	
FIU-F	Unconfined	TBD	SS, Screen										Y																	
AQUIFER SAMPLING TUBES																														
59-D	Unconfined	1997	Poly, mesh	108.0	107.8								N																	No monitoring objective
59-M	Unconfined	1997	Poly, mesh	109.8	109.7								N																	No monitoring objective

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4	Sample	Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
59-S	Unconfined	1997	Poly, mesh	111.5	111.4								N																No monitoring objective
60-D	Unconfined	1997	Poly, mesh	106.9	106.8								N																No monitoring objective
60-M	Unconfined	1997	Poly, mesh	109.7	109.5								N																No monitoring objective
60-S	Unconfined	1997	Poly, mesh	112.4	112.3								N																No monitoring objective
61-D	Unconfined	1997	Poly, mesh	106.9	106.8								N																No monitoring objective
61-M	Unconfined	1997	Poly, mesh	109.7	109.5								N																No monitoring objective
61-S	Unconfined	1997	Poly, mesh	112.5	112.3								N																No monitoring objective
62-M	Unconfined	1997	Poly, mesh	109.8	109.6								N																No monitoring objective
62-S	Unconfined	1997	Poly, mesh	112.7	112.6								N																Single depth sufficient
63-D	Unconfined	1997	Poly, mesh	108.1	107.9								N																Redundant with nearby tubes
63-M	Unconfined	1997	Poly, mesh	110.2	110.1								N																Redundant with nearby tubes
63-S	Unconfined	1997	Poly, mesh	112.0	111.9								N																Redundant with nearby tubes
64-D	Unconfined	1997	Poly, mesh	106.8	106.7								N																Single depth sufficient
64-M	Unconfined	1997	Poly, mesh	109.9	109.7	X		X					Y			A		A	A		A		A	A		B		B	B	
64-S	Unconfined	1997	Poly, mesh	113.1	112.9								N																Single depth sufficient
66-D	Unconfined	1997	Poly, mesh	105.9	105.7								N																No monitoring objective
66-M	Unconfined	1997	Poly, mesh	108.6	108.4								N																No monitoring objective
66-S	Unconfined	1997	Poly, mesh	111.4	111.2								N																No monitoring objective
67-M	Unconfined	1997	Poly, mesh	108.8	108.7								N																No monitoring objective
67-S	Unconfined	1997	Poly, mesh	111.9	111.7								N																No monitoring objective
68-D	Unconfined	1997	Poly, mesh	107.8	107.7								N																No monitoring objective
68-M	Unconfined	1997	Poly, mesh	109.9	109.7								N																No monitoring objective
68-S	Unconfined	1997	Poly, mesh	112.3	112.1								N																No monitoring objective
69-D	Unconfined	1997	Poly, mesh	110.4	110.3								N																No monitoring objective
72-D	Unconfined	1997	Poly, mesh	103.6	103.5								N																No monitoring objective
72-M	Unconfined	1997	Poly, mesh	106.7	106.5								N																No monitoring objective

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Sample	Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4		Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
72-S	Unconfined	1997	Poly, mesh	109.3	109.1								N																	No monitoring objective
74-D	Unconfined	1997	Poly, mesh	103.3	103.1								N																	No monitoring objective
74-M	Unconfined	1997	Poly, mesh	106.9	106.8								N																	No monitoring objective
75-D	Unconfined	1997	Poly, mesh	103.9	103.7								N																	No monitoring objective
75-M	Unconfined	1997	Poly, mesh	106.3	106.2								N																	No monitoring objective
75-S	Unconfined	1997	Poly, mesh	108.8	108.6								N																	No monitoring objective
76-D	Unconfined	1997	Poly, mesh	104.5	104.3								N																	No monitoring objective
76-M	Unconfined	1997	Poly, mesh	106.3	106.2								N																	No monitoring objective
76-S	Unconfined	1997	Poly, mesh	108.8	108.6								N																	No monitoring objective
77-D	Unconfined	1997	Poly, mesh	104.1	103.9								N																	No monitoring objective
77-M	Unconfined	1997	Poly, mesh	106.5	106.4								N																	No monitoring objective
77-S	Unconfined	1997	Poly, mesh	108.9	108.8								N																	No monitoring objective
80-D	Unconfined	1997	Poly, mesh	104.2	104.0								N																	No monitoring objective
AT-F-1-D	Unconfined	2004	Poly, mesh	106.8	106.6								N																	Redundant with nearby tubes
AT-F-1-M	Unconfined	2004	Poly, mesh	109.2	109.1								N																	Redundant with nearby tubes
AT-F-1-S	Unconfined	2004	Poly, mesh	111.6	111.5								N																	Redundant with nearby tubes
AT-F-3-D	Unconfined	2004	Poly, mesh	108.4	108.2								N																	Redundant with nearby tubes
AT-F-3-M	Unconfined	2004	Poly, mesh	109.4	109.2								N																	Redundant with nearby tubes
AT-F-3-S	Unconfined	2004	Poly, mesh	110.8	110.6								N																	Redundant with nearby tubes
AT-F-4-D	Unconfined	2004	Poly, mesh	102.3	102.1								N																	Redundant with nearby tubes
AT-F-4-M	Unconfined	2004	Poly, mesh	106.6	106.5								N																	Redundant with nearby tubes
AT-F-4-S	Unconfined	2004	Poly, mesh	109.9	109.8								N																	Redundant with nearby tubes
C6302	Unconfined	2008	Poly, mesh	111.3	111.1	X		X					Y			A		A	A		A		A	A		B		B	B	
C6303	Unconfined	2008	Poly, mesh	109.4	109.3	X		X					Y			A		A			A		A			B		B		
C6305	Unconfined	2008	Poly, mesh	111.1	111.0								N																	Single depth sufficient
C6306	Unconfined	2008	Poly, mesh	109.4	109.2	X		X					Y			A		A	A		A		A	A		B		B	B	

Table 6. Monitoring Wells, Aquifer Sampling Tubes, and Seeps Considered for 100-FR-3 Monitoring Network

Well Name	Screened Unit	Year Installed	Casing and Screen Type	Elevation Top Screen or Perf (m)	Elevation Bottom Screen or Perf (m)	Rationale							Sample	Wtr Lvl		Yr 1 Frequency					Yr 2 to 5 Frequency					Yr 6+ Frequency[b]				Rationale for Not Monitoring, or Other Comment
						PSQ 1a, 1b	PSQ 1c	PSQ 1d	PSQ 1e	PSQ 2	PSQ 3	PSQ 4		Automated	Manual [a]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	Trace Metals[c]	Cr(VI)	TCE & Deg. Prod.	Nitrate	Sr-90	
C6307	Unconfined	2008	Poly, mesh	108.6	108.4								N																	Single depth sufficient
C6308	Unconfined	2008	Poly, mesh	111.0	110.8								N																	Single depth sufficient
C6309	Unconfined	2008	Poly, mesh	108.9	108.7	X		X					Y			A		A	A		A		A	A		B		B	B	
C6311	Unconfined	2008	Poly, mesh	110.8	110.7								N																	Redundant with nearby tubes
C6312	Unconfined	2008	Poly, mesh	108.9	108.7								N																	Redundant with nearby tubes
C6314	Unconfined	2008	Poly, mesh	111.1	110.9								N																	Single depth sufficient
C6315	Unconfined	2008	Poly, mesh	109.0	108.9	X		X					Y			A		A	A		A		A	A		B		B	B	
C6316	Unconfined	2008	Poly, mesh	106.3	106.2								N																	Single depth sufficient
SEEPS																														
Seep 207-1	Shoreline	N/A	N/A	N/A	N/A								N																	No monitoring objective
Seep 187-1	Shoreline	N/A	N/A	N/A	N/A	X		X					Y			A		A			A		A			B		B		
RIVER STAGE																														
100-F gauge	River Stage						X	X			X			X																

Note: “X?” and “N?” indicate contingency wells. If evaluation indicates that 699-60-32 does not monitor the unconfined aquifer, 699-59-32 will be sampled instead. If 699-60-32 monitors the unconfined aquifer, then 699-59-32 will be used for water levels only.

a. Manual measurements three times per year at low, moderate, and high river stages.

b. Frequency will be evaluated during year 5; assume biennial for planning purposes.

c. Monitoring for trace metals will cease after eight independent samples have concentrations below action levels or practical quantitation limits.

d. Monitors unconfined aquifer and >1 m of the RUM.

A = to be sampled annually
B = to be sampled biennially (every other year)
Cr(VI) = hexavalent chromium
CS, Perf = carbon steel casing, perforated casing
FY = fiscal year
Galv, unkn = galvanized metal casing; unknown material screen
N or Y in sample column = no (not sampled) or yes (sampled)
N/A = not applicable
Poly, mesh = flexible polyethylene tubing with stainless steel mesh screen
PSQ = principal study question
PVC = polyvinyl chloride casing and screen
Q = to be sampled quarterly
RUM = Ringold upper mud unit
S = to be sampled semiannually (twice per year)
Sr-90 = strontium-90
Wtr Lvl = water level
Yr = year
SS, Screen = stainless steel casing and screen
TBD = to be determined
TCE & Deg Prod = trichloroethene and degradation products
Trace Metals = antimony, cadmium, and cobalt

Table 7. 100-F Wells with Action Level Exceedances for Trace Metals

Antimony (5.6 µg/L)		Cadmium (0.25 µg/L[a,b])		Cobalt (4.8 µg/L)	
Well	**Result, Method**	**Well**	**Result, Method**	**Well**	**Result, Method**
199-F5-4	51.7, 6010	None	None	199-F5-43A	13.1 C, 6010
199-F5-4	43.6 C Y, 6010			199-F5-43A	11.6 C, 6010
199-F8-7	34.8 B, 6010			199-F5-44	12.1 C, 6010
				199-F5-44	12.7 C, 6010
				199-F5-48	9 B, 6010

Note: Highlighted wells selected for further analysis of antimony, cadmium, and cobalt.

a. Applies to river.

b. Only 114 of 370 results had detection limits below the 0.25 µg/L action level. Thus, cadmium is included despite no exceedances.

B = below required detection limit and above method detection limit

C = blank contamination

Y = suspected error

Table 8. Assumed Number of Wells for Attainment Monitoring

COC	Number of Wells[a]	Number Samples[b]	Total Samples
Hexavalent Chromium	10	11	110
Nitrate	20	11	220
Strontium-90	7	11	77
Trichloroethene	10	11	110

a. Assumed to be approximately half the number of wells sampled for the COC before cleanup levels achieved. Excludes aquifer tubes and seeps.

b. Assume quarterly sampling for 2 years and annual sampling for 3 years.

COC = contaminant of concern

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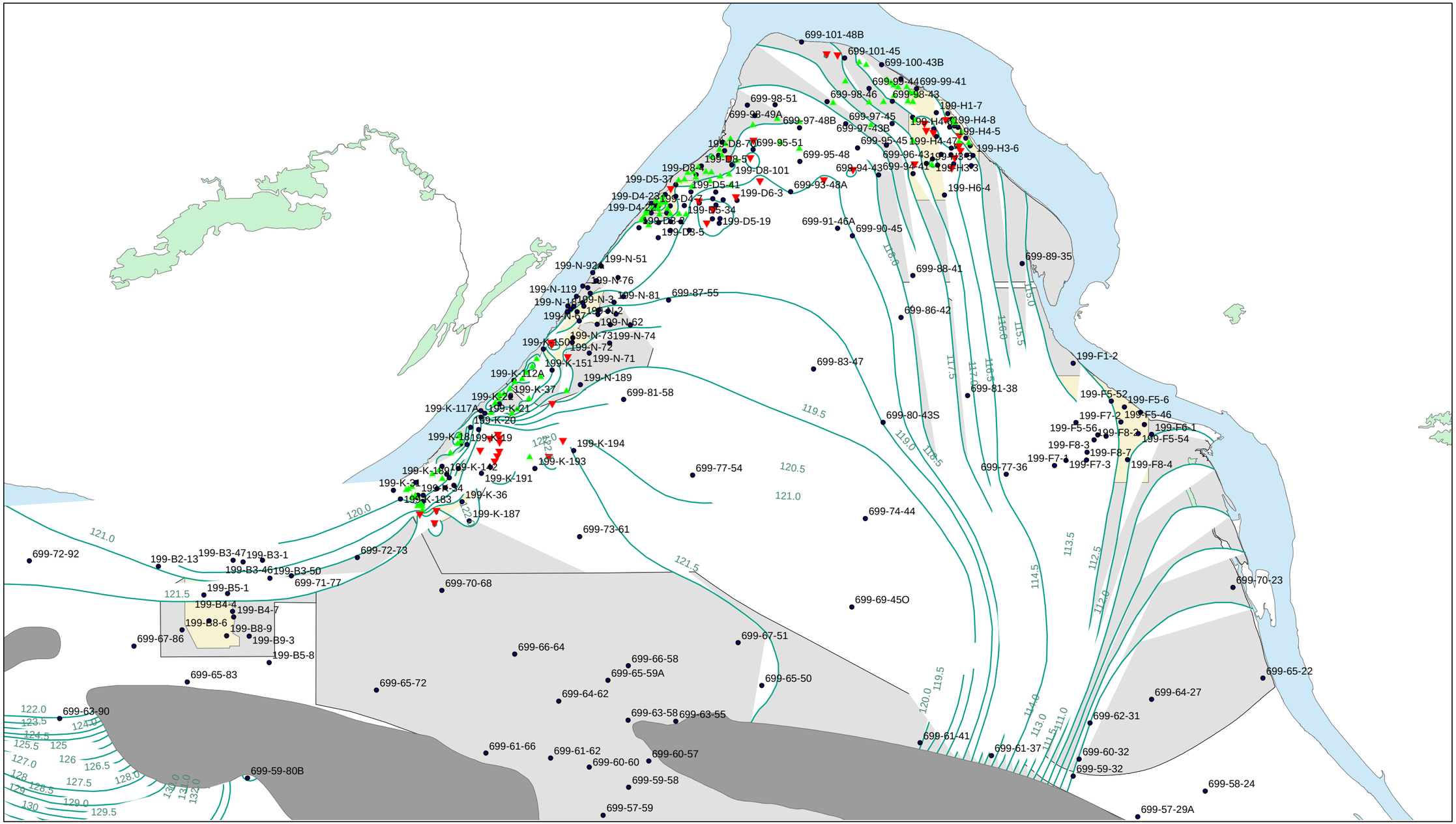

Figure 1. March 2014 Water Table in the Northern Portion of the Hanford Site (Showing Wells Used to Interpret Water Table)

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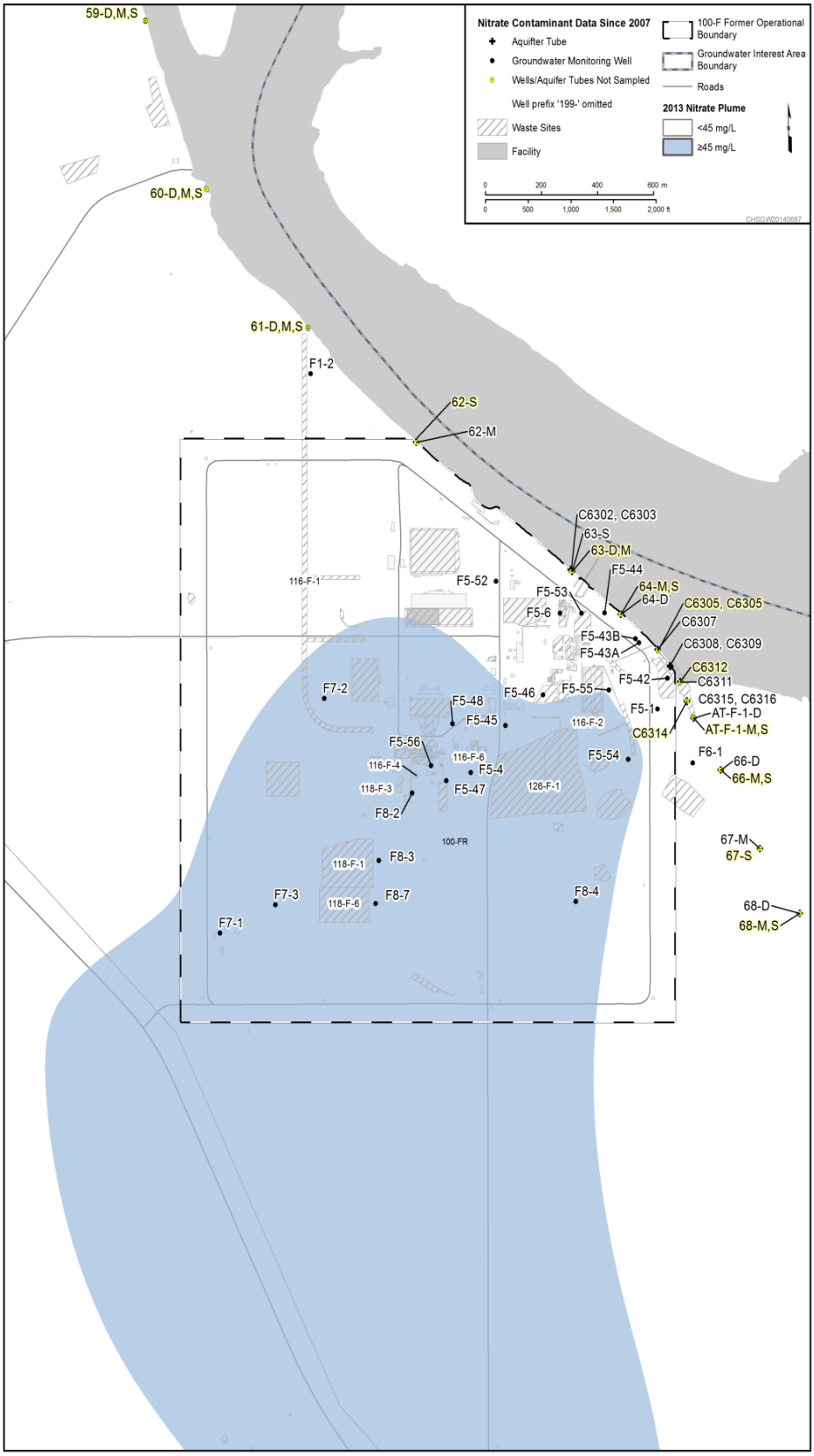

Figure 2. 2013 Nitrate Plume (with Wells Sampled for Nitrate since 2007)

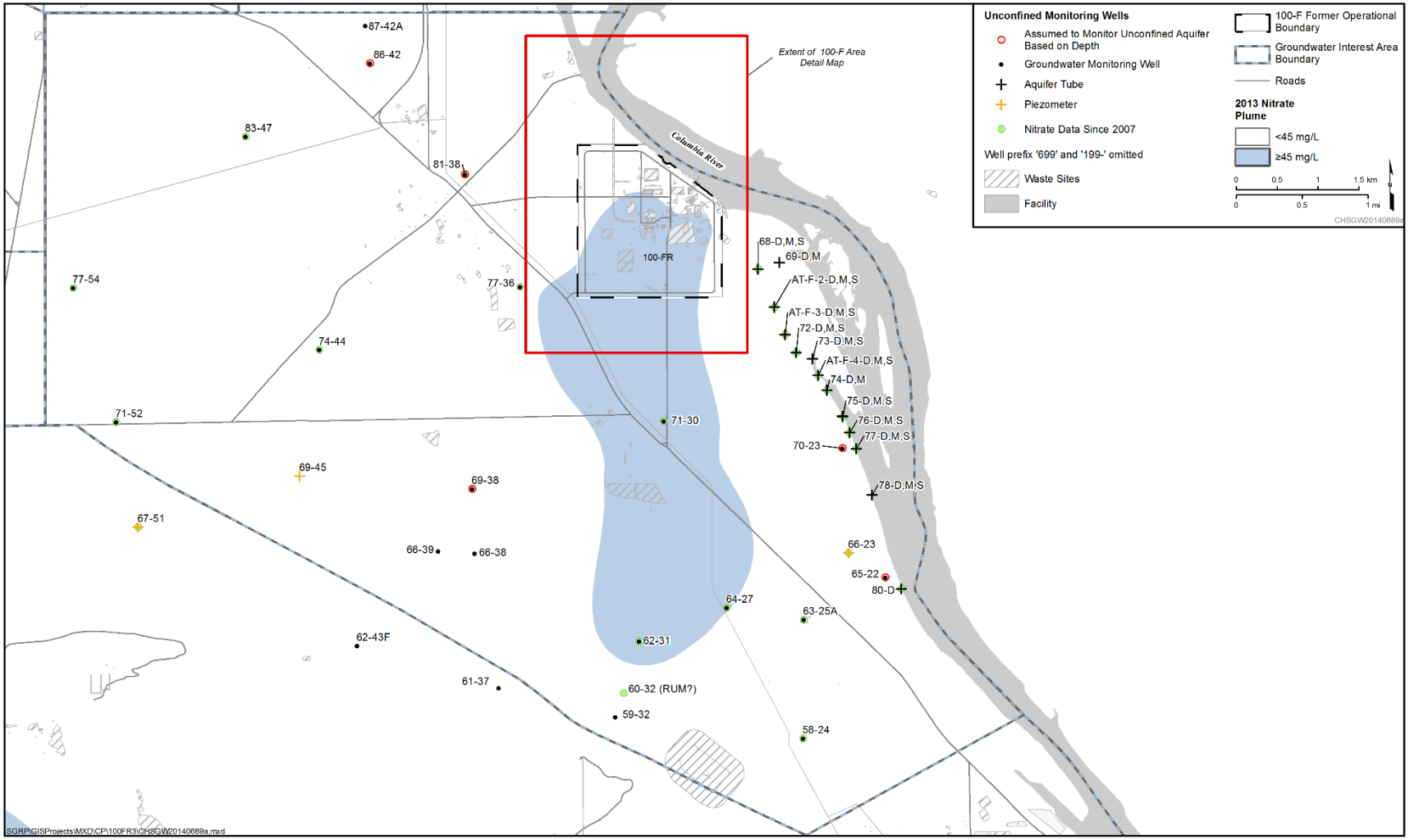

Figure 3. Available Unconfined Aquifer Monitoring Wells in the 600 Area Near 100-F (with 2013 Nitrate Plume)

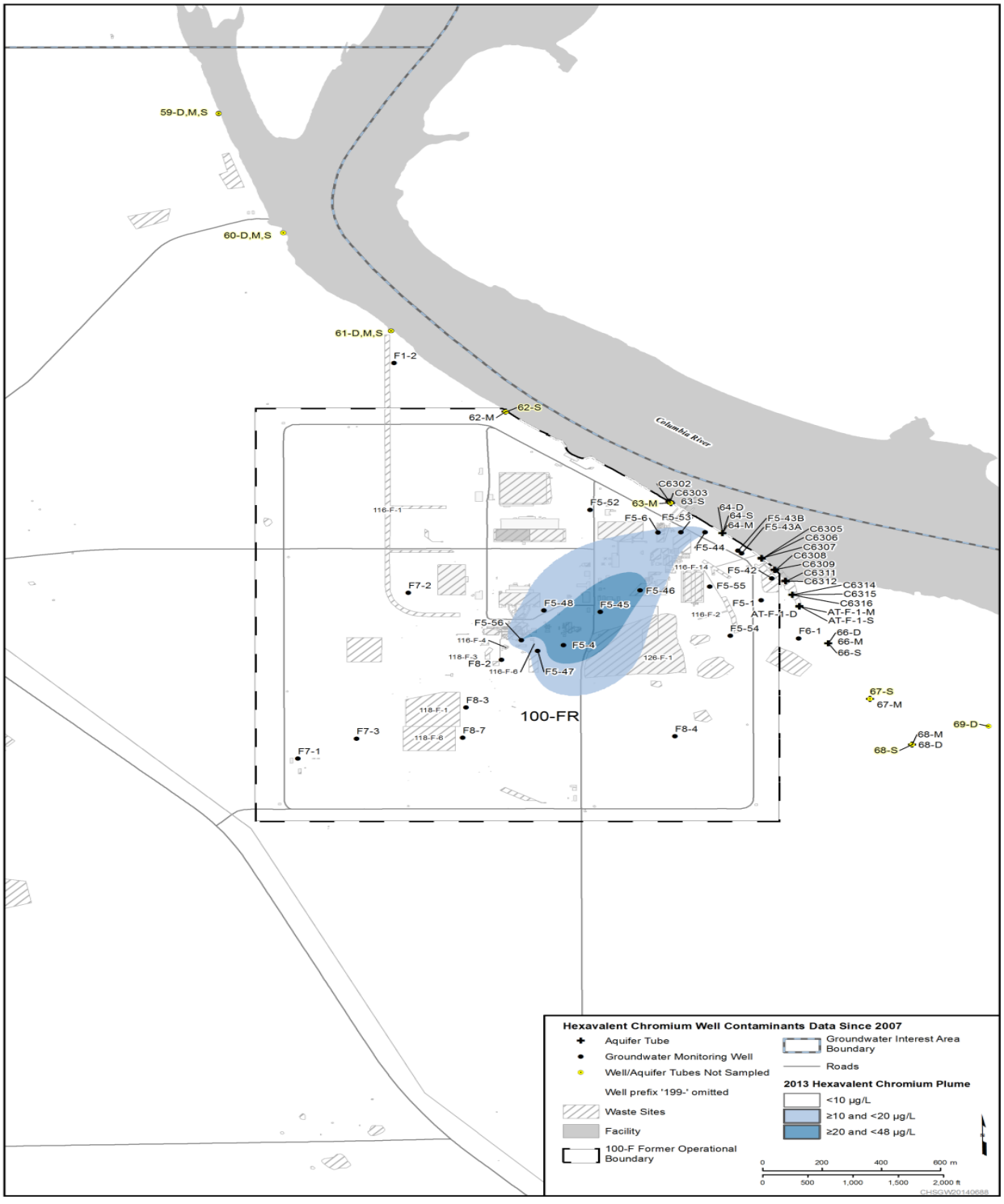

Figure 4. 2013 Chromium Plume (with Wells Sampled for Chromium since 2007)

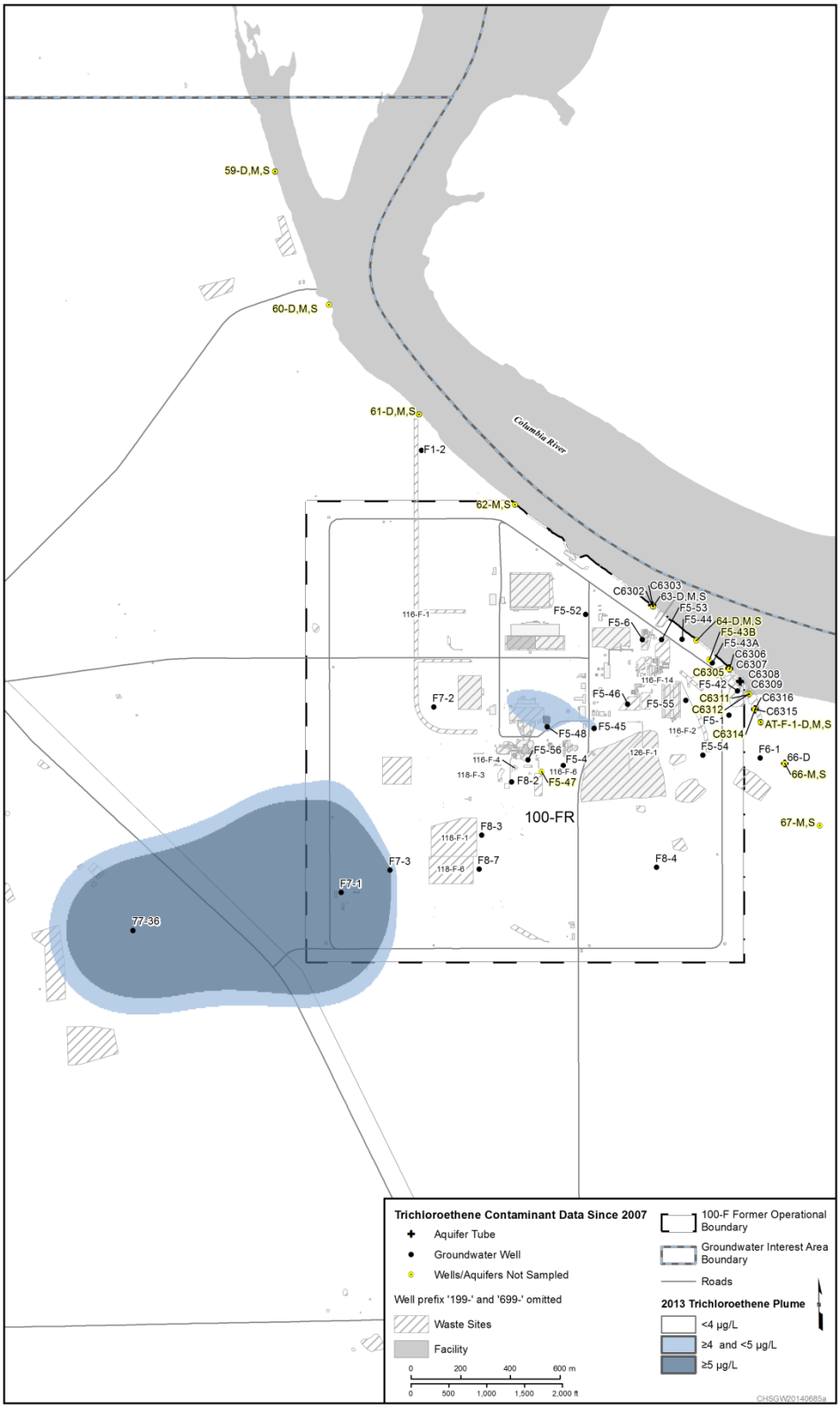

Figure 5. 2013 Trichloroethene Plume (with Wells Sampled for TCE since 2007)

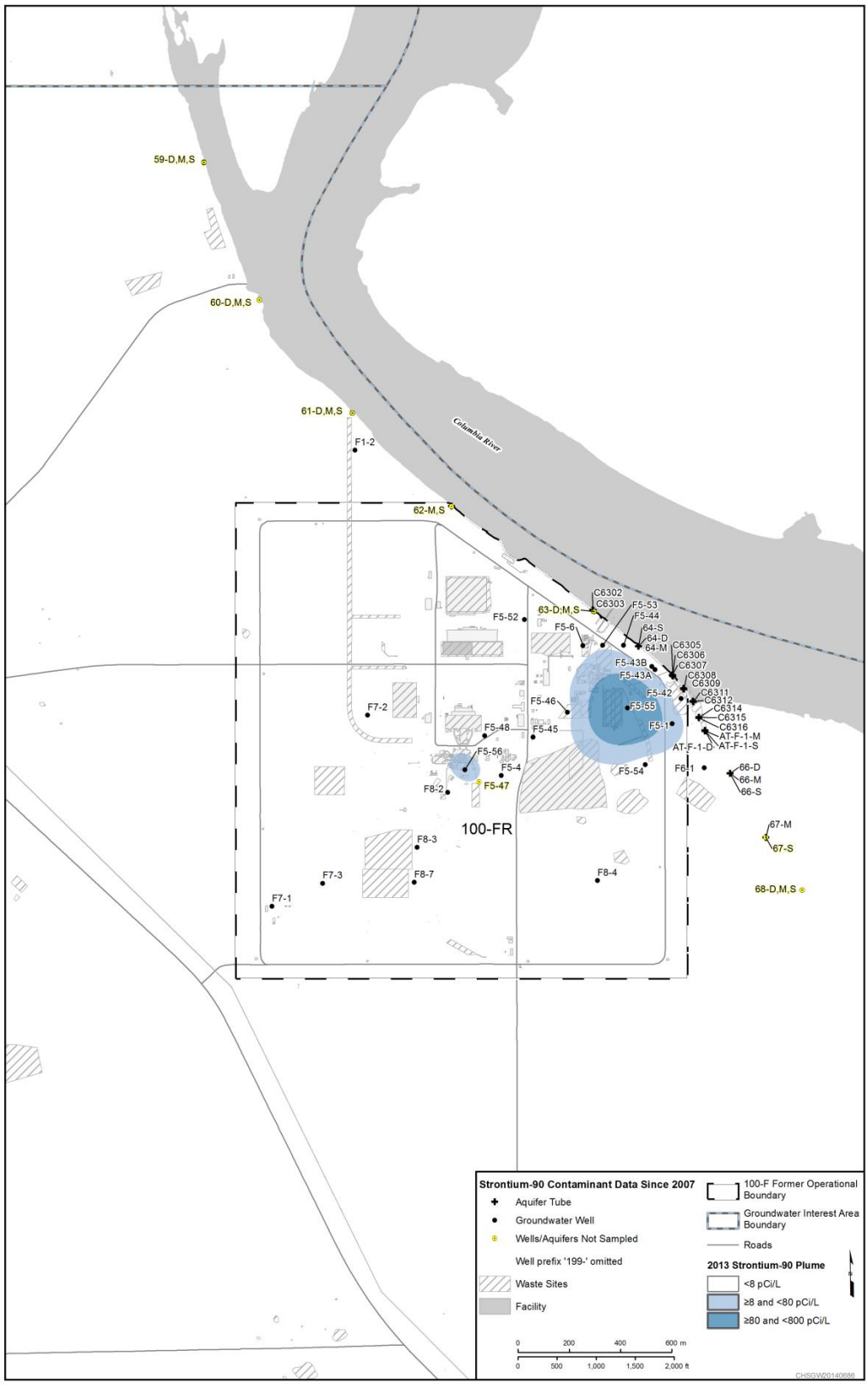

Figure 6. 2013 Stronium-90 Plume (with Wells Sampled for Strontium-90 since 2007)

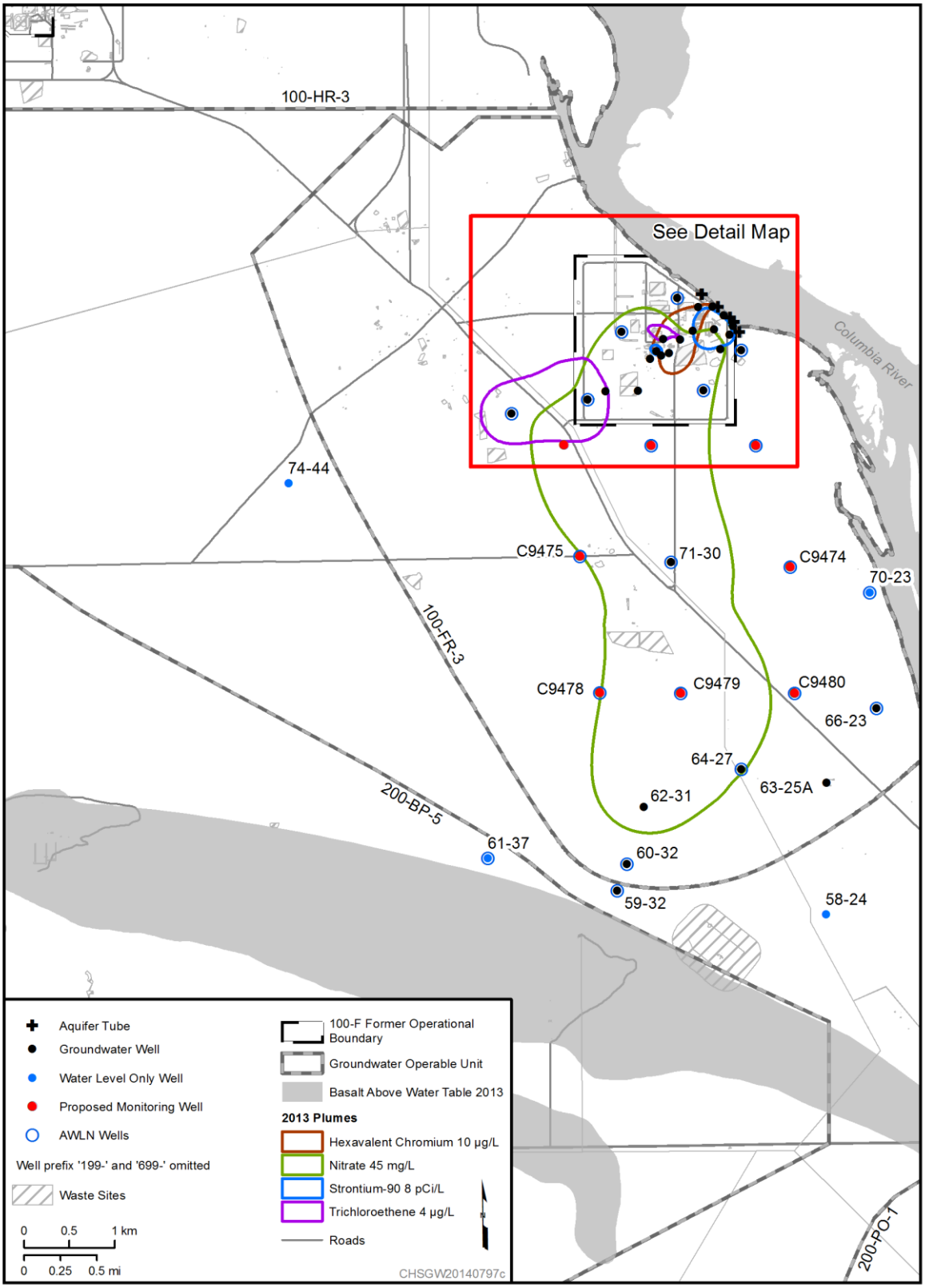

Figure 7. Proposed Monitoring Network, Including New Well Locations (Phase 1)

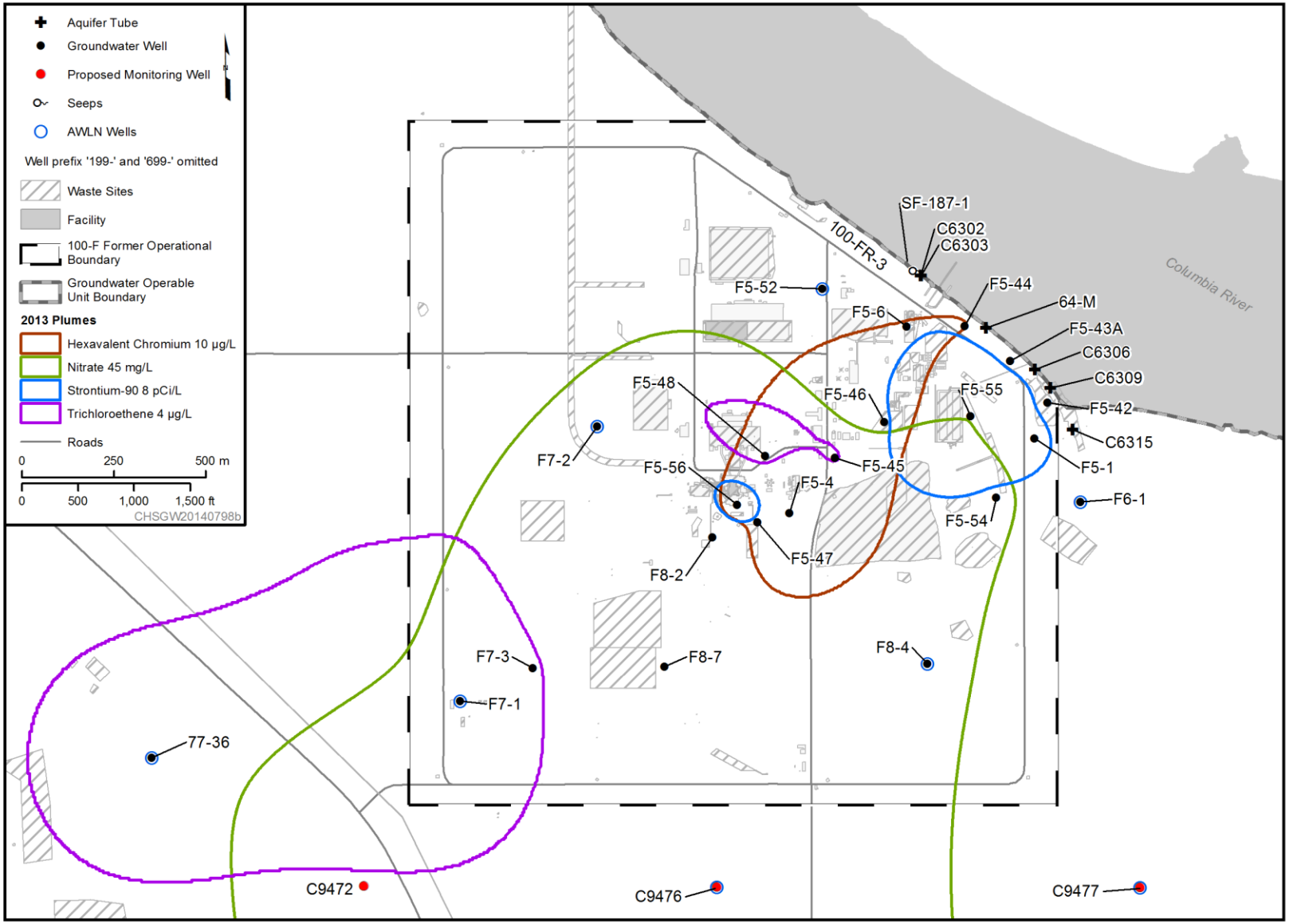

Figure 8. Proposed Monitoring Network (100-F Area Detail)

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