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Preparing Environmental Information for Transition to Long Term Stewardship

Preserving the Data, the Decisions, and the Legacy

November 2026

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REMPLEX
CENTER FOR THE REMEDIATION OF COMPLEX SITES
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Summary

As Department of Energy (DOE) sites transition from active remediation to long-term stewardship and maintenance (LTS&M), a consistent challenge is emerging: while physical infrastructure, monitoring programs, and organizational responsibilities may be ready for transfer, environmental data often is not. Environmental information accumulated over decades of characterization, remediation, and monitoring is frequently distributed across multiple databases, spreadsheets, geographic information system platforms, legacy applications, individual staff work products, electronic data storage locations, document repositories, and contractor-specific systems. Critical workflows, technical assumptions, and decision rationale may exist only in the experience of a small number of subject matter experts, creating significant risk as stewardship responsibilities change.

This challenge is not the result of a lack of policy. Federal law, DOE directives, records management requirements, and federal data governance initiatives establish clear expectations that environmental information must remain accessible, understandable, reliable, and usable throughout its lifecycle. DOE Office of Legacy Management guidance further emphasizes the importance of transferring not only environmental records, but also the information necessary to support LTS&M and informed decision-making.

This report does not establish new policy or introduce new requirements. Instead, it translates existing DOE, U.S. Army Corps of Engineers, National Archives and Records Administration, Office of Management and Budget, and federal data governance guidance into practical actions that organizations can implement today to improve transition readiness. Its focus is on execution—helping organizations prepare environmental information before transition activities accelerate.

Successful transition requires more than preserving records. It requires ensuring that future stewards can confidently access, understand, trust, and use environmental information to support long-term surveillance, maintenance, regulatory compliance, and informed decision-making. More importantly, it requires preserving the scientific context behind the data—including metadata, conceptual site models, groundwater model assumptions, technical rationale, workflow documentation, and decision history—so that future organizations understand not only **what** was done, but **why** it was done.

This report presents a practical framework built around eight actions that improve environmental data readiness:

- Establish data readiness as a formal transition workflow.
- Consolidate environmental information into clearly defined authoritative data sources/systems.
- Standardize data structures, formats, and metadata at DOE enterprise level or higher.
- Preserve the knowledge behind the data through documentation and knowledge capture.
- Replace manual processes with repeatable and sustainable workflows.
- Validate and characterize data prior to transition.
- Create standardized data turnover packages.
- Manage data transition as a formal project with defined deliverables and accountability.

Together, these actions preserve the environmental information, scientific understanding, and operational knowledge needed to sustain DOE's long-term stewardship mission across organizational and personnel transitions. By making data accessible, reliable, interpretable, and supported by documented technical rationale, sites equip future stewards to maintain remedies, use the latest available technologies for efficient and effective analysis, demonstrate continued protection of human health and the environment, meet regulatory obligations, and respond to changing site conditions. Early preparation reduces the risk of transition delays, costly reconstruction of historical knowledge, and disruption to monitoring and reporting. The overarching mission benefit is continuity of informed, defensible stewardship that protects both cleanup investments and the communities and environments those investments serve.

Importantly, the same activities that improve environmental data readiness for LTS&M also position organizations to take advantage of advanced analytics, automation, and artificial intelligence. Regardless of whether these capabilities are applied at the site, program, or DOE enterprise level, they depend on trusted data, standardized structures, documented workflows, metadata, and effective governance. Investments made to support transition readiness therefore provide value beyond stewardship by creating the information foundation needed for future innovation.

Ultimately, successful stewardship depends on more than maintaining physical assets and preserving records. It depends on ensuring that future generations inherit the ability to understand, defend, and build upon decades of environmental science. By intentionally leaving breadcrumbs through documentation, metadata, technical rationale, and well-defined workflows, today's organizations create a lasting legacy that enables tomorrow's stewards to understand not only what was done, but why—and to confidently continue the stewardship mission for decades to come.

Acknowledgments

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While this report reflects the ideas, experience, and perspectives of many colleagues, any interpretations, recommendations, or typographical errors remain solely the responsibility of the report authors.

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[1] https://www.pnnl.gov/remplex

Acronyms and Abbreviations

CSM	conceptual site model
DOE	Department of Energy
EPA	Environmental Protection Agency
FUSRAP	Formerly Utilized Sites Remedial Action Program
GIS	geographical information system
ITRC	Interstate Technology & Regulatory Council
LM	Office of Legacy Management
LTS&M	long-term stewardship and maintenance
ML	machine learning
NARA	National Archives and Records Administration
NNLEMS	Network of National Laboratories for Environmental Management and Stewardship
OCIO	Office of the Chief Information Officer
OMB	Office of Management and Budget
PNNL	Pacific Northwest National Laboratory
RemPlex	PNNL Center for the Remediation of Complex Sites
QA	quality assurance
QC	quality control
USACE	U.S. Army Corps of Engineers

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1.0 Introduction – Transitioning to Long-Term Stewardship

For decades, Department of Energy (DOE) sites have generated and managed vast amounts of environmental information to support characterization, remediation, monitoring, regulatory compliance, and risk management activities as part of waste site environmental management responsibilities. As a site looks to transition from an environmental cleanup mission to long-term stewardship and maintenance (LTS&M), that transition process is often viewed as the transfer of responsibility from one organization to another. In practice, however, successful transition depends on something much more fundamental: the transfer of environmental information, scientific understanding, and long-term accountability. Groundwater and surface water monitoring results, laboratory analytical data, geospatial information, engineering records, remedial action documentation, groundwater models, conceptual site models, and regulatory correspondence collectively become the foundation upon which future stewardship decisions are made. That is, for transition from cleanup to LTS&M, data is the deliverable and meeting that deliverable requires appropriate planning and preparation to preserve the data and the historical decision-making context.

As sites move towards the process of transitioning to LTS&M, physical infrastructure and operational programs often receive significant attention. Environmental monitoring networks are evaluated, land use controls are documented, maintenance responsibilities are defined, and contractual obligations are transferred. Yet the environmental information that future stewards will rely upon to understand site conditions, demonstrate environmental protectiveness, support regulatory decisions, and manage long-term monitoring frequently receives less focused attention until late in the transition process.

This reduced attention creates a common challenge. Over years or decades of operation, environmental information often becomes distributed across multiple databases, spreadsheets, geographical information system (GIS) platforms, legacy applications, individual staff work products, electronic data storage locations, document repositories, and contractor-specific systems. Reporting processes may depend on undocumented workflows or manual calculations. Critical assumptions, historical decisions, and technical rationale may exist only in the experience of a few subject matter experts. While these conditions may be manageable during active operations, they create increasing risk as organizations prepare to transfer stewardship responsibilities.

Guidance [DOE-LM 2023, 2026a] from the DOE Office of Legacy Management (LM)[2] emphasizes that successful transition depends not only on transferring records, but also on preserving the environmental information, documentation, and context necessary for that information to remain complete, accessible, understandable, and usable throughout the stewardship lifecycle. Future organizations must be able to understand site history, evaluate environmental conditions, reproduce historical analyses, support regulatory obligations, and confidently continue stewardship activities without relying on the personnel who originally developed the program.

This expectation fundamentally changes how environmental information should be viewed. Environmental data is not simply a byproduct of site activities—it is a long-term stewardship

[2] DOE Office of Legacy Management: https://www.energy.gov/lm/office-legacy-management

asset and a foundational deliverable transferred to future organizations. Future stewards must be able to locate information, understand its meaning, evaluate its quality, reproduce historical analyses, and explain the technical decisions that shaped the site's stewardship strategy. Achieving this objective requires more than preserving records—it requires preserving scientific context, technical rationale, metadata, documentation, and the relationships between datasets. Even then, organizations should recognize that no amount of documentation can fully recreate the understanding that exists while a program is active. Knowledge naturally evolves and dwindles over time as personnel retire, move on, and memories fade. The goal is not to capture everything, but to preserve enough context that a future steward—perhaps decades from now—can open an environmental database, review historical reports, or search archived project files and reconstruct not only the environmental data itself, but also the thinking, assumptions, and scientific reasoning behind the decisions that shaped the site.

Organizations that recognize this need for data and context early can approach transition deliberately and systematically. They can assess data readiness, improve data quality, document critical knowledge, establish governance processes, and implement sustainable workflows while the individuals who understand the data are still available. Organizations that delay these efforts often face compressed schedules, increased costs, competing priorities, and a greater risk of transferring unresolved challenges to future stewards.

Federal law, DOE guidance, records management requirements, and data governance principles already establish clear expectations for how environmental information should be managed throughout its lifecycle. The challenge for organizations working on transition is no longer determining **what** is required—it is determining **how** to translate those expectations into practical, repeatable activities that prepare environmental information for successful long-term stewardship.

This report discusses what data readiness means in the context of transition to LTS&M, covers why environmental data is a strategic asset, identifies common data readiness challenges, then translates data management expectations into practical activities that prepare environmental information for long-term use. A practical framework built around eight actions that improve environmental data readiness is proposed for adoption by sites. And finally, this report discusses how readiness for LTS&M complements readiness for evolving advanced analytics to make the process future ready.

2.0 What "Ready for LTS&M" Actually Means

Federal law, DOE policy, records management requirements, and DOE-LM guidance collectively define what readiness for LTS&M should look like. The challenge for many organizations is not determining **what** is required—it is translating those expectations into practical activities that prepare environmental information for long-term use.

Federal records management and data governance principles recognize that information must be managed throughout its lifecycle to preserve its accessibility and usability. DOE policy reinforces these principles through records management requirements, data governance initiatives, information technology strategies, and transition planning guidance.

Building on these principles, Figure 1 presents an environmental information lifecycle developed for this report to illustrate how environmental information can be managed from collection through transfer and LTS&M. DOE-LM's *Transition and Transfer Guidance for FUSRAP Sites* and its accompanying data needs list [DOE-LM 2023], along with the joint DOE-LM and U.S. Army Corps of Engineers (USACE) information transfer/transition protocol [DOE-LM and USACE 2023], provide guidance relevant to the information, documentation, and technical materials associated with transition to long-term stewardship.

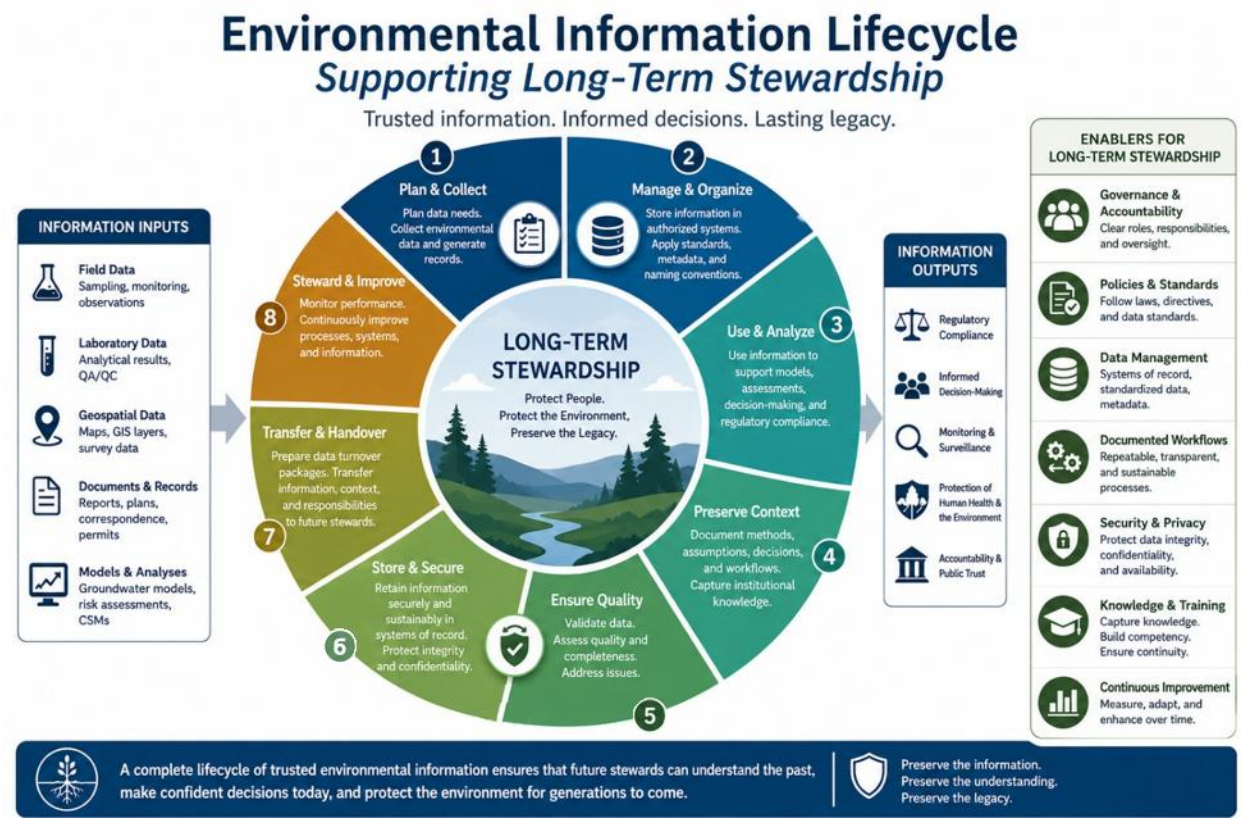


Figure 1. Environmental information lifecycle supporting long-term stewardship. The process takes information inputs, proceeds through lifecycle steps from 1 to 8, and produces the indicated information outputs, with a range of enablers supporting the process.

Key guidance describing the records lifecycle, records management, data governance, information technology, and transition planning includes:

- DOE Order 243.1D – Records Management Program [DOE 2026]
- DOE FY25-28 Enterprise Data Strategy [DOE 2025]
- DOE-LM *Transition and Transfer Guidance for FUSRAP Sites* , including the data needs list in Appendix E [DOE-LM 2023]
- DOE-LM *Site Management Guide* [DOE-LM 2026a]
- Federal Records Act [3]
- National Archives and Records Administration (NARA) Records Management Regulations and Guidance [4]
- Office of Management and Budget (OMB) Circular A-130 – *Managing Information as a Strategic Resource* [OMB 2016a, 2016b]
- Federal Data Strategy [OMB et al. 2019]

Collectively, these policies and guidance documents establish a consistent expectation that environmental information must remain accessible, interpretable, reliable, well-documented, and sustainable throughout its lifecycle. They also recognize that successful stewardship depends on preserving not only environmental records, but also the supporting information necessary to understand, interpret, and confidently use those records decades into the future.

For sites approaching transition to LTS&M, readiness extends well beyond retaining records or preserving existing software systems. Environmental information must be capable of supporting future stewardship activities independent of the personnel, contractors, software platforms, or organizational structures that originally created and maintained it. Receiving organizations should inherit not only the environmental data itself, but also the metadata, documentation, technical rationale, and contextual information needed to understand and confidently continue long-term stewardship activities.

A practical way to evaluate readiness is to consider whether a receiving organization could assume responsibility for the site and continue stewardship activities with minimal disruption. Future site managers should be able to locate information, understand its meaning, evaluate data quality, reproduce historical analyses, generate required reports, understand historical decisions, and support regulatory obligations without extensive reconstruction efforts or reliance on former project personnel.

In practical terms, site data is ready for LTS&M when:

- Data is not fragmented across uncontrolled systems.
- Authoritative data sources are clearly identified.
- Data can be understood and used without relying on undocumented program knowledge.
- Reporting processes are repeatable, transparent, and defensible.

[3] NARA. 2025. "*The Federal Records Act*." (website). National Archives and Records Administration, Washington, D.C. https://www.archives.gov/news/topics/federal-records-act

[4] NARA. 2026. "*Records Management Regulations and Guidance*." (website). National Archives and Records Administration, Washington, D.C. https://www.archives.gov/records-mgmt/policy

- Data meets established quality, documentation, and metadata standards.
- Environmental information can be separated from the software platform in which it resides without losing meaning, relationships, or utility.
- Data ownership, stewardship responsibilities, and governance processes are clearly established.
- Historical records, monitoring results, conceptual site models, and supporting documentation can be readily located and interpreted.
- Environmental information can support future decision-making without extensive manual intervention.

Conversely, a site's data may not be transition-ready when critical information is dispersed across multiple databases, spreadsheets, GIS platforms, legacy applications, individual staff work products, electronic data storage locations (local, network, cloud storage), document repositories, and contractor-specific systems. Undocumented technical rationales or workflows also contribute to lack of readiness. In these situations, future stewardship organizations may struggle to identify authoritative information sources, understand historical decisions, reproduce analyses, or demonstrate the technical basis supporting long-term stewardship activities.

One of the greatest transition risks is not that data are missing, it is that context is missing. Over time, organizations develop scientific understanding, technical assumptions, historical knowledge, and operational practices that may never be formally documented because they become part of normal day-to-day operations and practitioner knowledge. While this knowledge supports active remediation programs, it becomes increasingly vulnerable as personnel retire, contractors change, and organizations transition.

True readiness is achieved when environmental information can stand on its own—supported by sufficient documentation, metadata, governance, scientific context, and quality controls—to establish its continued usability regardless of future organizational, personnel, or technology changes.

3.0 Environmental Data as a Strategic Asset

Environmental data is often viewed as the final product of characterization, monitoring, remediation, and long-term surveillance activities. In reality, environmental data is a strategic organizational asset that supports regulatory compliance, protects human health and the environment, enables informed decision-making, and preserves the scientific foundation upon which future stewardship depends. As sites transition to LTS&M, environmental data becomes one of the most valuable assets being transferred.

The value of environmental data extends well beyond analytical laboratory results. Environmental information includes field observations, sampling locations, chain-of-custody records, quality assurance documentation, validation records, geospatial information, metadata, groundwater models, conceptual site models, engineering evaluations, technical memoranda, and historical reports. Together, these resources provide the context necessary for future organizations to understand, defend, and build upon decades of environmental work.

An often-overlooked component of transition readiness is preserving the knowledge that exists behind the data. While monitoring results may show changing groundwater conditions over time, they rarely explain why wells were installed or abandoned, why analytical methods changed, why conceptual site models evolved, or why one remediation alternative was selected over another. Similarly, groundwater models often preserve the final results, but not the assumptions, calibration decisions, interim analyses, or technical discussions that led to those results.

For transition to LTS&M, the objective is therefore not simply to preserve data, but to preserve enough supporting information and scientific context for future stewards to understand how the data was generated, interpreted, and used in decision-making. Years from now, a future steward may have access to all the environmental results collected for a site yet still need to answer a fundamental question: *Why was this remedy considered protective?* Preserving the context allows future stewards to reconstruct the scientific reasoning behind those decisions.

Managing environmental information as a strategic asset creates benefits that extend beyond transition. The characteristics that make environmental data usable for long-term stewardship—including standardized formats, documented workflows, complete metadata, robust governance, and high-quality information—also create the foundation for advanced analytics, predictive modeling, automation, and artificial intelligence. Organizations that invest in environmental data readiness are simultaneously preparing for the future of environmental decision support.

Ultimately, environmental data tells future stewards **what** happened. The knowledge behind the data explains **why** it happened. Successful long-term stewardship depends on preserving both as a strategic asset.

4.0 Common Data Readiness Challenges Observed During Transition

While every site is unique, many organizations encounter similar data management challenges as they prepare for LTS&M. These challenges are rarely the result of poor management or inadequate effort. Rather, they are often the natural consequence of decades of evolving regulatory requirements, changing contractors, technology transitions, and shifting program priorities.

Common challenges include:

- Environmental data distributed across multiple databases, spreadsheets, GIS platforms, legacy applications, individual staff work products, electronic data storage locations, document repositories, and contractor-specific systems
- Uncertainty regarding which datasets represent the authoritative data source
- Inconsistent naming conventions, location identifiers, and data formats
- Reporting processes dependent on manual manipulation or undocumented calculations/workflows
- Critical program knowledge residing with a small number of subject matter experts
- Incomplete metadata, data dictionaries, or system documentation
- Historical data that cannot be readily integrated with newer information systems
- Multiple versions of reports or datasets with no clear governance process
- Data quality issues that have accumulated over time but have not been systematically addressed

These challenges are not unique to any single site or program. In fact, they are among the most common obstacles encountered during transition planning efforts across both federal and commercial environmental programs.

The good news is that these challenges are typically manageable when identified early. By treating data readiness as a deliberate component of transition planning, organizations can systematically reduce risk and improve the usability of environmental information before stewardship responsibilities are transferred.

4.1 Example Data Readiness Gaps

Several examples illustrate potential issues when there are gaps in data readiness.

- During transition planning, organizations commonly discover a situation like having historical groundwater data that resides in one system, laboratory deliverables in another, GIS information in a third platform, and reporting logic existing only within analyst-maintained spreadsheets. While each system may function independently, the lack of integration and documentation can significantly complicate data transfer and long-term stewardship activities.
- Geospatial data, delivered without complete metadata, may hold multiple volume calculations or other analysis with insufficient context to interpret what they represent.

- Continuous monitoring data may be delivered without concrete reference to the precise location of each sensor, leaving the LTS&M team to be unable to construct an accurate picture of the monitored flows or other parameters.
- Data collected for a specific study, project, or regulatory requirement may lack the context needed for future interpretation. For example, vegetation studies may use local abbreviations rather than standardized classifications, or historical well logs may use terminology that does not align with current site documentation and formal stratigraphic nomenclature.

Each of these issues can be resolved with the right people connecting after transition, but all too often the people who knew the references or context are no longer available by the time the data comes to LTS&M.

5.0 From Guidance to Execution: What Sites Should Do Now

Organizations that begin preparing early for transition to LTS&M can systematically address data quality issues, fragmented systems, undocumented processes, and institutional knowledge dependencies before transition activities accelerate. Those that delay often find themselves conducting costly, resource-intensive cleanup efforts under compressed schedules.

The following actions provide a practical framework for translating federal requirements into measurable progress toward LTS&M readiness. While every site has unique operational and regulatory drivers, these activities represent foundational elements of a successful data transition strategy.

5.1 Establish Data as a Managed Transition Workflow

Environmental data is often treated as a supporting element of site transition rather than a primary transition deliverable. As a result, data-related activities frequently receive attention late in the process, after physical assets, contracts, and operational responsibilities have already been addressed. This delayed approach to the environmental data can create significant risk, because unresolved data issues often require substantial effort to correct.

To avoid these challenges, sites should establish data readiness as a formal transition workflow with dedicated ownership, resources, milestones, and deliverables.

Action

- Develop a data and records transition plan
- Assign ownership and accountability
- Take inventory of:
  - Data sources
  - Applications and databases
  - Authoritative data sources
  - Data owners and custodians
  - Current data quality and documentation status
- Define readiness criteria and transition milestones
- Integrate data readiness activities into overall transition planning

Result

Data readiness becomes a managed and measurable effort rather than a last-minute activity. Risks can be identified earlier, resources can be allocated appropriately, and transition objectives can be achieved more predictably.

5.2 Consolidate Data into a Usable System

Many sites discover that environmental information is distributed across multiple databases, spreadsheets, GIS platforms, legacy applications, individual staff work products, electronic data

storage locations, document repositories, and contractor-specific systems. While these environments may support ongoing operations, they often create significant challenges during transition when future users must identify authoritative information sources.

Consolidation does not necessarily require a single software platform. Rather, it requires a clear and intentional architecture in which authoritative data sources are defined, data quality and lineage are understood, and information can be consistently located and accessed.

Action

- Inventory all environmental data repositories and storage locations (personal files, local drives, network drives, cloud storage, records systems, etc.) and systems containing data (databases, GIS platforms, etc.)
- Identify duplicate, conflicting, outdated, and superseded datasets
- Evaluate data quality, pedigree, and completeness to establish authoritative data sources for each data domain (e.g. groundwater, surface water, laboratory analytical, geospatial, ecological, or modeling data)
- Consolidate redundant information where appropriate, preserving necessary historical records
- Establish a centralized or integrated information environment
- Implement a data catalog or equivalent inventory with consistent metadata to support data discovery, traceability, and interpretation
- Document data flows and system interfaces

Result

Environmental information becomes searchable, accessible, traceable, and reliable. Future stewards can identify authoritative datasets, understand their origins and limitations, and confidently locate and use information for long-term stewardship.

5.3 Standardize the Data Structure and Metadata

Data that lacks consistent structure and documentation often becomes increasingly difficult to interpret over time. Inconsistent naming conventions, varying units of measure, undocumented abbreviations, and incomplete metadata can significantly reduce the long-term usability of environmental information.

Standardization allows future users to understand and integrate information without extensive interpretation or rework.

Action

- Establish standard naming conventions
- Standardize units of measure and reporting formats
- Implement metadata requirements
- Develop and maintain data dictionaries
- Document business rules and data relationships
- Apply consistent location identifiers and monitoring point nomenclature

Result

Data becomes easier to understand, integrate, analyze, and maintain. Consistent nomenclature improves interpretation, while well-defined and populated metadata makes relevant datasets easier to discover and use. Standardized data structures improve interoperability, reduce reliance on institutional knowledge, and support future reporting and analytical needs.

5.4 Preserve the Knowledge Behind the Data

Long-term stewardship organizations cannot rely on the continued availability of the personnel who developed and managed environmental programs during active operations. Yet many sites depend heavily on undocumented scientific rationale, historical program knowledge, conceptual understanding, and technical expertise that exists only in the experience of individual staff members. Preserving the knowledge behind the data is one of the most important aspects of transition readiness.

Action

- Document data structures and relationships
- Record reporting methodologies and calculations
- Capture system configurations and dependencies
- Conduct structured interviews with subject matter experts
- Develop process documentation and user guides
- Embed operational knowledge into systems, metadata, and documentation
- Document stewardship responsibilities, monitoring expectations, and decision rationale, not just technical procedures, thus allowing future organizations to understand how long-term stewardship activities are intended to be carried forward
- Document why major technical decisions were made—not simply what decisions were made
- Capture conceptual site models, groundwater model assumptions, calibration approaches, and the reasoning behind significant changes over time
- Record the rationale for accepting or rejecting major alternatives, particularly where those decisions influence long-term stewardship activities
- Preserve lessons learned and decision history alongside technical documentation so future stewards understand the evolution of the site, not just its final condition

Result

Environmental information becomes better documented, more interpretable, and more transferable. While no documentation effort can fully replace decades of experience, capturing key assumptions, workflows, metadata, conceptual site models, groundwater modeling decisions, and technical rationale significantly reduces reliance on individual memory. Future stewards inherit not only the environmental data itself, but also the scientific context necessary to reproduce analyses, understand historical decisions, and confidently continue long-term stewardship activities.

5.5 Replace Manual Processes with Repeatable Workflows

Many environmental programs continue to rely on spreadsheets, manual calculations, repetitive data manipulation, and labor-intensive reporting processes. While these approaches may function during active operations, they introduce risk, increase costs, and create challenges for long-term stewardship organizations responsible for multiple sites. Repeatable workflows improve consistency, transparency, and operational efficiency.

Action

- Identify manual processes and workflow bottlenecks
- Evaluate opportunities for automation
- Implement automated data validation rules
- Standardize reporting workflows
- Reduce reliance on manual calculations and spreadsheet-based processes
- Establish documented and repeatable procedures

Result

Processes become more consistent, efficient, and defensible. Organizations reduce operational risk while improving the quality and repeatability of environmental reporting and analysis.

5.6 Validate and Characterize Data Before Transition

The value of environmental information depends on its quality and the receiving organization's understanding of its limitations. While organizations should strive to identify and resolve significant data quality issues before transition, achieving complete validation of decades of historical environmental data may not always be practical or cost-effective. In many cases, documenting known limitations and providing clear indicators of data quality enables informed decision-making while avoiding unnecessary delays to transition.

When feasible, organizations should assess environmental data prior to transition to improve confidence in its completeness, accuracy, consistency, and usability. Where data does not fully meet current quality standards, it should not necessarily be excluded. Instead, known limitations, assumptions, and quality considerations should be documented so future users can evaluate the information within the appropriate context.

Action

- Establish data acceptance and fitness-for-use criteria
- Assess completeness, accuracy, and consistency where practical
- Verify metadata, supporting documentation, data dictionaries, acronym and abbreviation definitions, and references that are needed to interpret the data
- Conduct quality assurance/quality control (QA/QC) reviews for high-priority or high-risk datasets
- Resolve known data quality issues when feasible
- Flag datasets with known limitations or uncertainties using documented quality indicators or confidence measures

- Document data provenance (or dataset pedigree), including how data progressed from collection through validation, cleaning, transformation, processing, and interpretation
- Confirm that datasets can be interpreted independently by future users, with sufficient context to explain why the data was collected, how it was used, and what program, study, permit, or decision it supported
- Document assumptions, limitations, remaining risks, recommended future improvements, and any known gaps in scientific context (such as undefined abbreviations, undocumented study objectives, historical naming conventions, or missing references to permits, projects, or conceptual site models)

Result

Receiving organizations inherit environmental information that is transparent, well-documented, interpretable, and fit for its intended use. Rather than striving for perfect data, they receive information with sufficient quality indicators, provenance, and scientific context to understand where the data came from, how it was processed and interpreted, and how it should be applied. This reduces uncertainty while preserving valuable historical information for future stewardship.

5.7 Create Standardized Data Turnover Packages

Effective turnover packages should provide more than environmental datasets and supporting records. They should preserve the knowledge needed to understand how those datasets were created, interpreted, and applied throughout the site's history. Future organizations should inherit sufficient context to understand stewardship obligations, monitoring programs, institutional controls, technical assumptions, and the rationale behind significant decisions. The objective is not simply to transfer information—it is to transfer the capability to continue stewardship with confidence. Standardized turnover packages preserve the institutional knowledge and documentation necessary for effective long-term stewardship.

Action

For each major data domain (e.g. groundwater, surface water, laboratory analytical, geospatial, ecological, or modeling data) develop standardized data turnover packages:

- Include environmental monitoring data, laboratory analytical results, validation qualifiers, groundwater and surface water data, GIS information, well construction records, permits, and supporting documentation
- Include metadata, data dictionaries, database schemas, entity relationship diagrams, coordinate systems, and system documentation needed to understand and reuse the information
- Preserve conceptual site models, groundwater model assumptions, calibration approaches, interim model versions, and supporting technical rationale alongside final model outputs
- Document known data limitations, assumptions, and relationships between datasets
- Establish acceptance criteria and verify package completeness before transfer

Result

Future stewards receive more than a collection of files—they inherit a complete information package containing the environmental data, supporting documentation, metadata, scientific context, and technical rationale needed to understand site conditions, reproduce historical analyses, maintain remedies, and support informed decision-making throughout LTS&M.

5.8 Manage Data Transition as a Formal Project

Successful data transitions rarely occur through informal efforts or ad hoc activities. Given the volume, complexity, and long-term significance of environmental information, transition readiness should be managed using the same discipline applied to other critical project deliverables. A structured project approach improves accountability, visibility, and overall transition success.

Action

- Define scope, schedule, and deliverables
- Establish readiness metrics
- Conduct periodic readiness assessments
- Track risks, issues, and corrective actions
- Assign clear ownership and responsibilities
- Perform formal transition readiness reviews
- Verify completion of acceptance criteria before transfer

Result

Data transition preparation becomes predictable, measurable, and manageable. Organizations reduce uncertainty, improve stakeholder confidence, and increase the likelihood of a successful transfer to long-term stewardship.

6.0 Future-Ready Data: Supporting Stewardship and Innovation

As federal agencies continue to modernize information management practices, interest in automation, advanced analytics, machine learning (ML) and agentic/generative methods is growing. These capabilities offer opportunities to improve efficiency, accelerate analysis, enhance decision-making, and derive greater value from decades of environmental and operational data collected throughout a site's history.

Potential applications supporting LTS&M include:

- Automated report generation
- Data quality assessment and anomaly detection
- Trend analysis and predictive modeling
- Knowledge retrieval across large document repositories
- Regulatory document review and summarization
- Environmental monitoring optimization
- Decision support for long-term stewardship activities

While these technologies offer significant potential, their effectiveness depends on the same foundation required for LTS&M: accessible, well-governed, and high-quality data.

Organizations frequently discover that the primary barrier to advanced analytics is not technology, it is data readiness. Data that is fragmented across multiple repositories, dependent on undocumented workflows, or lacking consistent structure and metadata is difficult to leverage regardless of the analytical tools being applied. The importance of data readiness is recognized within DOE as agentic/ML methods are being explored. This is illustrated in work and discussions by the Network of National Laboratories for Environmental Management and Stewardship (NNLEMS)[5] and a RemPlex seminar[6] on "Data Readiness for Artificial Intelligence Applications in Environmental Remediation."

Many of the challenges that complicate LTS&M transition also limit an organization's ability to adopt new technologies, including:

- Data distributed across multiple systems
- Inconsistent naming conventions and formats
- Missing or incomplete metadata
- Undocumented business rules and workflows
- Reliance on institutional knowledge
- Data quality concerns
- Limited accessibility and interoperability

[5] https://www.energy.gov/em/articles/em-legacy-management-collaborate-expanded-national-laboratory-network

[6] https://www.pnnl.gov/projects/remplex/seminars/data-readiness-ai

Conversely, the actions that improve transition readiness also create the foundation necessary for future innovation. When organizations establish authoritative data sources, standardize data structures, improve data quality, document workflows, and implement governance practices, they create information environments that support both stewardship and advanced analytical capabilities.

This alignment presents a valuable opportunity. Rather than viewing stewardship readiness and agentic/ML method readiness as separate initiatives competing for resources, organizations should recognize them as complementary outcomes of the same data management strategy. Investments made to support transition planning today can continue to deliver value through efficiencies in monitoring, reporting, automation, and analytics, as well as readiness for future technology adoption.

The relationship between stewardship readiness and analytical readiness can be summarized as shown in Figure 2. The capabilities that enable successful long-term stewardship—trusted data, documented workflows, governance, metadata, and standardized information—are the same capabilities that enable automation, advanced analytics, and artificial intelligence. Organizations that invest in one are simultaneously preparing for the other.

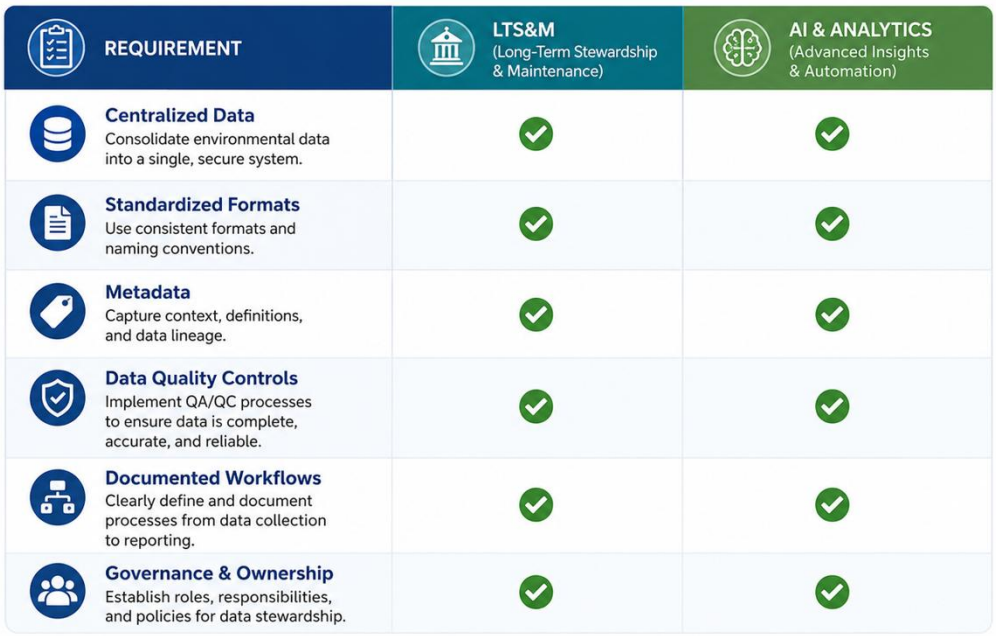


Figure 2. Shared data foundations for long-term stewardship and advanced analytics.

Ultimately, emerging technologies do not eliminate the need for sound data management practices, they reinforce the need. Whether the objective is successful stewardship, improved operational efficiency, automation, or advanced analytics, the starting point remains the same: trusted, accessible, and well-structured environmental information. Organizations that invest in one are simultaneously preparing for the other.

7.0 Conclusions

The policies governing environmental information management are already well established. Federal law, DOE guidance, records management requirements, and data governance principles provide a clear framework for how environmental information should be preserved, documented, and transferred throughout the stewardship lifecycle. The challenge facing organizations today is no longer determining **what** is required—it is determining **how** to implement those requirements in a practical, sustainable, and repeatable way before transition activities accelerate.

Preparing environmental information for LTS&M should not be viewed as a final project completed just before transition. It is an ongoing process that begins during active site operations and continues throughout the life of a program. Organizations that invest early in data governance, quality improvement, documentation, workflow standardization, and knowledge capture reduce transition risk while creating environmental information that is more accessible, reliable, and valuable for decades to come.

The same activities that improve transition readiness also strengthen day-to-day operations and prepare organizations for the future. Standardized, well-governed, and trusted environmental information supports more efficient reporting, better decision-making, improved operational resilience, and the adoption of emerging technologies such as advanced analytics, automation, and artificial intelligence. Preparing data for stewardship is therefore not simply an investment in transition, it is an investment in the future of environmental program management.

Successful transition is not measured by whether every document has been archived or every database has been transferred. It is measured by whether future stewards can confidently understand site history, reproduce historical analyses, explain technical decisions, maintain remedies, demonstrate protectiveness, and continue making informed, defensible decisions without having to rediscover the knowledge that already exists today.

Imagine a future steward, perhaps 20 or 30 years from now, opening an environmental database, reviewing historical reports, or searching through archived project files to answer a critical question about site conditions. The documentation, metadata, technical rationale, conceptual site models, model assumptions, and workflow descriptions intentionally preserved by today's teams become breadcrumbs for those who follow. Together, those breadcrumbs allow future generations to reconstruct not only the environmental data, but also the scientific thinking, assumptions, and decisions that shaped the site's stewardship journey.

The set of eight actions presented here provide a practical framework that organizations can implement today to meet the needs of future site stewardship. Together, these actions preserve the environmental information, scientific understanding, and operational knowledge needed to sustain DOE's long-term stewardship mission across organizational and personnel transitions. By making data accessible, reliable, interpretable, and supported by documented technical rationale, sites equip future stewards to maintain remedies, use the latest available technologies for efficient and effective analysis, demonstrate continued protection of human health and the environment, meet regulatory obligations, and respond to changing site conditions. Early preparation reduces the risk of transition delays, costly reconstruction of historical knowledge, and disruption to monitoring and reporting.

Ultimately, environmental data readiness is mission readiness. Preserving trusted data together with its scientific and decision-making context enables future stewards to maintain remedies, demonstrate continued protectiveness, meet regulatory obligations, and make informed, defensible decisions without having to reconstruct decades of lost knowledge. In the end, the most important asset being transferred is not simply environmental data, but the ability to understand, defend, and build upon decades of environmental science so that future generations can continue the stewardship mission with confidence and protect both cleanup investments and the communities and environments those investments serve.

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