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Information System for Monitoring the Progress of Clean Water Pipeline Installation Projects Using A Web-Based Dashboard and the Prototype Model Method at PT Bestindo Putra Mandiri

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Abstract

Project progress monitoring at PT Bestindo Putra Mandiri previously relied on Microsoft Excel, photographic documentation, and report submission through communication media, resulting in fragmented data management, delayed information retrieval, and inefficient progress recapitulation. This study aimed to develop a web-based information system for monitoring the progress of clean water pipeline installation projects using a dashboard and the Prototype Model at PT Bestindo Putra Mandiri. The study employed an empirical system-development design involving direct user interaction and functional evaluation of the developed application. System requirements were identified through observation and user interaction, followed by iterative development consisting of requirement identification, prototype design, prototype development, user evaluation, refinement, and implementation of the finalized system. The developed system integrates project data, work progress, project locations, field documentation, verification status, targets, realization, and reporting into a centralized web-based environment. The dashboard presents project completion percentages, progress status, target and realization information, and graphical representations to support monitoring by SPV Trunk Main/SPV Infill, Construction Manager, and Project Manager. Functional evaluation was conducted using Black Box Testing by examining authentication, project management, progress recording, documentation, verification, dashboard visualization, status information, and reporting functions. The testing results showed that the tested functions generated outputs consistent with their expected behavior. The system provides an integrated monitoring environment that improves information accessibility and supports structured project progress monitoring and managerial evaluation.

Keywords: *Black Box Testing, Dashboard, Information System, Project Monitoring, Prototype Model.*

INTRODUCTION

The rapid digitalization of infrastructure development has increasingly positioned information systems, web-based platforms, dashboards, and real-time monitoring technologies as strategic instruments for improving the visibility, coordination, and control of complex project activities, particularly in water infrastructure where project conditions may vary substantially across locations and implementation stages. Recent developments in water infrastructure monitoring demonstrate a shift from conventional reporting toward digitally connected monitoring environments that can integrate operational data, spatial information, and remote observations to support more responsive infrastructure management (Swan et al., 2026). The use of digital monitoring is also expanding through IoT and geolocation technologies, allowing field conditions and infrastructure-related information to be captured and associated with specific locations for more systematic monitoring (Abdirrahman et al., 2025). In parallel, web-based dashboards have emerged as decision-support interfaces capable of transforming dispersed operational data into visual information that enables managers to identify trends, compare performance, and respond to emerging conditions more efficiently (Banerjee et al., 2025). These developments indicate that the value of digitalization in project management is no longer limited to replacing paper-based records, but increasingly concerns the ability of organizations to transform continuously generated project data into accessible and actionable information. Within clean water pipeline installation projects, this requirement is particularly important because progress information is generated through geographically distributed field activities that must be communicated consistently between field personnel, project administrators, and management.

Previous studies have demonstrated that information systems can provide a technological foundation for improving the management of water infrastructure by integrating asset-related information, operational processes, and decision-support functions within a unified platform (Carriço et al., 2023). Research on participatory decision-support systems further indicates that dashboard-based environments can facilitate interaction between users and project or resource information while making complex datasets more accessible to stakeholders with different information requirements (Hermawan et al., 2026). At the construction-project level, dashboard applications have also been developed to visualize safety-related information and integrate project data with advanced digital representations, demonstrating that visual monitoring can support more timely identification and evaluation of field conditions (Machfudiyanto et al., 2024). However, these studies largely emphasize infrastructure asset management, resource planning, safety monitoring, or technologically advanced monitoring environments rather than the specific operational problem of monitoring daily progress in clean water pipeline installation projects through an integrated web-based dashboard. A related study on telemetric monitoring of water pipeline supply demonstrates the potential of digital technology to improve continuous observation of pipeline-related conditions, yet its focus remains on telemetry and system monitoring rather than administrative and managerial progress reporting throughout project implementation (Lainez et al., 2025). This distinction is important because project managers require not only technical measurements but also structured information concerning completed work, targets, status, locations, documentation, and deviations from planned progress.

The project-monitoring literature has increasingly reported the development of web-based systems as an alternative to fragmented spreadsheets and manually prepared reports, particularly because centralized systems can improve accessibility and facilitate the updating of project information. Purba et al. (2023) developed a website-based project monitoring information system that demonstrates how digital platforms can support the management and presentation of project-related information within a centralized environment. Putra and Putera (2024) similarly showed that website-based monitoring, evaluation, and reporting can be used to organize infrastructure program information and facilitate reporting activities across project implementation. More recent research has explored prototype-based development for project-monitoring systems, indicating that iterative interaction with users can help align system functionality with actual organizational requirements (Musva & Ramadhani, 2025). Nevertheless, much of this literature remains focused on general project-monitoring functionality and does not sufficiently address the integration of field progress, project status, location, target completion, and photographic documentation into a dashboard specifically designed for clean water pipeline installation. The gap becomes more pronounced when monitoring processes involve multiple field locations and require information to be updated repeatedly, because systems that merely digitize reporting forms may reproduce existing administrative limitations without substantially improving managerial visibility. The unresolved issue is therefore not simply whether project monitoring can be computerized, but how a monitoring system can transform fragmented field records into timely, integrated, and comprehensible information for project control.

A further limitation concerns the development approach used to translate operational requirements into system functionality, because a technically functional system may still fail to support organizational decision-making when its information structure and interaction mechanisms do not correspond to actual user workflows. Studies applying the prototype model to project-monitoring information systems suggest that iterative development can accommodate changing requirements and allow users to provide feedback during the construction of system features (Pratiwi & Kholil, 2024). Saputra and Hidayat (2024) likewise emphasize the applicability of the prototype model in developing monitoring systems where system requirements need to be clarified through repeated interaction between developers and users. Recent work has combined prototype-based development with ISO/IEC 25010 evaluation, illustrating a growing concern that project-monitoring systems should be assessed not only from the perspective of functionality but also from broader software-quality dimensions (Rifaldy P. et al., 2026). Yet the literature still provides limited empirical evidence concerning prototype-driven development of monitoring dashboards for clean water pipeline installation projects in which field supervisors, administrators, and management possess different information needs and responsibilities. Testing studies using black-box approaches have established the importance of verifying whether web-system functions operate according to their specified requirements (Irawan et al., 2025). Similar findings from boundary-value-based black-box testing reinforce the need for systematic validation of input and output behavior in web-based information systems before such systems are relied upon for operational activities (Kartono et al., 2024).

The practical urgency of this problem is evident at PT Bestindo Putra Mandiri, where preliminary observation indicates that progress monitoring for clean water pipeline installation projects remains dependent on daily field reports, photographic documentation, Microsoft Excel, and communication through channels such as WhatsApp or electronic mail. Such fragmented procedures create a sequential information flow in which field data must first be recorded, transmitted, re-entered or consolidated, and subsequently interpreted before management can obtain an overview of project conditions. Manual data processing can also increase exposure to inconsistent records, duplicate entries, delayed updates, and discrepancies between actual field progress and reported project conditions, particularly when several projects or work locations are handled simultaneously. From a data-management perspective, organizational information becomes more valuable when its accuracy, consistency, and availability are maintained throughout the processing cycle rather than being treated merely as an output of administrative reporting (Suryani et al., 2025). The conversion of raw project data into useful information requires systematic processes of input, processing, storage, output, and feedback so that operational data can support managerial activities rather than remain isolated records (Prasetyo et al., 2023). The absence of an integrated monitoring mechanism consequently represents both an operational inefficiency and an information-management problem because management decisions depend on the timeliness and reliability of the information generated from field activities.

This study is positioned within the intersection of web-based information systems, project-progress monitoring, dashboard-based visualization, and iterative software development, with a specific focus on the operational requirements of clean water pipeline installation projects at PT Bestindo Putra Mandiri. The proposed system is intended to integrate project data, customer information, work locations, installation progress, project status, field documentation, and reporting into a centralized web-based environment that can provide management with a more coherent representation of project conditions. Its development adopts the Prototype Model because direct and iterative involvement of prospective users is considered necessary to translate field-monitoring practices into system functions that are technically appropriate and operationally relevant. The system is also designed around dashboard visualization so that project information can be interpreted through indicators of progress, status, targets, and supporting documentation rather than requiring managers to examine dispersed spreadsheets and individual reports. The research aims to develop and evaluate a web-based information system for monitoring the progress of clean water pipeline installation projects at PT Bestindo Putra Mandiri using the Prototype Model, while addressing the information fragmentation and delayed reporting inherent in the existing monitoring process. Theoretically, the study contributes an empirically grounded perspective on how web-based dashboard systems can support project-progress information management in a water infrastructure context, while methodologically it demonstrates an iterative approach for translating field and managerial requirements into an integrated monitoring system whose functionality can be validated against the operational needs of its users.

RESEARCH METHODS

This study employs an empirical system-development design because it involves the implementation of a web-based information system, direct interaction with users, and functional testing of the resulting application at PT Bestindo Putra Mandiri. The Prototype Model was selected as the development approach because it enables users to participate iteratively in identifying requirements, reviewing the initial design, and providing feedback for subsequent system refinement, which is particularly appropriate for project-monitoring processes whose operational requirements need to be clarified through direct interaction with users (Pratiwi & Kholil, 2024). The system architecture consists of a web-based application layer for user interaction, an application-processing layer for managing project-monitoring functions, and a centralized database layer for storing project, customer, location, progress, documentation, and reporting data. The main implementation stages comprise requirements identification, initial prototype design, prototype development, user evaluation, prototype refinement, and implementation of the finalized web-based monitoring system, following the iterative characteristics of prototype-based information-system development (Saputra & Hidayat, 2024). The dashboard functions as the primary information-visualization component and integrates indicators of project completion percentage, daily progress, work status, completion targets, project locations, progress graphs, and field documentation into a centralized interface. The system is implemented using web-based technologies with a relational database to ensure that field inputs and administrative updates can be stored, retrieved, and presented consistently across the monitoring workflow. The resulting architecture is intended to replace fragmented manual records and spreadsheet-based recapitulation with an integrated information environment in which field personnel, administrators, and management can access information according to their respective operational requirements.

The implemented system was evaluated using Black Box Testing, which examines system functionality through specified inputs and expected outputs without requiring inspection of the internal program structure, making it suitable for validating whether the developed functions conform to the defined user requirements (Irawan et al., 2025). Testing scenarios were prepared for the principal functions of the application, including user authentication, project-data management, customer-data management, location management, progress recording and updating, field-documentation management, dashboard visualization, status information, and report-related functions. For each scenario, predefined input conditions were entered into the system, the resulting output was observed, and the observed behavior was compared with the expected functional specification. A function was categorized as successful when the system generated the expected output and completed the intended process without functional errors, whereas an unsuccessful result indicated the need for corrective refinement before final implementation. This functional-validation procedure follows the principle that web-based applications should be systematically tested against their specified behavior, including input validation and the processing of core application functions (Kartono et al., 2024). The evaluation metric was calculated from the proportion of successfully executed test scenarios relative to the total number of tested scenarios, providing a functional-success percentage as the principal performance indicator. Boundary-oriented verification was also considered for input fields requiring specific constraints so that the system could be assessed not only under normal inputs but also at relevant input limits, consistent with the use of Boundary Value Analysis in web-application testing (Kusuma et al., 2024).

RESULTS AND DISCUSSION

Analysis of the Existing Project Progress Monitoring System

The analysis of the existing project progress monitoring system at PT Bestindo Putra Mandiri shows that project information is still managed through a sequential reporting process involving field personnel, the Construction Manager, and the Project Manager. SPV Trunk Main/SPV Infill performs field activities, records completed work, prepares progress reports, and provides supporting documentation before submitting the information to the Construction Manager. The Construction Manager then examines the submitted information, identifies incomplete or inconsistent data, and performs progress recapitulation before the information is forwarded to the Project Manager. The Project Manager uses the recapitulated information to monitor the achievement of project targets and evaluate the relationship between planned and actual progress. This workflow indicates that the monitoring process already contains defined responsibilities, but the information exchange between responsibilities remains dependent on manual reporting and separate data storage. Such conditions are relevant to the development of web-based project monitoring systems because centralized information management can improve the accessibility and consistency of project data across different organizational roles (Purba et al., 2023).

The operational sequence of the existing system is illustrated in Figure 1, which represents the movement of information from data acquisition to subsequent use by project personnel. The process begins when sales or administrative personnel obtain information from internal or external sources, after which the information is stored in files or other storage media that are not fully centralized. When information is required, users must search through files and folders or communicate directly with personnel responsible for the relevant information. The same pattern creates an additional dependency when data require updating because users must submit requests to the personnel who maintain the information. From an information-system perspective, this workflow reflects fragmented data accessibility because information retrieval is determined by storage location and personnel availability rather than by a unified information repository. Research on infrastructure information systems emphasizes the importance of structured platforms for consolidating infrastructure-related information and improving access to operational data (Carriço et al., 2023).

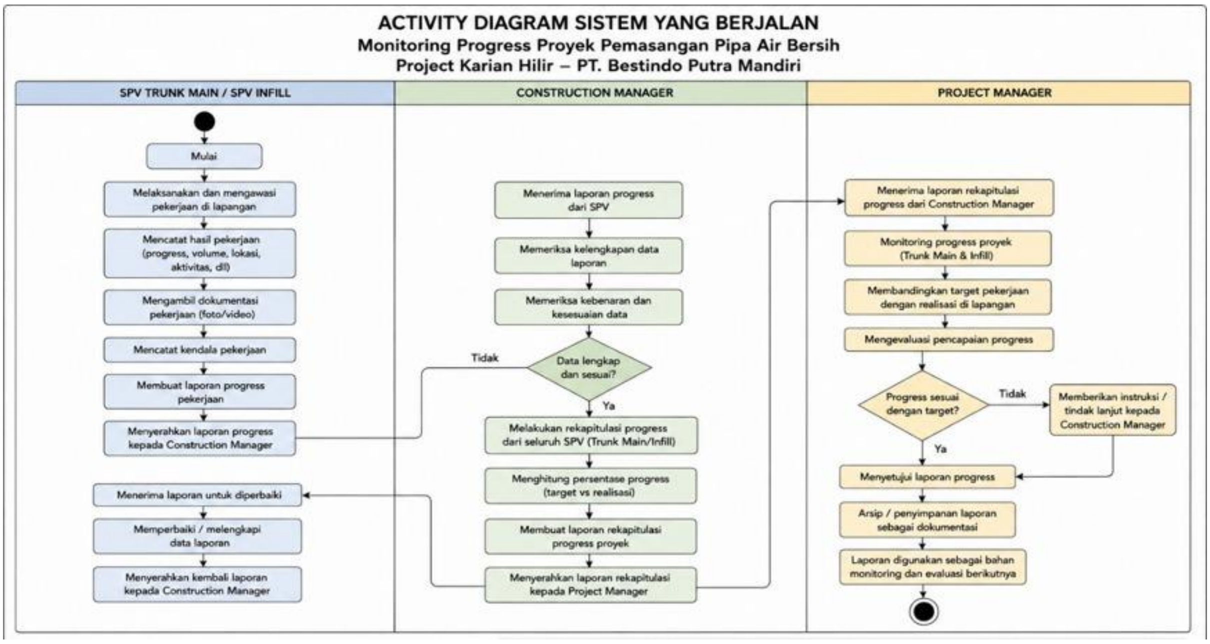

Figure 1. Existing System Flow

The conditions represented in Figure 1 demonstrate that the existing mechanism creates several information-management gaps that are relevant to project monitoring. Progress information originating from field activities is not immediately transformed into a centralized project record, while supporting documentation may remain separated from the progress information to which it relates. The absence of a centralized repository can also increase the possibility of duplicated records, outdated information, and differences between versions used by different personnel. These limitations become more significant when project monitoring requires continuous comparison between work targets and field realization across different locations. Digital monitoring approaches for water infrastructure emphasize the value of integrated information environments because infrastructure conditions and operational data need to be accessed in a coordinated manner (Swan et al., 2026). The comparison between the observed process and the required monitoring mechanism is presented in Table 1 to identify the functional gap that needs to be addressed through system development.

Table 1. Comparison of Existing and Required Project Monitoring Processes

Monitoring Aspect	Existing Process	Required Process
Progress Recording	Recorded through field reports and separate files	Recorded through an integrated web-based system
Data Storage	Distributed across files or storage media	Centralized relational database
Progress Verification	Checked manually by Construction Manager	Supported through structured system verification
Progress Recapitulation	Manually consolidated from submitted reports	Generated from centralized project data
Documentation	Stored separately from progress information	Linked to corresponding project progress
Information Retrieval	Depends on files, folders, and personnel	Accessible through the web-based system
Management Monitoring	Based on submitted recapitulation reports	Supported by dashboard indicators and visualization

Table 1 indicates that the main difference between the existing and required processes lies in the integration of information rather than merely changing the medium used for data entry. The existing process separates recording, storage, verification, documentation, and monitoring activities, whereas the required process connects these activities through a common database and defined system workflow. This integration is important because project progress is meaningful only when target, realization, documentation, location, and verification status can be interpreted as related information rather than isolated records. Web-based dashboards provide an appropriate mechanism for transforming structured operational data into visual indicators that can be interpreted by organizational decision makers (Banerjee et al., 2025). In water infrastructure contexts, the integration of spatial and operational information can also strengthen monitoring because project activities are associated with specific physical locations and implementation conditions (Carriço et al., 2023; Syafrudin et al., 2025). The identified gap therefore establishes a direct relationship between the problems observed in the existing workflow and the functional requirements of the proposed monitoring system.

The role of the Construction Manager represents an important control point within the existing monitoring process because information submitted by the SPV must be examined before it becomes part of the project-level progress record. Incomplete documentation or inconsistent progress information requires additional communication with the originating field personnel, creating a repeated correction cycle before the information can be consolidated. This condition can affect the timeliness of project information, particularly when progress from multiple work areas needs to be reviewed within a similar reporting period. The proposed information system addresses this requirement by providing structured project and progress fields, documentation facilities, verification status, and notes that can be associated with individual progress records. The approach is consistent with Prototype Model development because user interaction during prototype evaluation allows functional requirements to be refined according to actual operational needs (Pratiwi & Kholil, 2024). The system requirement therefore extends beyond data storage and includes mechanisms that support the existing verification responsibility of the Construction Manager.

The Project Manager requires a different level of information because managerial monitoring emphasizes the relationship between planned targets, actual realization, project status, and development of progress over time. In the existing process, this information is received after field reporting, checking, and recapitulation have been completed, making managerial visibility dependent on the completion of preceding administrative activities. A dashboard-based approach can consolidate these indicators into a single interface so that project conditions can be interpreted without manually combining information from multiple reports. Research on strategic web-based dashboards shows that visualized organizational information can support monitoring by making operational conditions more accessible for analysis and decision making (Banerjee et al., 2025). The same principle is applicable to project infrastructure monitoring because progress information needs to be presented in a form that allows management to identify achievement and deviations efficiently. The requirement for centralized and accessible monitoring information is also consistent with recent developments in participatory dashboard-based decision-support systems for water-resource planning (Hermawan et al., 2026).

Based on the empirical analysis, the existing monitoring process requires improvement in five interconnected areas: data centralization, progress recording, documentation management, verification, and management-level visualization. These requirements arise directly from the observed workflow rather than from technological considerations alone, allowing the developed system to remain aligned with the responsibilities of SPV Trunk Main/SPV Infill, Construction Manager, and Project Manager. The integration of these functions is particularly relevant to clean water pipeline installation because project progress must be associated with work locations, physical implementation, supporting documentation, and achievement targets. Contemporary water-infrastructure monitoring research similarly emphasizes the role of digital and remote monitoring mechanisms in improving the management of complex infrastructure information (Swan et al., 2026). The identified requirements provide the empirical foundation for translating the existing workflow into a prototype-based system architecture in which user roles, data structures, and monitoring functions are explicitly connected. The next stage therefore focuses on the Prototype Model and the resulting system architecture developed to address the information gaps identified in the existing process.

Prototype-Based Design and System Architecture

The development of the proposed monitoring system was based on the requirements identified from the existing project progress monitoring process and implemented using the Prototype Model. The selection of this model was appropriate because the operational requirements of project monitoring involved several users with different responsibilities, making direct interaction necessary to clarify how information should be recorded, verified, and presented. The prototype was developed through an iterative process consisting of requirement identification, initial interface and function design, prototype development, user evaluation, refinement, and implementation of the finalized system. This approach allows discrepancies between the initial system concept and actual user requirements to be identified before the system is finalized, which is particularly relevant for project-monitoring applications with operational workflows that may evolve during development (Pratiwi & Kholil, 2024). Previous research also demonstrates that the Prototype Model can be applied to project-monitoring information systems because iterative user evaluation helps align system functions with practical monitoring requirements (Saputra & Hidayat, 2024). The resulting development process positioned user requirements as the primary basis for defining the system architecture, functional modules, and information flow.

The proposed system maintains the organizational roles found in the existing monitoring process while providing a digital environment for connecting their activities. SPV Trunk Main/SPV Infill functions as the field-level user responsible for entering work progress, recording realization, uploading documentation, and reporting field conditions. The Construction Manager functions as the verification authority who reviews submitted progress information, checks its completeness, and provides verification status or notes when corrective information is required. The Project Manager functions as the management-level user who monitors project achievement through consolidated progress information and dashboard visualization. The separation of responsibilities is important because project information systems should reflect actual organizational authority rather than treating all users as having identical access and operational functions. The relationship between the identified actors and the principal functional requirements is presented in Table 2, which provides the basis for determining the system modules and access requirements.

Table 2. User Roles and Functional Requirements of the Monitoring System

User Role	Main Responsibility	Functional Requirement	System Output
SPV Trunk Main/SPV Infill	Record field activities and progress	Input project progress, realization, documentation, and field information	Submitted progress record
Construction Manager	Examine and verify submitted progress	Review progress, verify data, provide notes, and update verification status	Verified or revised progress information
Project Manager	Monitor project achievement	View project progress, target, realization, status, and dashboard indicators	Consolidated project monitoring information

Table 2 shows that the system architecture is organized according to a role-based workflow in which each user receives functions corresponding to their operational responsibilities. The SPV is positioned at the data-generation level, while the Construction Manager operates at the validation level and the Project Manager operates at the monitoring and evaluation level. This arrangement establishes a controlled information flow in which field data are not immediately treated as finalized management information before passing through a verification process. Such a structure is important for maintaining data reliability because project-monitoring information needs to distinguish between newly submitted field records and information that has already been reviewed by the responsible authority. Similar role-oriented structures have been applied in web-based infrastructure monitoring systems to connect field-level information with evaluation and reporting functions (Putra & Putera, 2024). The architecture therefore supports both operational data entry and managerial information requirements without eliminating the verification responsibilities embedded in the existing project workflow.

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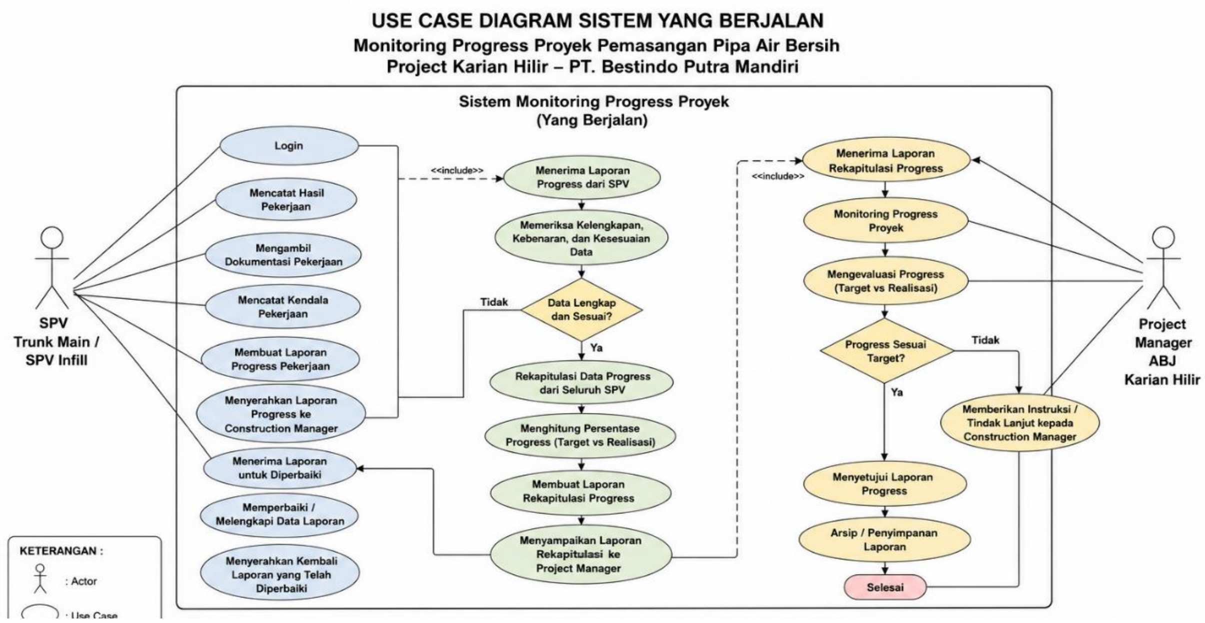

Figure 2. Activity Diagram of the Proposed Project Progress Monitoring Process

The activity diagram in Figure 2 illustrates the transformation of the existing manual workflow into a structured digital monitoring sequence. The process starts with SPV Trunk Main/SPV Infill conducting field activities and recording the resulting progress, documentation, and relevant work information in the system. The submitted information is then received by the Construction Manager, who examines the data and determines whether the information is sufficiently complete and appropriate for inclusion in project progress monitoring. When the information requires correction or completion, the workflow returns the record to the SPV so that the required information can be revised before verification. When the information satisfies the verification requirements, the Construction Manager confirms the progress and the validated information becomes available for project-level monitoring. This iterative verification mechanism corresponds with the logic of prototype-based development because the system is designed around repeated interaction between users and information processes rather than a single one-way transaction (Saputra & Hidayat, 2024).

The architecture developed from the activity flow consists of three principal layers, namely the web-based presentation layer, the application-processing layer, and the centralized database layer. The presentation layer provides interfaces through which users authenticate themselves, enter project information, submit progress, review records, and access dashboard indicators according to their roles. The application-processing layer manages business logic such as data validation, progress processing, verification status, access control, and the relationship between project records and progress information. The database layer stores structured information related to projects, customers, locations, progress, targets, realization, documentation, verification status, and reporting requirements. This layered organization separates user interaction from application processing and data storage, allowing system functions to be managed in a more structured manner. The integration of centralized information is also consistent with infrastructure information-system research emphasizing the need to organize diverse operational data within a common platform for more effective management and retrieval (Carriço et al., 2023). The architecture consequently provides the technical foundation required to transform field-generated information into consistent monitoring information for different organizational levels.

The prototype-based architecture also establishes a direct connection between operational activities and dashboard-oriented information visualization. Data entered by field personnel are not treated as isolated records because they become part of a connected information structure that can subsequently be reviewed, verified, and presented as project indicators. The relationship between target and realization enables the system to represent the level of project completion, while documentation and verification information provide contextual evidence for interpreting the recorded progress. This design is particularly relevant to water infrastructure projects because monitoring requires coordination between physical work conditions, project locations, progress records, and supporting evidence. Digital monitoring studies in water infrastructure similarly emphasize integrated information environments as a means of supporting continuous observation and more coordinated infrastructure management (Swan et al., 2026). Dashboard-based visualization further strengthens this architecture by converting structured project records into information that can be interpreted more efficiently by management (Banerjee et al., 2025). The resulting design establishes the conceptual and technical basis for the implementation of the web-based monitoring dashboard presented in the following section.

Implementation of the Web-Based Project Monitoring Dashboard

The implementation stage translated the requirements and architecture defined through the Prototype Model into a functional web-based project monitoring application at PT Bestindo Putra Mandiri. The implemented system provides a centralized environment for managing project information, recording progress, storing field documentation, conducting verification, and presenting project conditions through an integrated interface. The system was designed to ensure that information generated by SPV Trunk Main/SPV Infill could be processed within the same environment used by the Construction Manager and Project Manager. This integration reduces the separation between field-level reporting and management-level monitoring because progress information can be stored as structured records and subsequently accessed according to user responsibilities. Web-based project monitoring research has demonstrated that centralized applications can support project evaluation and reporting by connecting operational information with monitoring functions (Putra & Putera, 2024). The implementation therefore represents a functional transformation of the previously fragmented monitoring process into a structured digital information workflow.

The login interface constitutes the initial access point for the monitoring system and provides authentication before users enter project-related functions. Figure 3 presents the implemented login page, which requires users to provide their registered credentials before accessing the system. Authentication is important because the application contains project progress, documentation, verification information, and other operational records that should not be accessible without appropriate authorization. After successful authentication, the system directs users to functions corresponding to their assigned role, supporting the separation of field-level, verification-level, and management-level activities established in the system architecture. Role-based access is particularly relevant to project information systems because different users require different levels of access according to their operational responsibilities (Purba et al., 2023). The implementation therefore establishes access control as an initial mechanism for maintaining the integrity of information throughout the monitoring workflow.

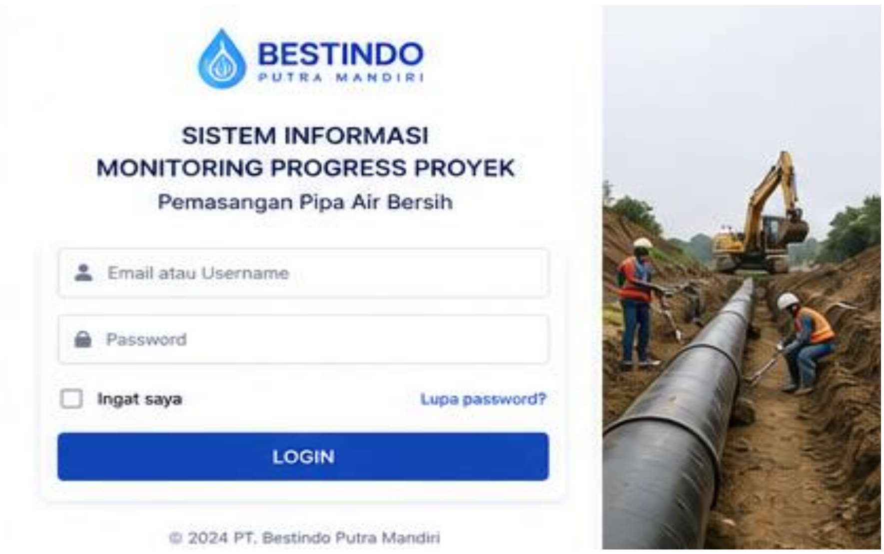

Figure 3. Login Page

The project-data interface provides the central entry point for organizing project information before progress records are associated with specific work activities. Figure 4 shows the implemented project-data page, which presents project information in a structured interface that allows users with appropriate authority to access and manage project records. The availability of centralized project records provides a reference for subsequent progress recording because progress information can be associated with an identifiable project rather than stored as an independent report. This structure also supports information retrieval because users no longer need to locate project information across separate files or communication channels. Centralized data management is consistent with the principles applied in infrastructure information systems, where project and asset information needs to be organized within an integrated platform to support efficient retrieval and monitoring (Carriço et al., 2023). The project-data interface therefore functions as an information foundation for connecting project identity with subsequent progress, documentation, and verification records.

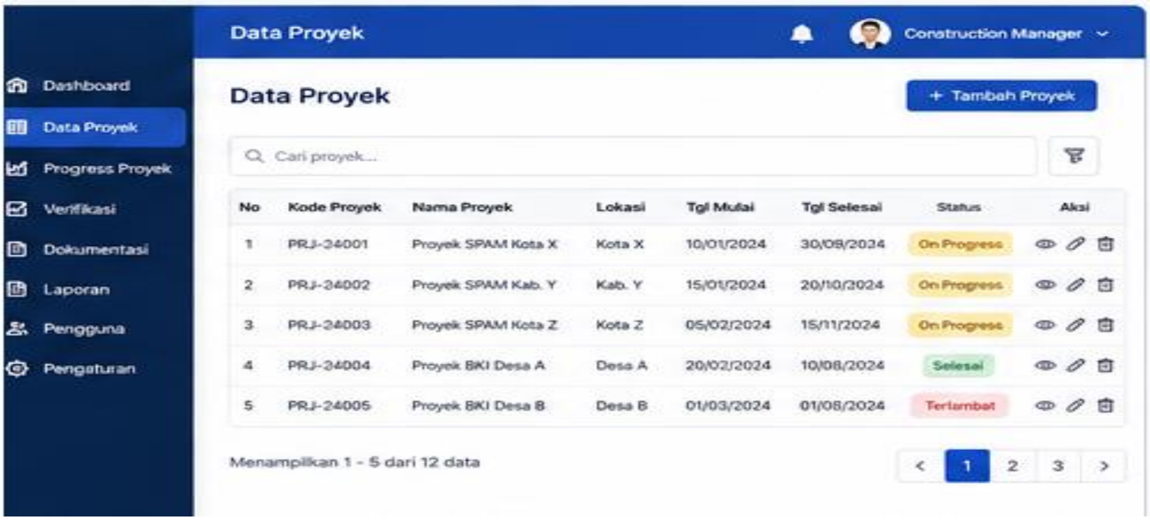

Figure 4. Project Data Page

The project-input interface shown in Figure 5 provides a structured mechanism for entering project information into the centralized database. The form-based approach reduces reliance on unstructured reporting because required information is entered through predefined system fields and can subsequently be processed by the application. Project data entered through this interface become the basis for associating progress records with the corresponding project, allowing subsequent monitoring information to maintain a consistent project reference. Structured input is also important for reducing ambiguity in data processing because information entered through predefined fields can be validated and stored according to the system's database structure. Similar web-based project-monitoring implementations have used structured input functions to convert operational project information into records that can be accessed for subsequent monitoring and reporting (Musva & Ramadhani, 2025). The implementation therefore demonstrates that the system does not merely provide a digital form but establishes a standardized data-entry mechanism supporting the broader monitoring workflow.

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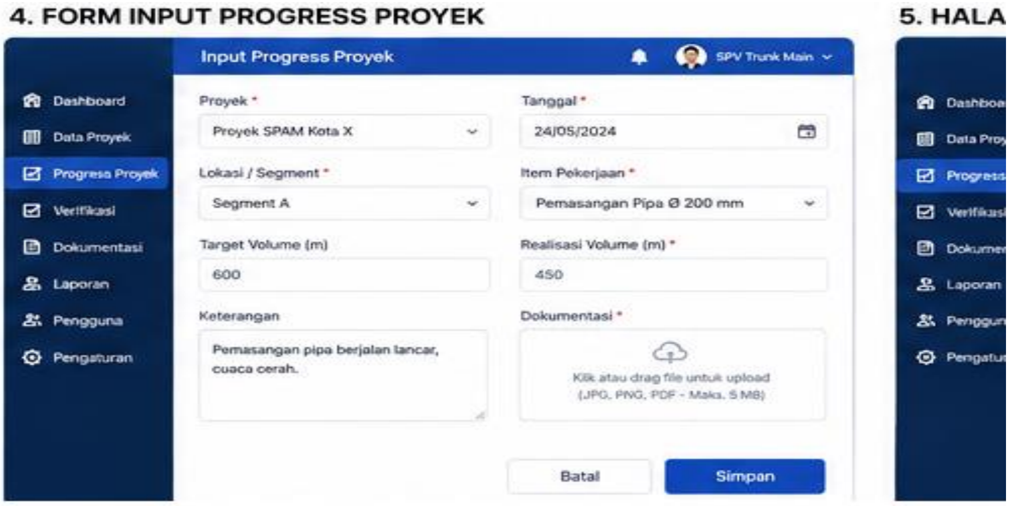

Figure 5. Project Input Form

The progress-detail and verification functions provide the principal connection between field reporting and managerial control within the implemented system. The detail-progress interface presents work information together with target, realization, percentage of completion, documentation, verification status, and Construction Manager notes, allowing the information to be interpreted as an integrated progress record. The Construction Manager can examine submitted information before confirming its status, while incomplete or inconsistent information can be identified through the verification process rather than immediately being treated as finalized project information. Figure 6 presents the implemented progress-verification interface, demonstrating how the system accommodates the review stage within the digital workflow. The integration of progress data and documentation is important because visual project-monitoring systems become more useful when indicators can be interpreted together with supporting operational evidence (Machfudiyanto et al., 2024). This implementation also supports the Prototype Model objective of aligning system functions with actual user activities by embedding the existing verification responsibility into the digital application rather than introducing an unrelated workflow.

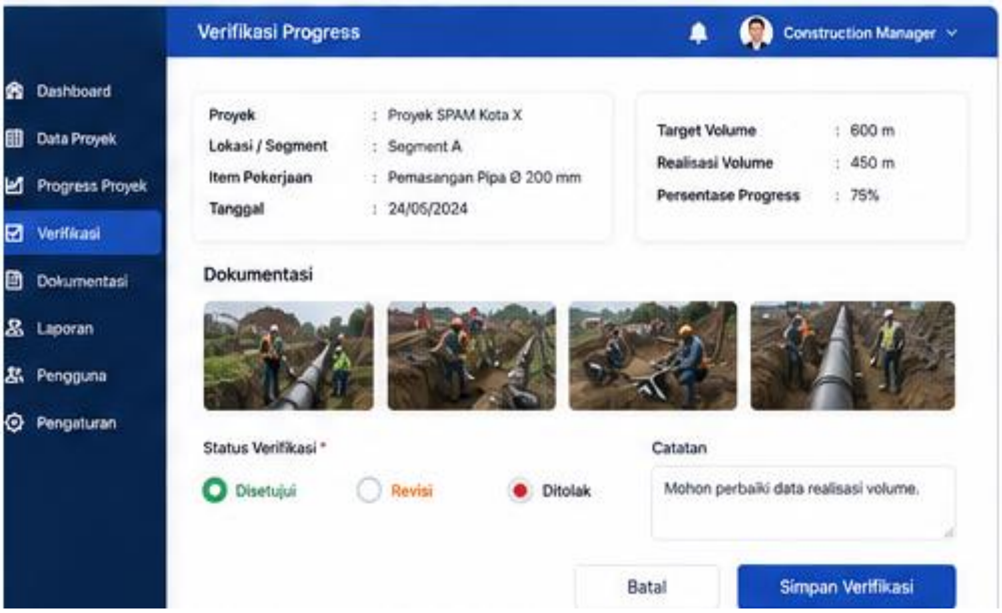

Figure 6. Progress Verification Page

The implemented dashboard consolidates project information into a monitoring-oriented interface that supports interpretation at the management level. Progress percentage, daily progress, work status, completion targets, project locations, progress graphs, and field documentation can be presented as related information rather than separate records. This arrangement changes the information flow from a report-oriented process toward a dashboard-oriented process in which project conditions can be reviewed through centralized indicators. Dashboard visualization is particularly relevant when project managers need to compare achievement with targets and identify the current status of ongoing work without manually consolidating multiple reports. Research on strategic web-based dashboards indicates that integrated visual information can strengthen monitoring by making organizational conditions more accessible for interpretation and decision making (Banerjee et al., 2025). In water infrastructure management, digital monitoring environments similarly provide value by connecting operational observations with information needed for continuous infrastructure oversight (Swan et al., 2026). The implemented dashboard therefore functions not only as a visual interface but also as the final information layer connecting field data, verification processes, and project-level monitoring.

Functional Testing and System Performance Evaluation

Functional evaluation was conducted using Black Box Testing to determine whether the implemented monitoring system operated according to the functional requirements established during the development process. The testing focused on the observable behavior of the application by providing specified inputs and comparing the resulting outputs with the expected system behavior. This approach was appropriate because the principal objective of the evaluation was to verify whether users could execute the required monitoring functions without examining the internal source-code structure. Black Box Testing is commonly applied to web-based applications because it enables functional requirements to be validated from the user's perspective through predefined test scenarios (Irawan et al., 2025). The evaluation in this study covered the principal functions associated with authentication, project management, progress management, documentation, verification, dashboard visualization, and reporting. The testing therefore assessed the operational completeness of the system as an integrated monitoring application rather than evaluating individual interface components independently.

The authentication function was evaluated to ensure that users could access the system through valid credentials and proceed to the functions available according to their authorization. Project-data management was then examined through data-entry and data-access scenarios to determine whether project information could be stored and retrieved through the implemented interface. Progress management was evaluated by entering project progress and checking whether the submitted information could be represented in the corresponding project record. The documentation function was assessed to verify whether supporting field information could be associated with project progress, while the verification function was examined through the Construction Manager's review process. This functional scope reflects the principle that web-based project-monitoring systems should validate not only data-entry functions but also the interaction between data processing and monitoring outputs (Lubis & Ginting, 2024). The principal testing functions and their expected operational behavior are summarized in Table 3.

Table 3. Black Box Testing Results of the Project Monitoring System

No.	Tested Function	Test Scenario	Expected Result	Actual Result	Status
1	User Authentication	Enter valid login credentials	User is authenticated and enters the system	System processes authentication and provides access	Pass
2	Project Data Management	Add and access project data	Project data are stored and displayed	Project data are stored and displayed	Pass
3	Progress Input	Submit project progress data	Progress information is recorded in the system	Progress information is recorded	Pass
4	Progress Update	Update existing progress information	Updated information replaces the previous record appropriately	Progress information is updated	Pass

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5	Documentation Management	Add project documentation	Documentation is stored and associated with project information	Documentation is stored and displayed	Pass
6	Progress Verification	Review and verify submitted progress	Verification status and notes are recorded	Verification information is processed	Pass
7	Dashboard Visualization	Access monitoring dashboard	Project indicators and progress information are displayed	Monitoring information is displayed	Pass
8	Project Status	View project status	Current project status is presented	Project status is presented	Pass
9	Reporting Information	Access project monitoring information	Required project information is available for monitoring/reporting	Project information is available	Pass

Table 3 indicates that the tested functions produced outputs corresponding to their specified operational objectives. Authentication successfully provides controlled access, while project-data and progress-management functions support the storage and retrieval of information required throughout the monitoring workflow. The documentation and verification functions also operate as interconnected components because supporting evidence and verification status can be associated with the corresponding progress record. The dashboard and project-status functions extend the stored data into an information layer that can be accessed for monitoring purposes. This functional relationship is important because a monitoring system should not only accept data but also transform stored records into information that can be used by different organizational roles. Similar findings in functional testing of web-based applications indicate that successful Black Box Testing demonstrates conformity between predefined functional specifications and observable application behavior (Irawan et al., 2025).

The verification process represents an important functional component because project progress should pass through an examination stage before being used as validated monitoring information. The test of this function examined whether submitted progress could be reviewed by the Construction Manager and whether the resulting verification information could be represented in the system. The presence of verification status and notes provides an explicit distinction between submitted information and information that has undergone managerial checking. This distinction strengthens traceability because users can identify the state of a progress record without relying exclusively on external communication. Boundary-oriented testing is also relevant to this type of application because input fields may have defined requirements concerning acceptable values, completeness, or limits, and testing at relevant boundaries can reveal functional errors that may not appear under ordinary inputs (Kartono et al., 2024). The testing approach therefore provides evidence that functional validation needs to consider both normal execution and input constraints when assessing the reliability of web-based monitoring applications.

The successful operation of the dashboard function is particularly significant because the dashboard represents the principal output layer of the developed information system. The dashboard consolidates project progress information into a visual environment in which status, target, realization, and other monitoring indicators can be accessed without manually combining separate records. This functionality supports the managerial requirement identified in the analysis of the existing system, where Project Manager monitoring previously depended on information that had passed through several manual reporting stages. Web-based dashboards have been identified as useful monitoring instruments because they can transform operational datasets into structured visual information that facilitates organizational observation and interpretation (Banerjee et al., 2025). The result is also consistent with developments in water infrastructure monitoring that emphasize integrated digital environments for improving access to operational and infrastructure information (Swan et al., 2026). The functional success of the dashboard therefore has significance beyond interface operation because it demonstrates the connection between the system's database layer and its intended management-monitoring function.

Based on the Black Box Testing presented in Table 3, the developed system demonstrated successful execution across the principal functions defined for the project monitoring workflow. The results indicate that the implemented application can support the sequence from user authentication and project-data management to progress recording, documentation, verification, and dashboard-based monitoring. This functional consistency suggests that the Prototype Model successfully translated the identified operational requirements into executable system functions, particularly because the developed modules correspond to the responsibilities of the SPV, Construction Manager, and Project Manager. Comparable project-monitoring research has reported the applicability of Prototype Model development for producing web-based systems that align application functions with user requirements (Musva & Ramadhani, 2025). The testing outcome also supports the use of Black Box Testing as a practical validation mechanism for determining whether the developed functions conform to their expected behavior (Lubis & Ginting, 2024). At the functional level, the system can therefore be considered capable of supporting the intended project progress monitoring workflow, while further evaluation using quantitative usability or software-quality metrics would be required to assess dimensions beyond functional correctness.

CONCLUSION

The developed web-based information system successfully integrates the project progress monitoring process for clean water pipeline installation at PT Bestindo Putra Mandiri. The system connects progress reporting by SPV Trunk Main/SPV Infill, examination and verification by the Construction Manager, and project-level monitoring by the Project Manager within a centralized information environment. Project data, work progress, field documentation, verification results, and project status can be managed through interconnected system functions. The dashboard presents target achievement, work realization, progress percentage, project status, and progress visualization, enabling project information to be accessed in a more structured manner. The implementation of the Prototype Model supported the development process through iterative communication, planning, prototype construction, evaluation, and refinement based on user requirements. Functional evaluation using Black Box Testing showed that the tested login, user management, project management, progress input, documentation, verification, dashboard, and reporting functions generated outputs consistent with their expected behavior. These findings indicate that the developed system provides a functional digital environment for replacing fragmented manual project-monitoring activities with an integrated web-based workflow.

Future system evaluation should be conducted periodically with the involvement of SPV Trunk Main/SPV Infill, Construction Manager, and Project Manager to ensure that system functions remain aligned with operational requirements. Periodic evaluation is important because project-monitoring requirements may change as project activities, reporting procedures, and information needs develop. User feedback can be used to identify functions that require refinement, additional information fields, interface improvements, or expanded monitoring capabilities. Further development can also consider quantitative usability evaluation and broader software-quality assessment to complement the functional validation obtained through Black Box Testing. Integration with additional digital technologies may provide opportunities to strengthen location-based monitoring, real-time data acquisition, and evidence-based project evaluation in future implementations. The system can also be expanded to support more comprehensive project reporting when organizational requirements and data availability permit. Continuous evaluation and iterative improvement will maintain the relevance of the monitoring system as an operational information infrastructure for clean water pipeline installation projects.

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