Web Based Water Quality Management System For National Water Supply and Drainage Board

R.W.M. NandaThilak 2018



Web Based Water Quality Management System For National Water Supply and Drainage Board

A thesis submitted for the Degree of Master of Information Technology

R.W.M. NandaThilak University of Colombo School of Computing 2018



Declaration

The thesis is my original work and has not been submitted previously for a degree at this or any other university/institute.

To the best of my knowledge, it does not contain any material published or written by another person, except as acknowledged in the text.

Student Name: R W M Nanda Thilak Registration Number: 2018/MIT/055 Index Number: 18550557

Level

Signature:

Date: 30/11/2021

This is to certify that this thesis is based on the work of Mr. R W M Nanda Thilak under my supervision. The thesis has been prepared according to the format stipulated and is of acceptable standard.

Certified by: Supervisor Name: Prof. G Kapila Dias

Leve Mais

Signature:

Date: 30/11/2021

Abstract

The National Water Supply and Drainage Board (NWSDB) is a government organization which is providing safe drinking water to nation and sanitation service in Sri Lanka. Currently NWSDB serves approximately 2.5 million of Consumers Island wide. NWSDB have 40 regional support centers (RSC) and 325 water supply schemes (WSS).

The problem identified that the process of water quality of the drinking water was not recorded in a repository. All documentations were in manual forms and stored in papers, which was inefficient as no security on the historical information about the water quality. Therefore, NWSDB required web-based solution to capture and store water quality data and provide alerts to act and correct the issues popup during the quality testing at laboratories.

To overcome the above issues and to increase the productivity of the laboratory staff was the concern of introducing the software product. All data stored in repository can be used by the top management to make decisions promptly.

After carefully studying the operational aspects of the laboratory process, the system which is capable to capture test results with minimum errors was introduced. The system was integrated with the testing parameters, tolerance limits and the sample location as a key input and validate for errors. Sample points were changed time to time and sample registration done through the system process. It reduced manual documentation and proceeded with the flow. All data were stored in the central database and produced dashboards, reports, and alerts at relevant time to correct stakeholder. There are 34 laboratories for testing the water quality island wide which facilitated to capture tested sample results to the system. This information is fully transparence to all the regions in NWSDB.

This online system has been used to the Rapid Application Development approach which is well applicable for this project. The online system was developed using .NET framework 4 environment using C #, MS SQL, IIS web server, HTML5 and JavaScript. Object oriented concepts have been used to build the system throughout the entire development process.

According to the design, development, and implementation process of the project up to now it fulfilled the NWSDB requirement such as keeping historical data, alerts for necessary actions, improved the laboratory efficiency etc. Proposed system properly supports to overcome the manual process and operate online water quality management System Island wide.

Acknowledgements

I would like to thank all those who gave me the support to complete this thesis. First of all, I am grateful to my supervisor Prof. G Kapila Dias, who helped with stimulating suggestions, guidance, and encouragement during the completion of the project especially in the research area and writing of this thesis.

I have gained knowledge of the laboratory process from the Assistant General Manager (Laboratory Services) Mr. Wijesinghe and the staff from National Water Supply & Drainage Board. I give my special thanks to them for helping me to understand the whole process of the laboratory services to design, develop and implement the project during this period.

Also, I would like to thank all the members of the academic and non-academic staff at UCSC for the support that was given.

I would also like to express my thanks to my friends for their valuable guidance and support that I will never forget.

Finally, I wish to thank my family for giving me support and helping me in many ways to complete my project successfully and on scheduled time.

Table of Contents

Declarationi
Abstractii
Acknowledgementsiii
List of Figures
List of Tablesix
List of Abbreviations xi
Chapter 1 – Introduction 1
1.1 Project Overview
1.1.1 About NWSDB
1.1.2 Current Method
1.2 Motivation
1.3 Objective
1.4 Background of the Study
1.5 Scope of the Study
1.6 Feasibility Study
1.6.1 Economic Feasibility
1.6.2 Technical Feasibility7
1.6.3 Operational Feasibility7
1.6.4 Legal Feasibility7
1.7 Structure of the Dissertation
Chapter 2 – Background
2.1 Introduction
2.2 Requirement Analysis
2.2.1 Requirement Gathering
2.2.2 Functional Requirements 11
2.2.3 Non-Functional Requirements

2.3 Review of Similar Systems	12
2.4 Related Technologies	15
2.4.1 Development Tools	15
2.4.2 Server Requirement	16
2.4.3 Client Requirement	16
2.5 Related Design Strategies	17
Chapter 3 - Design Architecture	19
3.1 Introduction	19
3.2 System Architecture	19
3.2.1 Proposed System Architecture	19
3.2.2 System Users	20
3.3 UML Diagrams	22
3.3.1 Use Case Diagram	22
3.3.2 Use Case Narratives	24
3.3.3 Sequence Diagrams	37
3.3.4 Class Diagram	42
Chapter 4 – Methodology	44
4.1 Introduction	44
4.2 Tools and Technologies	44
4.2.1 Microsoft Windows 10	44
4.2.2 Dot net framework 4.0	44
4.2.3 Visual Studio 2015	44
4.2.4 DHTML Menu	45
4.2.5 Hibernate	45
4.2.6 Microsoft SQL Server 2014	45
4.3 Hardware and Software Requirements	45
4.3.1 Server Installations	45
4.3.2 Client Installation	46
4.4 Modularity of the System	46
4.5 High Level Programming	47
Chapter 5 - Testing and Evaluation	51
5.1 Introduction	51
5.2 System Testing Methods	51
5.3 Functional Testing	52

5.3.1 Test Plan	52
5.3.2 Test Cases	57
5.4 Non-Functional Testing	65
5.4.1 Security Testing	65
5.4.2 Usability Testing	66
5.4.3 Performance Testing	66
5.5 Maintenance Testing	67
5.6 User Evaluation	68
5.7 User Evaluation Outcome	70
5.7.1 Appearance	70
5.7.2 Usability	71
5.7.3 Functionality	72
5.7.4 Performance	73
Chapter 6 - Conclusion	75
6.1 Problems Encountered and Lesson learned	75
6.2 Future Enhancements	77
References	
Appendix A – System Manual	79
Appendix B – User Manual	80
Login/Home Screen	80
Master Data Management	80
Transaction Data Management	87
Dashboard	90
Appendix C – Management Reports	94
Reports	

List of Figures

Figure 1.1: Current Water Quality Testing & Recording Process
Figure 1.2: Water Quality Testing & Recording Process with Repository5
Figure 2.3.1: Water Quality Dashboard13
Figure 2.3.2: Water Quality Management Screen Shots15
Figure 2.5.1: Rapid Application Development Model17
Figure 2.5.2: Object Oriented Programming
Figure 3.1: Architecture Diagram for Proposed System
Figure 3.2: WQM User Levels
Figure 3.3: WQM Use Case Diagram
Figure 3.4: Create Sample Point Sequence Diagram
Figure 3.5: Update Sample Point Sequence Diagram
Figure 3.6: Delete Sample Point Sequence Diagram
Figure 3.7: Create Test Parameter Sequence Diagram
Figure 3.8: Update Test Parameter Sequence Diagram40
Figure 3.9: Delete Test Parameter Sequence Diagram40
Figure 3.10: Update Test Result Sequence Diagram
Figure 3.11: Delete Test Result Sequence Diagram
Figure 3.12: View Dashboard Sequence Diagram
Figure 3.13: Class Diagram for Proposed System
Figure 4.1: User Interface Layer for Proposed System
Figure 4.2: Application Layer for Proposed System47
Figure 4.3: Data Mapping Layer for Proposed System
Figure 4.4: Domain Layer for Proposed System
Figure 4.5: Database Structure for Proposed System
Figure 5.1: Software Testing Types

Figure 5.2: Non-Functional Testing Parameters	65
Figure 5.3: Software Evaluation Form	69
Figure 5.4: Graphical Representation of Evaluation Result for Appearance	70
Figure 5.5: Graphical Representation of Evaluation Result for Usability	71
Figure 5.6: Graphical Representation of Evaluation Result for Functionality	72
Figure 5.7: Graphical Representation of Evaluation Result for Performance	73
Figure B.1: Login & Home Page	
Figure B.2: Master Data Management Menu	
Figure B.3: Scheme Management	81
Figure B.4: Scheme Management Add Record	81
Figure B.5: Scheme Management Modify Record	
Figure B.6: Source Type Management	
Figure B.7: Source Management	83
Figure B.8: Source Used Scheme Management	
Figure B.9: Sample Point Management	84
Figure B.10: Testing Parameter Management	
Figure B.11: Testing Parameter Tolerance Management	
Figure B.12: Testing Parameter Rate Management	86
Figure B.13: Testing Parameter Group Management	86
Figure B.14: Transaction Data Management Menu	
Figure B.15: Sample Registration Form	
Figure B.16: Sample Registration View with Search Option	
Figure B.17: Enter Test Results for Selected Sample Registration No	
Figure B.18: Approve the Test Results Enter by Chemist Using Sample No	
Figure B.19: Dashboards for Water Quality Management System	90
Figure B.20: Detail Analysis Dashboard	91
Figure B.21: Summary Analysis Analytical Data	91
Figure B.22: Summary Analysis Graphical View	92
Figure B.23: Source Type Analysis Analytical Data	92
Figure B.24: Source Type Analysis Graphical View	93
Figure C.1: Reports for Water Quality Management System	94

Figure C.2: Water Oualit	Monitoring Summary	 95
	,	

List of Tables

Table 3.1: Manage Users Use Case Narratives	24
Table 3.2: Manage Scheme Use Case Narratives	25
Table 3.3: Manage Source Type Use Case Narrative	26
Table 3.4: Manage Source Use Case Narrative	27
Table 3.5: Manage Scheme Source Mapping Use Case Narrative	28
Table 3.6: Manage Sample Point Use Case Narrative	29
Table 3.7: Manage Test Parameter Use Case Narrative	30
Table 3.8: Manage Test Parameter Tolerance Use Case Narrative	31
Table 3.9: Manage Test Parameter Rate Use Case Narrative	32
Table 3.10: Manage Sample Registration Use Case Narrative	33
Table 3.11: Capture Test Result Use Case Narrative	34
Table 3.12: Approve Test Result Use Case Narrative	35
Table 3.13: Manage Alert Use Case Narrative	36
Table 3.14: View Dashboards Use Case Narrative	37
Table 5.1: System Login Interface Test Plan	53
Table 5.2: Define Scheme Test Plan	54
Table 5.3: Define Test Parameters Test Plan	55
Table 5.4: Define Test Parameter Tolerances Test Plan	56
Table 5.5: Sample Registration Test Plan	57
Table 5.6: Save without click Register Button	58
Table 5.7: Save without Selecting RSC	59
Table 5.8: Save without Selecting Region	60
Table 5.9: Save without Selecting Scheme	61
Table 5.10: Save without Selecting Source.	62
Table 5.11: Save without Selecting Sample Point	63

Table 5.12: Save without Entering Sample Date	64
Table 5.13: Analysis of the results for execute of transaction	67
Table 5.14: Evaluation Result for Appearance	70
Table 5.15: Evaluation Result for Usability	71
Table 5.16: Evaluation Result for Functionality	72
Table 5.17: Evaluation Result for Performance	73

List of Abbreviations

HRM	-	Human Resource Management
HTML	-	Hyper Text Mark-up Language
NWSDB	-	National Water Supply and Drainage Board
OIC	-	Officer in Charge
RSC	-	Regional Support Center
SMS	-	Short Message Service
WQM	-	Water Quality Management
WSS	-	Water Supply Scheme
UI	-	User Interface

Chapter 1 – Introduction

This report is the final outcome of the thesis study for the Master of Information Technology (MIT) at University of Colombo School of Computing. National Water Supply and Drainage Board (NWSDB) operates laboratories island wide to check the quality of the water providing to the consumers. Operations related to water quality analysis was continued as a manual work for years. It is identified maintaining a central data repository for the water quality data of the NWSDB is important and selected as my academic project which has become a solution to the NWSDB and solves their burning issue on data management.

1.1 Project Overview

1.1.1 About NWSDB

The NWSDB has been established in 1973 as a public sector organization which was providing safe drinking water to the nation and reclamation the wastewater of Sri Lanka. NWSDB currently operated under ministry of water supply. We covered 45% of the water coverage and cater 2.5 M of customers. To provide safe drinking water, organization required to check and double check the water quality and store information to make decision.

1.1.2 Current Method

In present we have 31 labs island wide. They have responsible to test water samples and inform any water quality tolerance to relevant official to take remedial action. All tests are based on SLS standard. We are dealing with the 2.5M customers to provide safe drinking water by testing and maintain water quality standard. All labs are collected samples around the region define by the central lab and tested for quality of the water. All results are recorded in manual (book or paper). At the end of the month, they were entered to the excel sheet and send to central lab located in Head Office Ratmalana. There are issues during this monthly process and history is not in data format all are entered in Excel forms. Therefore, very difficult to analyse and prepare reports very quickly. (Refer figure 1.1).

Current Water Quality Testing and Recording Process

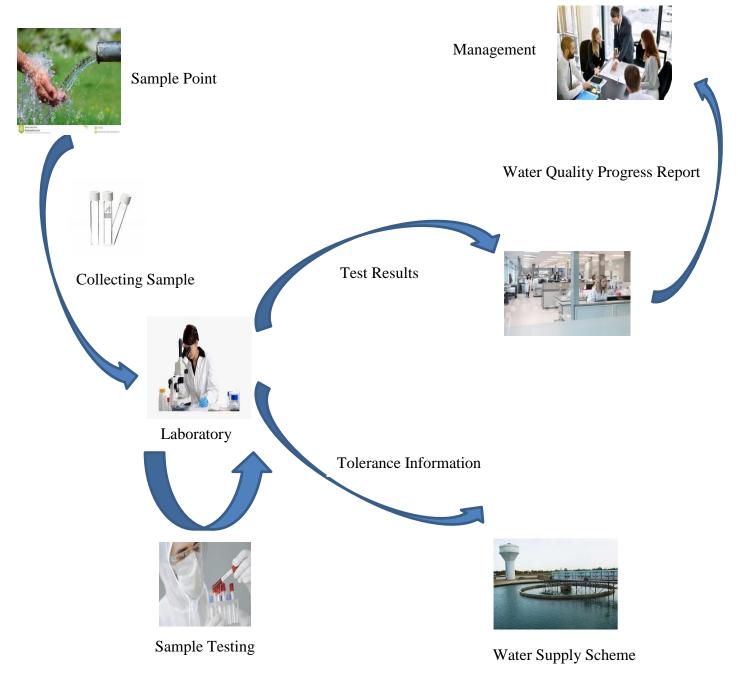


Figure 1.1: Current Water Quality Testing & Recording Process

1.2 Motivation

There are several barriers identified in this process are as follows.

- All the chemist and snr. Chemists who are used to this process and they must keep all data manually. When need historical data for any requirement they must find the record manually
- 2. They have released the pressure of keeping documents in manual format.
- 3. No need to do manual process to find out issues during their testing recordings
- 4. There are communication barriers which is important to inform unsatisfactory result to the relevant officials. For their action to provide safe drinking water to consumers. There is more sophisticated mechanism, and they have to waste their time for communication
- 5. Raw water analytical data required to future improvement of NWSDB. They do not fulfil the nation requirement for giving all people to water. Therefore, historical test result required for raw water is essential for build water supply schemes in the island.
- 6. No online information system to find out the results whenever required. To take decision they need unacceptable time to analyse from historical data.
- 7. Manual process was slower than time for the analysis is higher. When computerized it become low and officers can do more other required work to the organization

1.3 Objective

Final goal for the process is to remove all manual work and utilized central data repository to answer all requirement given by management time to time. Avoid manual document filling process and kept in the record room for years.

Improve the communication gap between OIC and the chemist. Because they have to make decision about the water quality before release to the consumer

Identified Key Objectives are

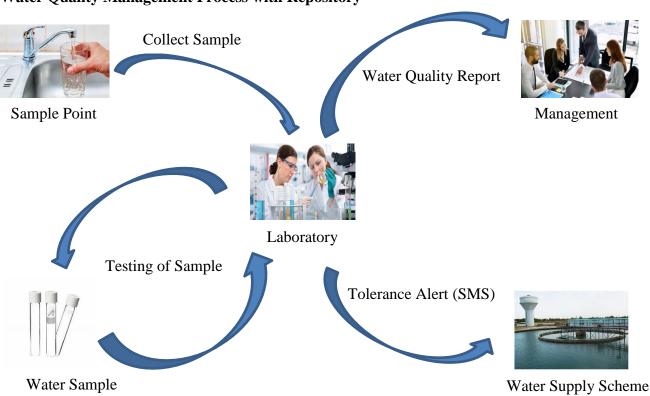
- 1. 100% paperless process for Lab operations for sample testing and reporting.
- 2. Water quality data in central data warehouse which required NWSDB as well as national need
- 3. Testing parameter tolerance can be popup where issue occurred.

- 4. 100% user satisfaction when all operations bundled into single solution
- 5. Higher management can view all important requirement of water quality management.
- 6. SMS alerts can be used to communicate within the data flow of the water quality of NWSDB
- 7. Top to bottom transparency of the water quality throughout the NWSDB
- 8. Maximum utilization of human resource by reducing manual work and other data entry work

1.4 Background of the Study

I studied the manual process of water quality management of NWSDB and summarise as follows.

- Study based on the Central Laboratory and Regional Laboratory in the NWSDB Island wide. There is day to day operations and record keeping is the most important fact.
- Water quality checking sample points and the scheme identified in this study
- SLS standard parameters were introduced to the WQM system as a master data
- All tolerance of parameters defines based on the water quality type (Raw Water, Treated Water and Wastewater)
- Water quality testing based on the Region, Cost Centre, Scheme, Source and Sample Point. They were identified through regional laboratory staff. All master data elements feed by regional Laboratory as a one-time job.



Water Quality Management Process with Repository

Figure 1.2: Water Quality Testing & Recording Process with Repository

1.5 Scope of the Study

Real time water quality capturing process through the Laboratory from island wide is necessary. Sample point water quality analysis is the most important factor. Therefore, we have decided to have water quality data viewed by single click on relevant GPS on the map

Data capturing basis dashboard produce to top management as a decision-making tool. They can view relevant information for the selected region (Refer Figure 1.2).

Through google map stakeholder can easily reach the destination wherever requirement occurred. There should be a possibility to visit physically to rectify the water quality issue obtain from the sample point.

Warning alerts are setting up to proper exclamation within the organization. Using this method, we can minimize the water quality issues arose during the water production/distribution process.

To reduce the manual work and provide reports warning alerts and other information from the system. Not necessary to collect Data Island wide and prepare the reports minimize the HRM issues.

NWSDB design new water supply scheme, design people required water quality for that area before finalizing the project. For this project scope raw water quality must needed requirement for past years. When we kept those data in central repository system is important to make decision to complete the new water supply scheme development process.

1.6 Feasibility Study

I have carefully done the feasibility of the project and identified 4 main categories as follows.

1.6.1 Economic Feasibility

As a first step we need to analyse whether the manual system than computerized system economical to the organization. There are lot of improvement can identify during this study as follows.

- Reduce time by removing separate data entry and analysis process
- Test result capturing to the central system. Therefore system must be capable of producing island wide test results and unsatisfied test easily
- SLS standards (Tolerance) are mapped to the testing parameters. It is very useful to produce warnings and quick SMS to get the precaution to minimize the water quality issue
- Minimize the printing cost by introducing dashboard concept to the NWSDB. We can reduce work force use to produce reports and other important documents.'
- System designed developed based on the user requirement. All the user interfaces are user friendly and minimize the data entry work at point of capturing test results to the system.

1.6.2 Technical Feasibility

This web-based solution developed to chief chemist, senior chemist and chemist located in the island wide Labourites. They are highly educated employees in the NWSDB and get their support is very easy. This product use as a in-house system and all labourites are connected to one NWSDB hub. NWSDB having datacentre to minimize the data losses by automated backing up facility and solution can be deployed in virtual environment which enabled high tech infrastructure available in the organization. NWSDB having system administrators stationed in regional level and they have a technical capability to solve the technical issues.

1.6.3 Operational Feasibility

To run the web-based solution each and every laboratory must need following requirement

- Newest computer which is capable to run web-based solution
- Connection to the NWSDB virtual private network as the web client.
- Computer literacy of every chief chemist, senior chemist, and chemist
- System integrated with the NWSDB HRM system to control the employee status
- Datacentre having 24x7 data security and reliability. Automated backup facility with 100% guarantee of data.

1.6.4 Legal Feasibility

Water Quality Management System should be fully capable with the security policy of NWSDB. System can access only for the valid employees in the NWSDB. These invalid statuses are retired, suspend interdict etc. Therefore, considering all these facts system will legal feasible than manual system.

1.7 Structure of the Dissertation

This dissertation is compiled with the following component as follows.

• Introduction:

Introduction to the problem domain identified as water quality management of NWSDB. This Solution converts the manual process to computerised solution.

• Background:

In this chapter we discuss about the functional and non-functional requirement. Also find out similar products in the problem domain.

• Methodology:

About this chapter I will produce my approach to solve problem domain. All analysis and evaluation of my methodology to solve the problem

• Evaluation:

Using evaluation forms distributed among the system users and get their consent about the product and product features which is over the manual system.

• Conclusion:

Introduction to conclusion will be produce based on the careful analysis of the project. Everything explains one by one and provides clear comparison of each scenario as

Chapter 2 – Background

2.1 Introduction

This chapter consists of requirement analysis, fact gathering, and interviews to identify the real situation of water quality management domain of NWSDB

2.2 Requirement Analysis

Requirement Analysis is the very first activity in SDLC followed by Functional Specification and so on. Requirement analysis is a important step in SDLC as it resonates with acceptance testing that is critical for product acceptance by customers. There are various steps involved, outcomes, challenges, and corrective measures in requirement analysis.

Requirement analysis starting from:

- Requirement gathering which is also called as elicitation.
- After that analysing the collected requirements to understand the correctness and feasibility of converting these requirements into a possible product.
- At last, documenting the requirements collected.

2.2.1 Requirement Gathering

Central Laboratory is the main customer of this system. There are another 30 Regional Laboratories around the NWSDB as users of the system. I have gathered information from central laboratory and regional laboratory to identify their operation in NWSDB. They are fully responsible to test water samples and produce reports to management and unacceptable tolerance limit must be informed to relevant water sample stakeholders. There are proven techniques to gather requirement from the stakeholders. These techniques are as follows.

2.2.1.1 Interviews

Interviews are one of the easiest and most powerful techniques available for gathering requirements. Accordingly, I have conduct interviews with the laboratory staff including chief

chemist, senior chemist, chemist and other people involved in the sample testing. To do this I have prepared questions and get the stakeholder acceptance to design the water quality management system.

These questions are.

- How many samples are tested for the day?
- Are they satisfied with the operational method used in the current (Manual) process?
- What are the parameters frequently check?
- Current methods of storing testing results are secured, accessible to the management, generating reports etc.

Discuss about easiness of having software solution instead of doing manually. These interviews allow giving quick answers and justifying with the manual process. I have examined the stakeholder reaction and get an idea of the new solution response during the interview. This method enables the collection of the most important information, the definition of the requirements, stakeholder roles and responsibilities, a clear understanding of the manual process and what is expected from the proposed system.

2.2.1.2 Stakeholder Observations

I have Observed the users in the water quality testing environment is a good accurate method to identify system requirements. In addition to the information that I collected from interviews there were hidden information's that I collect by observations.

My observations start from the Central Laboratory in Head Office. I observed how they test water samples and record in manual form and store in the record room. This process was totally manually driven system having more risk. Finally, I visited to the Regional Laboratory and observed their process and identified that, they have to communicate with WSS for their water quality tolerance exceed the SLS requirement. This is the important requirement where unsatisfactory of water quality cause issues in our drinking water distribution.

2.2.1.3 Analyzing Existing Documents

NWSDB water quality recording documentation was fully manual work. At the end of each month, they have entered to the excel form and send it to Central Laboratory for report generation. In this analysis I found that there is no method to get the information quickly whenever required?

I have analyzed the documents and generated reports based on the frequency used and the need of the report. These monthly reports are important to management for their decision making.

Analyzing existing documents can prove to be a useful technique in requirement gathering, on its own as well using it to supplement other techniques.

2.2.2 Functional Requirements

I have identified the functional requirement during the requirement analysis. In this project web based water quality management system is the solution provided to the laboratory to capture and reporting their sample testing process. Following are the list of functional requirements.

- System should provide facilities to manage Schemes as a master data.
- System should provide facilities to manage water sources with mapping to the schemes.
- System should provide facility to maintain testing parameters and their tolerance limits
- Sample points are maintained by the system which is the most required data element to capture water quality.
- System should provide facilities to capture daily water quality results to the system
- System should provide Reports and online Dashboard to monitor the water quality of the organization
- System should be able to send SMS in relevant stages to relevant users.
- System should provide facility to view all relevant details of captured water quality.
- System should provide secure access for each user only to relevant region and under relevant access rights

2.2.3 Non-Functional Requirements

There are non-functional requirements identify for the water quality management system as follows.

Performance - The solution should respond quickly to user request initiated from client machine. After processing data at server, the data will be ready and the request for information from the system will be available to view in the screen. The screen should load immediately.

User Friendly – The web-based application must be user friendly. NWSDB users are not fully fluent in computer literacy. Therefore, input screens must be in standard format, and then users can use system easily. User trainings are important to educate the users in the organization which they don't having fully awareness of the system otherwise they reject the system.

Reliability – Laboratory users are not using any software solution right now. Therefore, I have to build trust about the data and the outputs. To do this, I have to prove the reliability by demonstrating the structure of the data ware housing and connectivity of the solutions.

Availability - The water quality management system will be available to the user on VPN for all time. If we need a down time of the system, advance notification will be required to minimize data capturing process.

Security – User account for the water quality management system will be created and managed by system administrators in island wide. They are also responsible for the access rights of the users to prevent unauthorized transaction to be entered to the system. System and database backups are scheduled and transferred to the data store located in separate device.

Maintainability - System will be maintained by the IT division. All documentations and source codes of the system will be provided, and it will give instruction about use of and maintenance of the system.

2.3 Review of Similar Systems

I have gone through the internet and find out software solutions available which is applicable for my development. These solutions are as follows.

2.

1. Locus technologies provide cloud-based software solution manage water quality data and provide varies dashboards, reports and mobile app's to water utility companies. (Refer figure2.3.1) (Technologies, 2021)



Some of the key features are as follows.

- Take control of your drinking water and ops data and ditch the spreadsheets.
- Whether testing for the latest UCMR list, taste and odour, corrosion, customer complaints, new main construction, or basic water quality issues, trying to manage the abundance of data from various sources can get overwhelming— especially if you're storing this data in a complex web of spreadsheets and in-house databases.
- Flexible sample planning for routine sampling
- Pre-printed COCs
- Mobile app for samplers/Ops data
- Coliform and other routine reports
- Instant results on GIS maps
- Permits and DMRs
- CCR calculations and report inputs
- Custom mobile forms for Ops data
- Monitor contaminants such as per and polyfluoroalkyl (PFAS)
- Generate and submit XML via web services to EPA's Compliance Monitoring Data Portal

Dashboard screen shot.

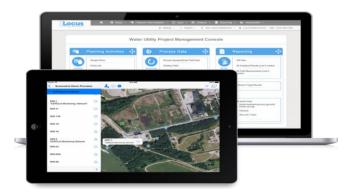


Figure 2.3.1: Water Quality Dashboard

3. Hydro-Comp enterprises provide water quality management software which having varies reports, information screens etc. (Water Quality Management | Laboratories, 2020)



Some of the important features are as follows.

The environmental Integrated Water Quality Management System (IQMS) can be used to monitor water / effluent quality by the Utility / Municipality.

Water quality management includes the systematic collection of physical, chemical, and biological information, and the analysis, interpretation and reporting of those measurements, according to a pre-planned design and structure. Effective quality management programs include the following components:

- Information requirements and objectives.
- Sampling programs including type, scale, and measurement parameters.
- Sampling methodology.
- Laboratory and field analysis.
- Quality assurance and quality control procedures
- Statistical analysis and interpretation of the data
- Reporting and dissemination of information to various stakeholders

The EDAMS Water Quality Management System has been specifically designed to meet the requirements identified above. It supports a proprietary data structure that makes it eminently suitable for use in both monitoring and management of quality data. The system can be used effectively as the main operational monitoring tool acting as a trigger for immediate corrective actions to operational procedures, thereby improving drinking quality. 4. Verdant's Drinking Water Quality Management Web-Based Software Compliance Solution. There are features which are very comprehensive and informative. (Tech, 2021)



Some of the key features are as follows.

- Verdant Web Technologies' Drinking Water Quality Management Software module provides web-based access to drinking water sampling reports and testing results
- Verdant's web-based software system provides a sortable list of buildings, making it easy to locate drinking water quality data for specific facilities. Easily upload new or archived sampling reports. Our drinking water quality management software allows facility owners and maintenance staff to access drinking water quality data paperless and with ease. (Refer Figure 2.3.2) dashboard of the system.



Figure 2.3.2: Water Quality Management Screen Shot

2.4 Related Technologies

According to the current technologies I have selected following tools to develop the web based water quality management system. The Server requirement & Client requirement for deployment also discussed.

2.4.1 Development Tools

• Microsoft Windows 10

Windows 10 is a latest operating system and use for my application development OS. This operating system is developed by Microsoft as a part of the Windows NT family.

- Dot Net framework 4.0 or higher The .NET Framework is a tool developed by Microsoft and works primarily on Microsoft Windows. It includes a class library called the Framework Class Library, which provides language integration to run many programming languages.
- Visual Studio 2015

Microsoft Visual Studio is an integrated development environment for Microsoft. It is used to develop my web-based applications. There are many more facility to develop websites, web applications, web services and mobile applications.

2.4.2 Server Requirement

- Microsoft Windows Server 2012
 Windows Server 2012 is the fifth version of Microsoft's Windows Server operating system, It also a part of the Windows NT family of operating systems.
- IIS web server

The Internet Information Service is a web server to host software developed by Microsoft for use in the Windows NT family.

• MS SQL 2014

Microsoft SQL Server is a database management system developed by Microsoft. Database Server can manage storing and retrieving data at the request of other software solutions.

2.4.3 Client Requirement

- Microsoft Windows 7 or above
 Windows is an operating system developed by Microsoft and part of the Windows NT family. In client environment manage by Windows OS in NWSDB.
- Web Browser Internet Explorer/Microsoft Edge, Firefox, Google chrome
 The web browser is a software application that accesses information about the World Wide
 Web. When a user needs to access the application from a web server, the browser
 downloads the necessary content from the web server and displays the page on the user's

device. NWSDB users can access water quality management system which is hosted in the datacentre webserver by locally.

2.5 Related Design Strategies

NWSDB IT division selected to use rapid application development method to design and develop the systems. This method was more suitable for the environment and culture of the organization. Their business processes are not computerized and manual operations are taken place.

Rapid Application Development Methodology

Rapid Application Development (RAD) is a form of agile software development methodology that prioritizes rapid prototype releases and iterations. Unlike the Waterfall method, RAD emphasizes the use of software and user feedback over strict planning and requirements recording (Refer Figure 2.5.1)

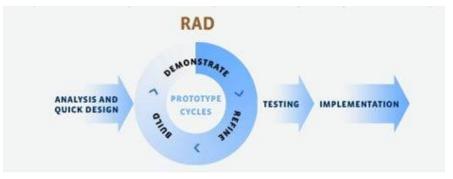


Figure 2.5.1: Rapid Application Development Model

There are 5 steps to use RAD as a standard. These steps are as follows.

Step 1: Define and finalize project requirements

During this step, stakeholders sit together to define and finalize project requirements such as project goals, expectations, timelines, and budget. When you have clearly defined and scoped out each aspect of the project's requirements, you can seek management approvals.

Step 2: Begin building prototypes

As soon as you finish scoping the project, you can begin development. Designers and developers will work closely with clients to create and improve upon working prototypes until the final product is ready.

Step 3: Gather user feedback

In this step, prototypes and beta systems are converted into working models. Developers then gather feedback from users to tweak and improve prototypes and create the best possible product.

Step 4: Testing

This step requires you to test your software product and ensure that all its moving parts work together as per client expectations. Continue incorporating client feedback as the code is tested and retested for its smooth functioning.

Step 5: System Presentation

This is the final step before the finished product goes to launch. It involves data conversion and user training.

Object Oriented Programming (OOP)

I have decided to use OOP method to develop the system. NWSDB have an existing OOP framework, which is used for existing system development. Therefore, I have used the same framework to develop water quality management system. (Refer Figure 2.5.2)

Object-oriented programming (OOP) is a computer programming model that organizes software design around data, or objects, rather than functions and logic. An object can be defined as a data field that has unique attributes and behaviour.

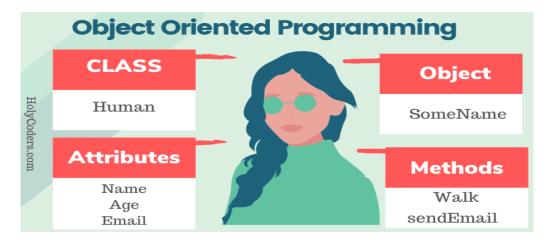


Figure 2.5.2: Object Oriented Programming Technique

Chapter 3 - Design Architecture

3.1 Introduction

Software design architecture refers to the fundamental structures of a software system and the discipline to creating such structures and systems. Each structure complied within software elements, relations between them, and attributes of both elements and relations.

3.2 System Architecture

The systems architecture has defined as architecture of new system that consists of both hardware and software. The main concern of the systems architecture is then the integration of software and hardware as a complete working model of connecting all devices. There is much broader definition, the term applies to the system architecture of any complex system which may be of technical, sociotechnical or social nature.

3.2.1 Proposed System Architecture

The Water Quality Management System is a Web Based solution hosted in centralized virtual server of Datacentre located at the Head Office of NWSDB. For the hosting we use windows 2012 R2 OS with IIS 6.0. This system only uses for the NWSDB users therefore it can be access through an intranet. Access URL is 10.0.0.200\erpapp which can be browse within the organization through VPN or RVPN. Figure 3.1 shows the system architecture diagram of the proposed Water Quality Management System.

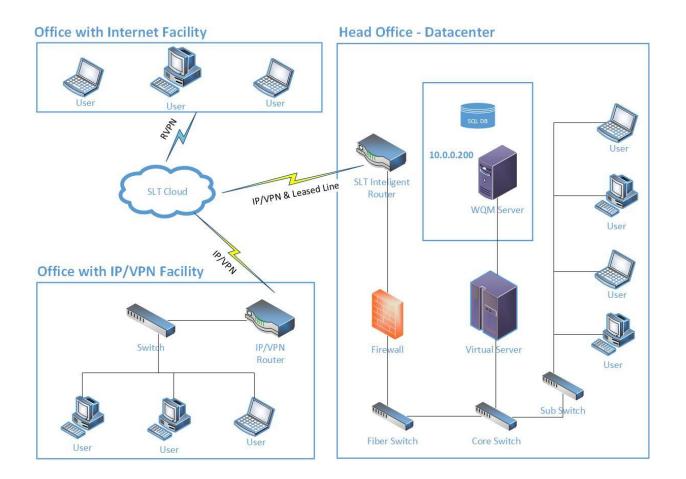


Figure 3.1: Architecture Diagram for the Proposed System

3.2.2 System Users

According to the system requirement we have analyse those four levels of users required to fulfil the operations of WQM system. In manual operation there is no operational levels, all data elements are written in manual document and signed by the higher officer (Chemist) before sending it to management. These proposed four levels are represented in figure 3.2.

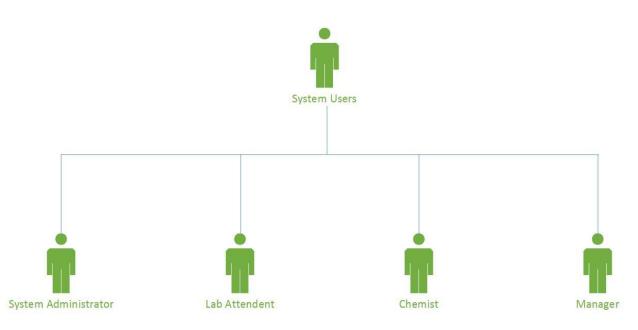


Figure 3.2 WQM User Levels

WQM process above user responsibilities and their roles are as follows.

System Administrator

All user's management responsibility goes to the system administrator. Some of the master data management process also handle by him. Access rights and user training handled by him within the region of NWSDB. All region having IT professional system administrator.

Lab Attendant

Most important job function assigned to him by laboratory service in NWSDB. He is the one responsible to register the sample which was taken from the field and conduct the testing according to the SLS stranded and guidance of the chemist. Maintain master data and the capturing test result also his duty within the WQM system.

Chemist

Approval authority given to him as a chief of the labourites island wide. WQM system generate alerts based on his approval. System checked the tolerance of each parameter and highlighted the un-satisfactory results in the approval stage of the system.

Manager

Dashboards are defined in the system to indicate unsatisfied water quality of the drinking water. This is open to higher management to monitor the WQM system.

3.3 UML Diagrams

In software development process, Unified Modelling Language is a standard visual modelling language intended to be used for following

- Modelling business and similar processes,
- Analysis, design, and implementation of software-based systems

According to the above facilities we have chosen UML as a tool for WQM design and development of the software product. There are two categories called Behavioural Diagram and Structural Diagram in this UML process. We have selected most required diagrams in each category as follows.

Behavioural Diagram

- Use Case Diagram
- Sequence Diagram

Structural Diagram

Class Diagram

3.3.1 Use Case Diagram

The most known diagram type of the behavioural UML types, Use case diagrams give a graphic overview of the actors involved in a WQM system, different functions needed by those actors and how these different functions interact the process. In this diagram we can easily identify the main actors involved and the main processes of the system. For the WQM system define use case diagram shown in the figure 3.3

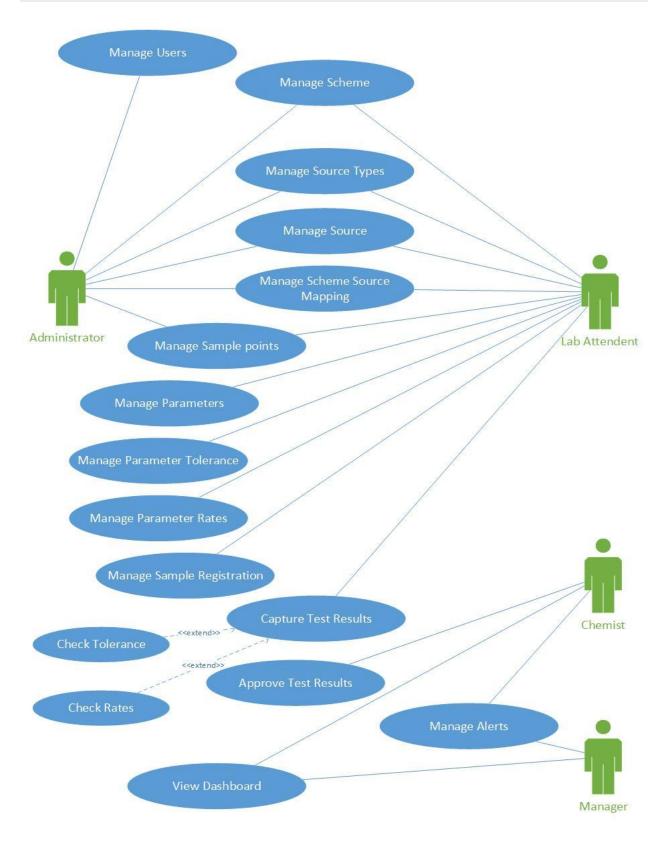


Figure 3.3 WQM Use Case Diagram

3.3.2 Use Case Narratives

Use case narration is represented as a text. Action of the sequence of events encountered when an actor is cooperating with the system. There can be several use cases associated with a system, each of them describes the system in a functional or behavioural point of view. Accordingly, we have developed the format to store use case narratives for the WQM system. We referred the (Google, 2021)to develop the use case narrative format.

3.3.2.1 Manage Users

Use Case ID:	1								
Use Case Name:	Man	Manage Users							
Process Owner:	Syste	em Administrato	r Last Updated By:	NandaThilak					
Date Created:	12/0	3/2021	Date Last Updated:						
Business A	ctor:	System Admin	istrator						
Description:		Manage system	users by creating and assign	access rights					
Preconditions:		User must be an employee of the NWSDB							
Postcondit	ions:	Retirement of the employee is used as end of the system access							
Performance	Goal:								
Basic Work	flow:	Create							
		 Select User from HRM Assign Default Password Save User 							
		Assign Access Rights							
		2. Select	User from HRM Modules & Roles to provide Access Rights	e Access					

Table 3.1: Manage Users Use Case Narratives

3.3.2.2 Manage Scheme

Use Case ID:	2	2						
Use Case Name:	Mana	ige Schem	e					
Process Owner:		System Administrator Lab Attendant		Last Updated By:	NandaThilak			
Date Created:	12/0	12/03/2021		Date Last Updated:				
Business A	ctor:	System A	Administr	ator, Lab Attendant				
Description:		0	re. GPS o	ply schemes by selecting coordinate provide locatin	appropriate region and the ng facility among the			
Precondit	ions:	User must have access rights to create/update /delete scheme in WQM system						
Postcondit	ions:	Cannot remove scheme where source is mapped to the scheme. Also any test result generated for this scheme cannot remove.						
Performance (Goal:							
Basic Workflow:		2. 1 3. 5 Update 1. 5 2. 1 3. 5 Delete 1. 5 2. 0	Input Na Save Sche Select Sch Modify E Save Sche Select Sch	neme from Grid View Elements eme neme from Grid View ete Button	s			

 Table 3.2: Manage Scheme Use Case Narratives

3.3.2.3 Manage Source Types

Use Case ID:	3	3							
Use Case Name:	Mana	Manage Source Types							
Process Owner:		System Administrator Lab Attendant		Last Updated By:	NandaThilak				
Date Created:	12/03/2021			Date Last Updated:					
Business A	ctor:	System	Administr	ator, Lab Attendant					
Description:		Source the sam	• •	lefine based on the water	product which are used for				
Preconditions:		Source types are categorize based on raw water, treated water and waste water							
Postcondit	ions:	Cannot remove where sources are defined for the source type							
Performance (Goal:								
Basic Work	flow:		Modify re Save Sour Select Sou	ailability rce Type urce Type from Grid Viev equired field					

 Table 3.3: Manage Source Type Use Case Narrative

3.3.2.4 Manage Source

Use Case ID:	4	4						
Use Case Name:	Manag	Manage Source						
Process Owner:	System Administrator Lab Attendant			Last Updated By:	NandaThilak			
Date Created:	12/03/	/2021		Date Last Updated:				
Business A	ctor:	System	Administr	ator, Lab Attendant	·			
Descrip	tion:	All sour	ces used f	or sample testing were de	fine as master data			
Preconditions:		Cannot remove where sample points or sample test data are available						
Postconditions:		Cannot Delete Source where test results are available						
Performance Goal:								
Basic Work	τ	Create 1. 2. 3. 4. Update 1. 2. 3. Delete 1. 2. 2.	Check Av Save Sour Select Sou Modify re Update So Select Sou	arce Details vailability rce arce from Grid View elevant fields				

 Table 3.4: Manage Source Use Case Narrative

3.3.2.5 Manage Scheme	Source Mapping
-----------------------	----------------

Use Case ID:	5							
Use Case Name:	Manage S	Manage Scheme Source Mapping						
Process Owner:	System A Lab Atter	dministrator 1dant	Last Updated By:	NandaThilak				
Date Created:	12/03/2021		Date Last Updated:					
Business A	ctor: Sys	tem Adminis	trator, Lab Attendant	·				
Description:		Defined source and scheme were mapped for the relevant RSC, Region and Cost Centre. It will helpful for the data capturing process of the sample test results						
Precondit	ions: Sou	Source can map for different schemes						
Postcondit	ions: Ma	Mapping relation used to retrieve the source for selected scheme						
Performance (Goal:							
Basic Workflow:		 Enter o Save Sc date Select S Select U Modify Save 	heme Source Mapping cheme Jpdate Source					

Table 3.5: Manage Scheme Source Mapping Use Case Narrative

3.3.2.6 Manage Sample Points

Use Case ID:	6	6 Manage Sample Points					
Use Case Name:	Man						
Process Owner:	-	System Administrator Lab Attendant		Last Updated By:	NandaThilak		
Date Created:	12/03/2021			Date Last Updated:			
Business A	ctor:	System Adm	inistr	rator, Lab Attendant	·		
Descrip	tion:	*		e defined before capture tl ge time to time.	he test results. Sample		
Precondit	ions:	Cannot capt	ure te	est result without sample p	point		
Postconditions:		Test results analyse based on the sample points					
Performance Goal:							
Basic Work	flow:	Create					
		2. Ente	er Sai	gion, Cost Centre, Schem nple Point Details ple Point	e, Source		
		Update					
		 Select Region, Cost Centre, Scheme, Source View Sample Points in Grid View Select Sample Point Modify required fields Save Sample Point 					
		Delete					
		 View Sele 	v San ct Re	gion, Cost Centre, Schem aple Points in Grid View quired Sample Point ecord	e, Source		

Table 3.6: Manage Sample Point Use Case Narrative

3.3.2.7 Manage Parameters

Use Case ID:	7	7						
Use Case Name:	Mana	Manage Parameters						
Process Owner:	Lab .	Attendant		Last Updated By:	NandaThilak			
Date Created:	12/0	3/2021		Date Last Updated:				
Business A	ctor:	Lab Atte	endant		1			
Description:				fined with the unit and te ed to capture the test resu				
Preconditions:		Capture test results only for define parameters						
Postconditions:		Cannot remove parameters where Tolerance, Rates and results were captured to the system						
Performance (Goal:							
Basic Work	flow:	2. 3. Update 1. 2. 3. Delete 1.	Enter Par Save Para Select Par Modify de Save Para	rameter from the Grid Vi ata meter rameter from the Grid Vi				

Table 3.7: Manage Test Parameter Use Case Narrative

Use Case ID:	8	8						
Use Case Name:	Mana	Manage Parameter Tolerance						
Process Owner:	Lab /	Attendan	t	Last Updated By:	NandaThilak			
Date Created:	12/0	3/2021		Date Last Updated:				
Business A	ctor:	Lab Att	endant					
Description:		Tolerance are used to monitor the satisfaction level of the water sample. It uses to show un satisfaction ratio and alerts to the stakeholders						
Preconditions:		Need parameter before define Tolerance						
Postconditions:		Cannot remove Tolerance where sample data stored in the system						
Performance (Goal:							
Basic Work	flow:	Create 1. 2. 3. Update 1. 2. 3. Delete 1. 2. 3.	Enter To Save Tole Select To Modify de Save Tole	lerance form the Grid Vie ata erance lerance from Grid View	₽₩			

Table 3.8: Manage Test Parameter Tolerance Use Case Narrative

3.3.2.9 Manage Parameter Rates

Use Case ID:	9	9						
Use Case Name:	Mana	Manage Parameter Rates						
Process Owner:	Lab .	Attendant	t	Last Updated By:	NandaThilak			
Date Created:	12/0	3/2021		Date Last Updated:				
Business A	ctor:	Lab Atte	endant		I			
Description:				ere define based on the c the NWSDB cost for test	ircular issued by the ing the sample parameter			
Preconditions:		Before define parameter rate, system required to enter parameter						
Postconditions:		Rates are not compulsory. There are no rates for the parameter, system shall consider the cost for testing as zero						
Performance (Goal:							
Basic Workflow:		2. 3. Update 1. 2. 3. Expire 1.	Enter Tes Save Test Select Tes Modify R Save Test	Parameter Rate st Parameter Rate	ective Date			

Table 3.9: Manage Test Parameter Rate Use Case Narrative

Use Case ID:	10	10						
Use Case Name:	Mana	Manage Sample Registration						
Process Owner:	Lab .	Attendant	Last Updated By:	NandaThilak				
Date Created:	12/0	3/2021	Date Last Updated:					
Business A	ctor:	Lab Attendant		·				
Description:		Sample received for the laboratory must be register and issue a number. This number required to trace sample within the lab or NWSDB. Number generated from the system based on the cost centre and initialized for each year.						
Precondit	Preconditions:		Required to fill RSC, Region, Cost Centre, Scheme, Source and Sample point. All these data were selected through lists.					
Postconditions:		After approval cannot remove sample data						
Performance (Goal:							
Basic Work	flow:	 Enter San Save & R Update Select Re View rele Select San Modify S Save Sam Delete Select Re View San 	nple Data egister the Sample gion, Cost Centre, Schem vant Sample Points nple Point ample Data ple Data gion, Cost Centre, Schem					

3.3.2.10 Manage Sample Registration

Table 3.10: Manage Sample Registration Use Case Narrative

3.3.2.11 Capture Test Results

Use Case ID:	11	11				
Use Case Name:	Capt	Capture Test Results				
Process Owner:	Lab .	Attendant	Last Updated By:	NandaThilak		
Date Created:	12/0	3/2021	Date Last Updated:			
Business A	Business Actor: Lab Attendant					
Description:		To capture the test result system required registered sample no. Test results are entered to the system shall be more than one labourite based on the capability of the testing.				
Precondit	ions:	Sample no required to proceed to entering test results				
Postconditions:		Cannot remove after approval of the test results				
Performance (Goal:					
Basic Work	flow:	 View sam Enter Ter Save Sam Delete Select reg View sam Check wh 	istered sample by enter re ple details st Parameter Results ple data with test parame istered sample by enter re ple details nether sample data approv ete sample data	ter results egistration no		

Table 3.11: Capture Test Result Use Case Narrative

3.3.2.12 Approve Test Results

Use Case ID:	12	12				
Use Case Name:	Арри	Approve Test Results				
Process Owner:	Cher	nist	Last Updated By:	NandaThilak		
Date Created:	12/0	3/2021	Date Last Updated:			
Business A	ctor:	Chemist				
Description:		Test results need to approve before published to the NWSDB. This approval must be important to the quality of the water and relevant remedial action must be taken from the stakeholders.				
Precondit	ions:	Popup the un satisfaction parameters to the user. Chemist must be check before approval.				
Postcondit	ions:	Cannot reverse results after approval				
Performance (Goal:					
Basic Workflow:		 Approve 1. Select registered sample by enter registration no 2. View sample details 3. Verify with test results 4. Approve sample data 				

Table 3.12: Approve Test Result Use Case Narrative

3.3.2.13 Manage Alerts

Use Case ID:	13					
Use Case Name:	Mana	Manage Alerts				
Process Owner:	Cher	nist, Manager	Last Updated By:	NandaThilak		
Date Created:	12/0	3/2021	Date Last Updated:			
Business Actor: Chemist, Manag		Chemist, Manager	:	·		
Description:		Alerts are generated based on the parameter tolerance compare with the results achieved from the testing. At the approval of the test results with the selected remedial action also send to the relevant officer in NWSDB				
Preconditions: I		Parameter tolerance must be defined before operation				
Postconditions:		Cannot reverse the alert which is send at the test result approval				
Performance Goal:						
Basic Work	flow:	 Enter Ale Save Aler Update Select Rep 	gion, Cost Centre, Schem rting persons details ata			

Table 3.13: Manage Alert Use Case Narrative

3.3.2.14 View Dashboards

Use Case ID:	14	14				
Use Case Name:	View	View Dashboards				
Process Owner:	Man	ager, Chemist	Last Updated By:	NandaThilak		
Date Created:	12/0	3/2021	Date Last Updated:			
Business A	ctor:	Manager, Chemist				
Description:		Multiple dashboards are defined in the system to monitor un satisfactory of test parameters. At the mean time summary of the results, testing performance etc can be view in data as well as graphical representation.				
Precondit	Preconditions:		Approved data can be view through the Dashboard. Selections are not a must. No selection mean considers results island wide			
Postcondit	ions:	No post conditions, view only facility available				
Performance (Goal:					
Basic Workflow:		Analysis 2. Generate	gion, Cost Centre, Schem Type, Water Type etc filter criteria based on the using the filter criteria	*		

Table 3.14: View Dashboards Use Case Narrative

3.3.3 Sequence Diagrams

According to the water quality management system design, we have selected important sequence diagrams are to be present for better understanding of the system. These are categorized as follows. Master Data

- Manage Sample Points
- Manage Parameters

Transaction Data

• Capture Test Results

Information

View Dashboard

3.3.3.1 Manage Sample Points

Create Sample Point (Refer Figure 3.4)

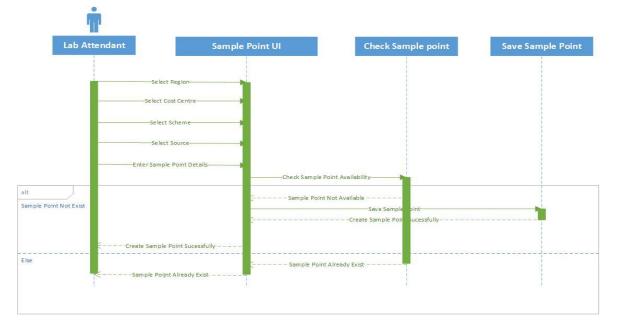
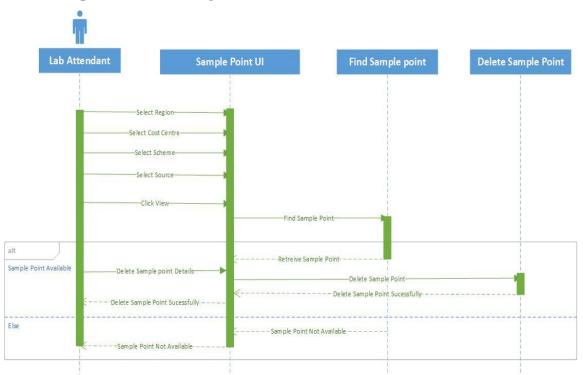


Figure 3.4: Create Sample Point Sequence Diagram



Update Sample Point (Refer Figure 3.5)

Figure 3.5: Update Sample Point Sequence Diagram



Delete Sample Point (Refer Figure 3.6)

Figure 3.6: Delete Sample Point Sequence Diagram

3.3.3.2 Manage Test Parameters

Create Test Parameter (Refer Figure 3.7)

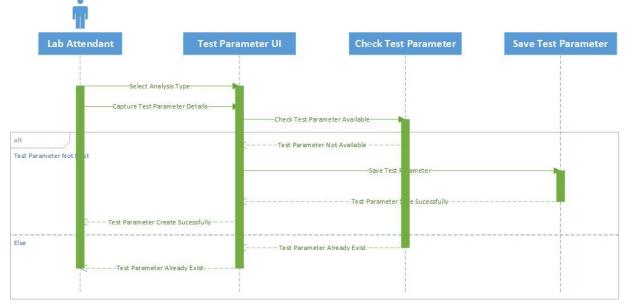
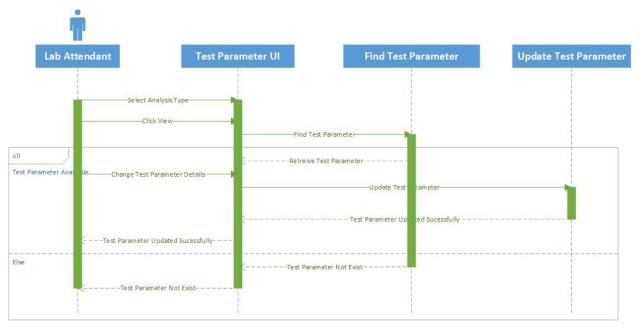
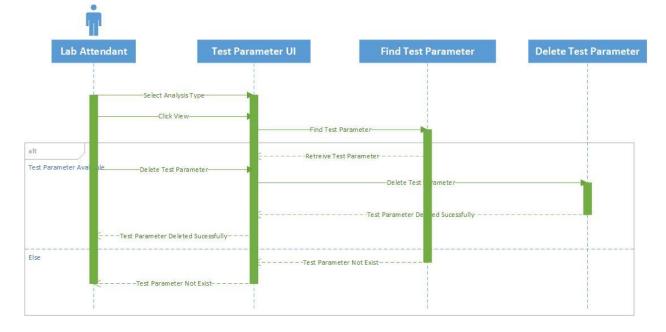


Figure 3.7: Create Test Parameter Sequence Diagram



Update Test Parameter (Refer Figure 3.8)

Figure 3.8: Update Test Parameter Sequence Diagram



Delete Test Parameter (Refer Figure 3.9)

Figure 3.9: Delete Test Parameter Sequence Diagram

3.3.3.3 Manage Test Results

Update Test Results (Refer Figure 3.10)

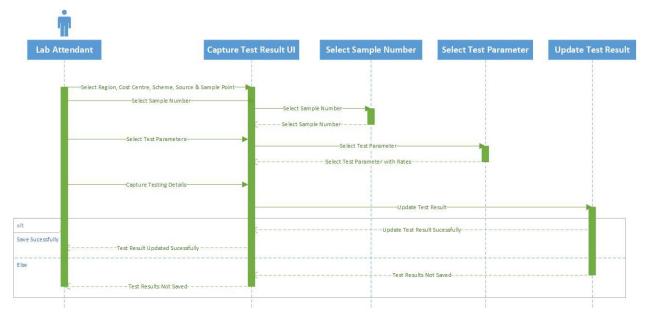


Figure 3.10: Update Test Result Sequence Diagram

Delete Test Results (Refer Figure 3.11)

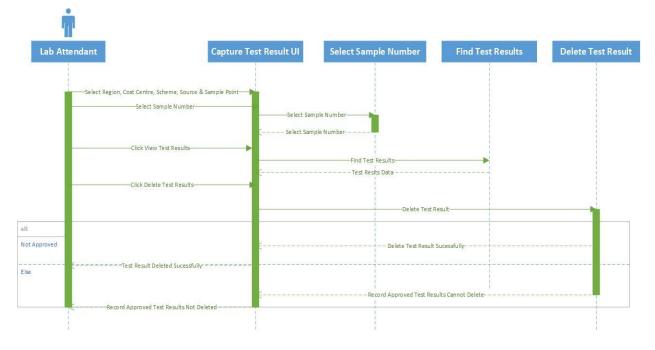


Figure 3.11: Delete Test Result Sequence Diagram

3.3.3.4 Dashboard

View Dashboard (Refer Figure 3.12)



Figure 3.12: View Dashboard Sequence Diagram

3.3.4 Class Diagram

In design stage, main purpose of class diagram is to model the static view of an application. This Class diagrams are the only diagrams which can be directly mapped with object-oriented languages and thus widely used at the time of development of the application. Also, it shows structural view of the application as well. This diagram describes attributes & methods used to develop the application in object-oriented concept.

The figure 3.13 shows the class diagram of the proposed system.

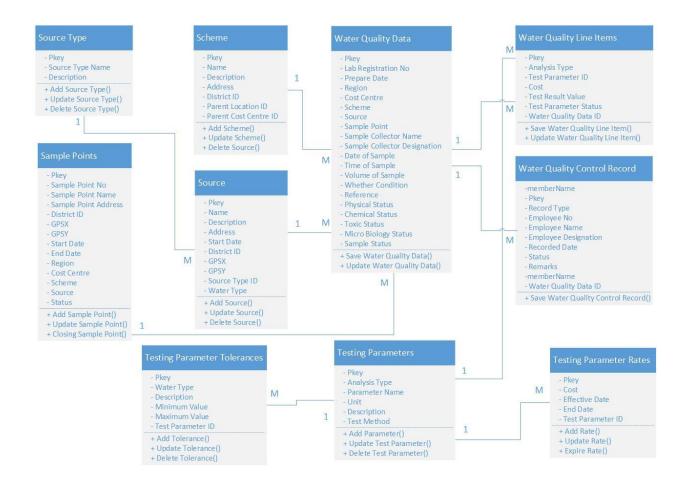


Figure 3.13: Class Diagram for Proposed System

Chapter 4 – Methodology

4.1 Introduction

This is the phase that designed software is being developed. This include all the documents, tools, techniques that are used to develop and implement the system using programming languages, scripting languages, frameworks, designing tools and techniques, database management systems, testing tools etc. Implementation stage consists of system installation (server side), technical support to end users and user training for the new system, etc.

4.2 Tools and Technologies

NWSDB has using the Microsoft technologies for their software development. Therefore very important to select software tools and technologies should be in line with NWSDB current systems. Because this product is a module that will be integrate to the existing system, therefore cannot choose any other platform and stick to the NWSDB development environment.

4.2.1 Microsoft Windows 10

Windows 10 is the newest operating system used in the organization. Therefore all developers are used this platform. This product was relative to the Windows NT family.

4.2.2 Dot net framework 4.0

The .NET Framework facilitate to managed execution environment that provides services to its running applications. This framework having two major components like, common language runtime (CLR), which is the execution engine that handles running applications hosted; and the .NET Framework Class Library, which facilitate a library of tested, reusable code that system developers can call from their applications.

4.2.3 Visual Studio 2015

Microsoft application development environment used to develop User Interfaces of the system. Also used to integrate other tools and the core modules developed in NWSDB.

4.2.4 DHTML Menu

This is the 3rd party product available in the market to generate java script-based menu can used in visual studio. These menu scripts are embedded in development tool.

4.2.5 Hibernate

This is the open-source product available in the market. This product was used to map objects to relational database. This is the method used to implement object-oriented concept with the relational database by using xml file and the classes in the system.

4.2.6 Microsoft SQL Server 2014

Microsoft SQL Server is a relational database management system developed by Microsoft. As a database server, it is a software product with the primary function of storing and retrieving data as requested by other software applications. This product was run either on the same computer or on another computer across a network

4.3 Hardware and Software Requirements

The web-based system required web server and the client machine to run the solution. Organization datacentre maintained by VMware technology to maintain virtual servers to manage systems.

4.3.1 Server Installations

• Windows Server 2012

This is the sixth version of the Windows Server operating system by Microsoft, as part of the Windows NT family of operating systems. This product was used to manage web server for the solution.

• IIS Server

Internet Information Services is extensible web server software created by Microsoft for use with the Windows NT family. IIS supports HTTP, HTTP/2, and HTTPS, FTP, FTPS, SMTP and NNTP.

• SQL Server 2014

Microsoft SQL Server is used to maintain water quality database with the integration of HRM system. This product is used throughout the organization as unique database tool.

4.3.2 Client Installation

Client machines (end user) are windows 10 operating system with the internet explorer as a web browser. There is no any special installation required to manage to run the solution.

4.4 Modularity of the System

Water Quality Management system designed and developed to integrate with the current ERP solution operated in the NWSDB. Therefore some of the key products need to integrate with the new development which will provide reusability and the integrity of the final product. These key integrated modules are as follows.

• Human Resource Management Module (HRM)

This module keeps all human resource details of the organization. System login are maintained with the validity of the employment. When confirmed login provide all information of the employee and retrieve as an object to the integrated solution.

• Development Framework

Organization maintains the development framework which is developed and deployed as dynamic link library. This library facilitate for module integrated and development standard throughout the organization. There is maximum capability of reusability shown in this method and reduce cost factor of the development work.

• Reporting functionality

All reports are standardized base on the crystal report format. All heading, body and the footer are in same structure. Object data source is the data input for the reporting module.

4.5 High Level Programming

According to the standard of the NWSDB, water quality management system development using the user interface and the module packages developed separately and integrated to the core system. User interfaces are developed from HTML5 and the tools available in the framework and the visual studio tool box component.

Module packages are totally couple with the following layers as follows

• User interface layer (IL) – Refer Figure 4.1

	• Project Build Debug Team Tools Test Analyze Window • 🏠 🔛 🔐 🤭 • 🖓 • 🖓 • Debug • Any CPU • 🕨 Start • 🎵		●江田祖田。 田田 国内 ■ 知知知。	
	ICs + X			Solution Explorer
QualityOr		CTL.ERP.WQM.WaterQualityData.II, JWaterQualityUC	GetWaterQualityById(int Pkey)	· 000 6-50 P-
	Busing System;			Example to the second s
2	using System.Collections.Generic;			
3	using System.Text;			Solution "WaterQualityQatalL" (1 project)
4	using System.ServiceModel;			Properties
5	using CTL.ERP.WQM.WaterQualityData.Model.Domain;			C* AssemblyInfo.ci
6	using CTL.ERP.WQM.WaterQualityData.Model.DTO;			A PH References
7	using CTL.ERP.MDM.Shared.Location.Model.Domain;			analyzers
8	using CTL.ERP.MDM.WQM.Model.Domain;			CTLERP.MDM.Shared.Location
9				 CTL.EP.MDM.WQM.Model CTL.EP.WQM.WaterQualityDate
10	Enamespace CTL.ERP.WQM.WaterQualityData.IL			 CTLERP.WQM/WaterQualityDate Iog4net
11	1			* System
12	[ServiceContract]			== System Data
	0 references			System.ServiceModel
13 0	public interface IWaterQualityUC			== System.Xml
14	1			D C* WaterQualityDataUC.cs
15	[OperationContract]			
	0 references			
16	WaterQuality GetWaterQualityById(int Pkey);		
17	[OperationContract]			
	O references			
18		ails(DateTime fromDate, DateTime toDate);		
19	[OperationContract]			
	0 references			
20		itySearchDetails(WaterQualitySearchDTO wate	rqualitysearchDTO);	
21	[OperationContract]			
22	0 references WaterQuality GetWaterQualityByLabNo(strin	- (-64-) -		
22	[OperationContract]	g LabNo);		
23	Oreferences			
24	bool SaveWaterQuality(WaterQuality saveWa	terOuality):		
25	[OperationContract]	cerquarry),		Properties
	0 references			WaterQualityDatall. Solution Properties
26	und d. Underschlatzenfund deurführt anflund deur unde	tableteennes1 (ter).		
				2 III II A
utput from	: Solution - 😓 🐂 💆	\$P		Active config Debug Any CPU
				Description Path EVNWSDBERP2
				Startup project WaterQualityD
				startup project waterQuartyD
op Service	Activity ErrorList Output			

Figure 4.1: User Interface Layer for Proposed System

• Application layer (AL) – Refer Figure 4.2

vality UC o			 Solution Explorer
riQuality(• 🔍 log	000 0.40 2-
1.9	Dusing System;		Search Solution Explorer (Colina)
2	using System.Collections.Generic:		
3	using System.Text:		Solution 'WeterQualityDetaAL' (1 project)
4	using CTL, ERP, WOM, WaterQualityData, IL:		WaterQualityDataAL Properties
ŝ	using WONData-CTL EBP, WOM, WaterQualityData.Dt;		b
6	using CTL.ERP.WQM.WaterQualityData.Model.Domain;		b Of WaterOuelityUCcri
7	using CTL.ERP.WOM.WaterQualityData.Model.DTO;		
8	only critica indimatel fact (hore in action)		
ŝ	using CTL.ERP.Framework.App.Utils.NHibernate;		
10	using Common.logging.log/Net;		
11	using Common: Using Common:		
12	using Common, Logging;		
13	using common.cogging; using mdmsqm=CTL:FRP.MDM.WQM.Hodel.Domain;		
13			
14	using mdmkDL-CTL.LRP.MDM.WQM.DL;		
	using CTL.ERP.MDM.Shared.Location.Model.Domain;		
16	using CTL.ERP.MDM.Shared.Location.DL;		
17			
18	Enamespace CTL.ERP.WQM.WaterQualityData.AL		
19	(
	1 reference		
20	public class WaterQualityUC 1 IWaterQualityUC		
21	{		
22	<pre>ILog _log = LogManager.GetLogger(typeof(WaterQualityUC).FullName);</pre>		
23			
24	private string _userName;		
25	private WorkLocation _location;		
26			
	0 references		
27	public void SetUserandLocationName(string userName, WorkLocation currentLocation)		
28	4		Properties
29	thislocation = currentlocation;		Wates Quality DataAL Solution Properties
30	thisuserName = userName;		24 V4 F
31	}		(Name) WaterQualitrData/
32			Active config Debug(Any CPU
	O references		Description
33	public WaterQuality GetWaterQualityById(int Pkey)		Parts Lawwood Read
34	t t		Startup project Water QualityData
35	<pre>_log.Debug("Entered - GetWaterQualityById() = " + Pkey);</pre>		
36	WQMData.WaterQualityRtvr WQDataRtvr = new WQMData.WaterQualityRtvr();		
37	WaterQuality WQData = WQDataRtvr.GetWaterQualityById(Pkey);		
38	_log.Debug("Leaving GetWaterQualityById()");		
39	return WQData;		× .
	record agoaca,		. *

Figure 4.2: Application Layer for Proposed System

• Data mapping layer (DL) – Refer Figure 4.3

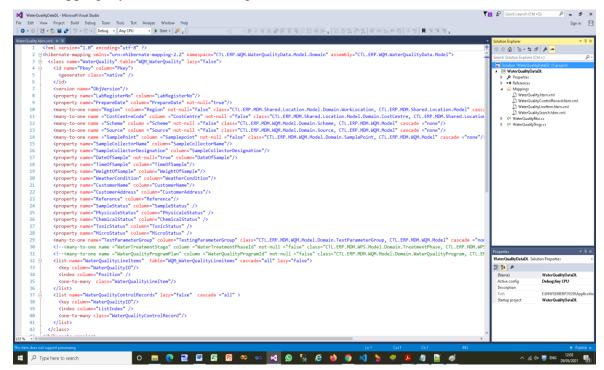


Figure 4.3: Data Mapping Layer for Proposed System

• Domain

layer

Definition of classes and other objects (Model) - Refer Figure 4.4

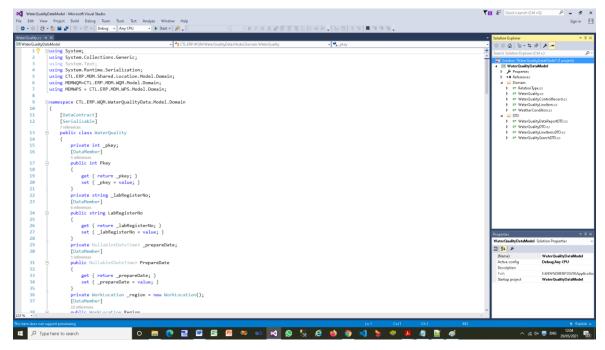


Figure 4.4: Domain Layer for Proposed System

These four packages are used in the user interface development as a communicator between relational database and classes.

During the implementation of the database of the water quality management system following relational database diagram was designed as follows; (Refer Figure 45)

50 | P a g e

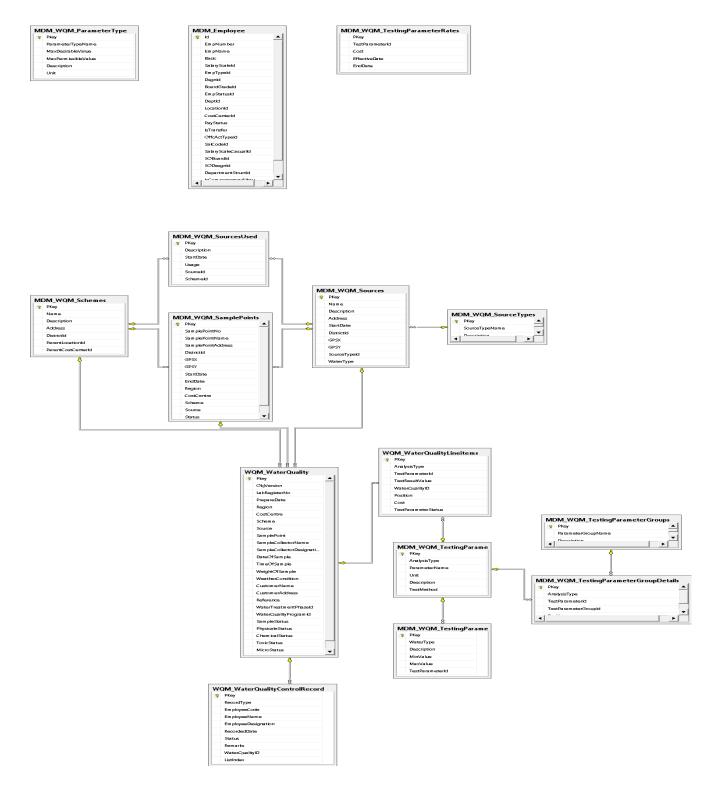


Figure 4.5: Database Structure for Proposed System

Chapter 5 - Testing and Evaluation

5.1 Introduction

Software testing is the process of verifying a system with the purpose of identifying any errors, gaps or missing requirement compare with the actual requirement. Software testing is broadly categorised into two types called functional testing and non-functional testing. There is another method of testing called Maintenance Testing. The diagrammatical representation of the method shown as follows.

5.2 System Testing Methods

There are proven methods of testing of software product are introduce early ages of software Engineering. After following these steps end users shall provide acceptance of the system and ready for the online operation.

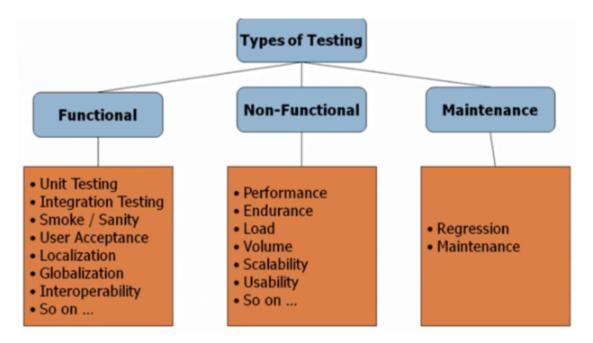


Figure 5.1: Software Testing Types

Figure 5.1 shows the system testing methods used for the project.

To fulfill the testing requirement 3 types of testing methods proposed to test the system. These three types are

- Functional Testing
- Non-functional Testing
- Maintenance Testing

5.3 Functional Testing

This is a type of software testing that validates the software system against the functional requirements and specifications. Purpose of the functional tests is to test each function of the software application, by providing appropriate input, verifying the output against the Functional requirements. To do this need to setup the test plan and proceed and complete the testing phase of the software system.

5.3.1 Test Plan

A Test Plan is a detailed document that describes the test strategy, objectives, schedule, estimation, deliverables, and resources required to perform testing for a software product. Test Plan is determining the effort needed to validate the quality of the application under test.

Water Quality Management System has several inputs which are needed to test for the accuracy. I have selected the important areas and documented as follows.

5.3.1.1 System Login

Test plan for the system login defined in Table 5.1

No	Function	Testing Process	Required Test Output	Priority
1	Login to the application not an employee	Insert employee ID and Password	Invalid user, not authorized	High
2	Login to the system without employee ID or the password	Not enter employee ID or the Password	Ask user to input login details	Low
3	Login to the system without employee ID	Input password only	Ask user to enter employee ID	Medium
4	Login to the system without password	Input employee ID only	Ask user to enter password	Medium
5	Login to the system incorrect Password	Incorrect password	Give a message as incorrect password	High
6	Login to the system with correct employee ID and password	Check user exist in employee table	Login to the system with displaying employee name and the work location	High

Table 5.1: System Login Interface Test Plan

5.3.1.2 Define Schemes

Test plan for the scheme definition defined in Table 5.2

No	Function	Testing Process	Required Test Output	Priority
1	Add without RSC	Without selecting RSC	Ask user to input RSC	Medium
2	Add without Region	Without selecting Region	Ask user to select Region	Medium
3	Add without Cost Center	Without selecting Cost Center	Ask user to select cost center	Medium
4	Add without Scheme name	Without entering Scheme Name	Ask user to enter Scheme name	High
5	Add available Scheme Name	Check Scheme Name	Warn user to Scheme name exist	High
6	Add blank Scheme name	Check Scheme name blank	Warn user to enter Scheme name	High

Table 5.2: Define Scheme Test Plan

5.3.1.3 Define Test Parameters

Test plan for the Test Parameter definition define in Table 5.3

No	Function	Testing Process	Required Test Output	Priority
1	Add without Analysis Type	Without selecting Analysis Type	Ask user to select Analysis Type	Medium
2	Add without Parameter Name	Without entering Parameter Name	Ask user to enter Parameter Name	High
3	Add without Parameter Description	Without entering Parameter Description	Ask user to enter Parameter Description	High
4	Add available Parameter Name	Check Parameter Name	Warn user to Parameter Name exist	High
5	Add blank Parameter Name	Check Parameter Name blank	Warn user to enter Parameter Name	High

Table 5.3: Define Test Parameters Test Plan

5.3.1.4 Define Test Parameter Tolerances

Testing Process No Function **Required Test Output Priority** Add without Water Without selecting 1 Ask user to select Water Type Medium Water Type Type Without selecting 2 Add without Test Ask user to select Test Medium Parameter **Test Parameter** Parameter Ask user to enter Description 3 Add without Without entering Medium Description Description Add without Without entering 4 Ask user to enter Minimum High Minimum Value Minimum Value Value Without entering High 5 Add without Ask user to enter Maximum Maximum Value Maximum Value Value

Test plan for the Test Parameter Tolerances definition define in Table 5.4

Table 5.4: Define Test Parameter Tolerances Test Plan

5.3.1.5 Sample Registration

Test plan for the Sample Registration in Table 5.5

No	Function	Testing Process	Required Test Output	Priority
1	Click "Register" button	Without click "Register" button	User cannot Register Sample, Save Button Disabled	High
2	Add without RSC	Without selecting RSC	Ask user to select RSC, Region, Scheme, Source, Sample Point	Medium
3	Add without Region	Without selecting Region	Ask user to select Region, Scheme, Source, Sample Point	Medium
4	Add without Scheme	Without selecting Scheme	Ask user to select Scheme, Source, Sample Point	Medium
5	Add without Source	Without selecting Source	Ask user to select Source, Sample Point	Medium
6	Add without Sample Point	Without selecting Sample Point	Ask user to select Sample Point	Medium
7	Add without Sample Date	Change Sample Date as Blank	Ask user to enter Sample Date	High

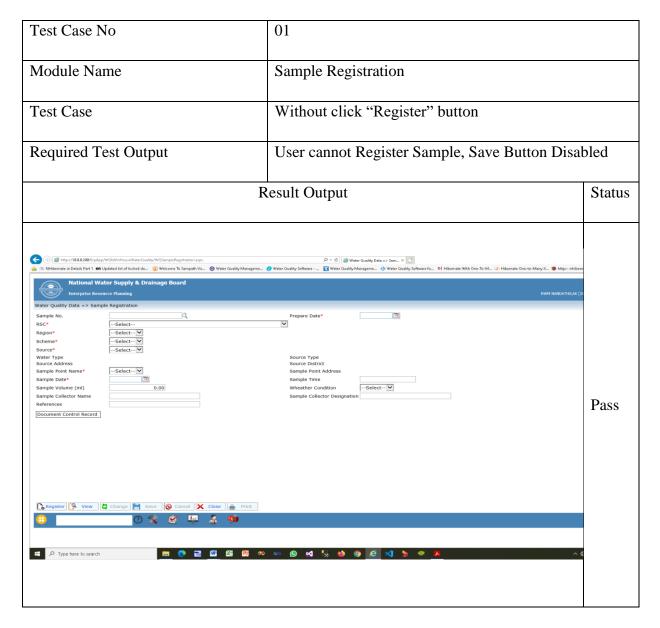
Table 5.5: Sample Registration Test Plan

5.3.2 Test Cases

A test case has components that describe input, action and an expected response, in order to determine if a feature of an application is working correctly. A test case is a set of instructions on "HOW" to validate a particular test objective/target, which when followed will tell us if the expected behavior of the system is satisfied or not. (Anon., 2021)

Accordingly, I have designed a format to record the test cases which are important to check the system. These test cases are execute based on the test plan developed in the above section. For the documentation purpose "Sample Registration Test Plan" which was defined in Table 5.5 was executed and recorded the results as follows.

Table 5.5 Test case for without click Register button in Sample Registration process described inTable 5.6



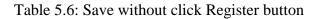


Table 5.5 Test cases for without selecting RSC in Sample Registration process described in Table5.7

Test Case No	02	
Module Name	Sample Registration	
Test Case	Without selecting RSC	
Required Test Output	Ask user to select RSC, Region, Scheme, Sample Point	Source,
Resu	lt Output	Status
National Water Supply & Drainage Board Laterprise Resource Planning Water Quality Data => Sample Registration Sample No. Pro RSC* -Select Region* Select Source* Select Source* Select Source* Solect Source* So Source Address So	Nexasys fram webpage The sease State the happen Present State the Searce Present State the Searce Present State the Searce The sease State the Searce The Searce The sease State the searce Th	Pass

Table 5.7: Save without Selecting RSC

Table 5.5 Te	est case for withou	it selecting Region	n in Sample Reg	istration proces	s described in T	able
5.8						

Test Case No	03	
Module Name	Sample Registration	
Test Case	Without selecting Region	
Required Test Output	Ask user to select Region, Scheme, Source, Point	Sample
Resu	lt Output	Status
National Water Supply & Drainage Board Enterprise Resource Planning Water Quality Data => Sample Registration Sample No. Pre RSC* RSC (Central) Region* Select Source* Select Source* Select Source* Source Source* Source Source Address Son Sample Point Name* Select Sample Point Name* Select	Rese Salet the Bagon Rese Salet the Server Prese Salet the Server Rese Salet the Salet the Server Rese Salet the Salet the Salet Rese Rese Salet the Salet the Salet the Salet the Salet Rese Rese Salet the Salet the Salet the Salet Rese Rese Salet the Sal	Pass

Table 5.8: Save without Selecting Region

Table	5.5	Test	case	for	without	selecting	Scheme	in	Sample	Registration	process	described	in
Table	5.9												

Test Case No	04	
Module Name	Sample Registration	
Test Case	Without selecting Scheme	
Required Test Output	Ask user to select Scheme, Source, Sample Po	oint
Resu	ult Output	Status
National Water Supply & Drainage Board Exerptise Recorce Planating Water Quality Data => Sample Registration Sample No. PRSC. RSC.* RSC (central) Region* Regional Manager (Kandy East) Scheme* Select- Source* Select- Source* Select- Source* Select- Sample Date* 10/07/2021 Sample Collector Name S References S Document Control Record S	Implementation	Pass

Table 5.9: Save without Selecting Scheme

Table 5.5 Test case for without selecting Source in Sample Registration process described in Table5.10

Test Case No	05	
Module Name	Sample Registration	
Test Case	Without selecting Source	
Required Test Output	Ask user to select Source, Sample Point	
Resu	llt Output	Status
National Water Supply & Drainage Board Entryptive Resource Planning Water Quality Data => Sample Registration Sample No. R RSC* RSC (Central) Region* Regional Manager (Kandy East) Scheme* Ginigathhena Source Address So Source Address So Sample Date* 10/07/2021	P • © Weter Outsky Managene. Weter Outsky Software E. D) Hätemata Weth One To ML. C Hätemata Dave to Muny X. Integr- obdermatisfier eparer Date* Int/07/2021 Integr- obdermata Dave to Muny X. Integr- obdermatisfier urce Type Integr- obdermata Integr- obdermata Dave to Muny X. Integr- obdermatisfier urce Type Integr- obdermata Integr- obdermata Integr- obdermata urce Type Integr-	Pass

Table 5.10: Save without Selecting Source

Table 5.5 Te	est case for	without s	selecting	Sample	Point in	Sample	Registration	process	described
in Table 5.11	1								

	06	
Module Name Sample Registration		
Test Case	Without selecting Sample Point	
Required Test Output	Ask user to select Sample Point	
F	Result Output	Status
National Water Supply & Drainage Board Daterprice Resource Flamming Water Quality Data => Sample Registration Sample No. RSC* Region* Gingathhen I and Manager (Kandy East) Scheme* Gingathhen I and Manager (Kandy East) Scheme* Gingathhen I and Manager (Kandy East) Scheme* Source Address Kanduru Oya Sample Point Name* -Select- Sample Point Name* -Select- Sample Collector Name References Document Control Record	Wet Quality Saftwar - Wet Quality Managame. Wet Quality Saftwar for. P Hermath Web Over-To-M. (1) Hermath Que to-Managame). We Happen Duals - Prepare Date - 10/07/2021	

Table 5.11: Save without Selecting Sample Point

Table 5	.5 Te	est c	ase	for	without	enter	Sample	Date in	n Sample	Registration	process	described	in
Table 5	.12												

Test Case No	07		
Module Name	Sample Registration		
Test Case	Without enter Sample Date		
Required Test Output	Ask user to enter Sample Date		
Resu	llt Output	Status	
National Water Supply & Drainage Board Concepted Resource Planning Water Quality Data => Sample Registration Sample No. Region* Region* Region* Scheme* Source* Water Type Fully TreatedWater Source* Sample Point Name* -Select- Sample Point Name* -Select- Sample Point Name* -Select- Sample Collector Name References Document Control Record	Perse Sector Sample Cr	Pass	
🛱 🏸 Type here to search 🛛 📕 💽 🖬 🔀 😢 ∞ 😒) 🕺 🍢 🧶 🧟 🗐 🍃 🧶 📕 📃 🛆 @ 44 1		

Table 5.12: Save without Entering Sample Date

5.4 Non-Functional Testing

Non-functional testing is defined as a type of Software testing to check non-functional aspects (performance, usability, reliability, etc.) of a software application developed. It is designed to test the readiness of a system as per nonfunctional parameters which are never reviewed by functional testing.

There are key parameters to be check for the readiness of the system. These key parameters are shown in Figure 5.2

Security	Availability	Efficiency	Integrity
Reliability	Survivability	Usability	Flexibility
Scalability	Reusability	Interoperability	Portability
		ating Davanatas	© Guru99.com

Non Functional Testing Parameters

Figure 5.2: Non-Functional Testing Parameters

Some of the important parameters are used to test the project.

5.4.1 Security Testing

In security of the solution followings were checked

- Login to the system with active employees for valid employee no and password
- Can manage Scheme details
- Can manage testing parameters
- Can manage water quality data

5.4.2 Usability Testing

In this process usability testing was conducted based on following instances

5.4.2.1 Onsite usability testing

Central laboratory is the main division used this system to capture testing results and monitor all operations island-wide. As operational users (Chemist) of the lab have used to operate the workflow of the system simultaneously and monitor throughout the process and identify the usability issues.

5.4.2.2 Remote usability testing

There are 36 Laboratories Island wide with more than 36 users to do operational activities like register, capture and approve sample testing to the system. This process was closely monitored by using system logs and the database logs.

5.4.3 Performance Testing

Performance of the product revolves around speed, response time, load time and scalability.

• Speed testing

As a web based solution measure the startup time for all lab user's login simultaneously to the system and select the test result capturing screen. This was done and most of the locations get less than 10 second result. The best time recorded as 9 second in central laboratory.

• Response time

In this solution test result capturing is the most important screen. There are selections of information, input data and verify the information within this transaction screen. To check the response time 5 lab users were selected in the network and check for the input data and save data to the system. All users are completed the transaction less than 2 minute. The best time recorded from Western South Laboratory to input the test result in 1.75 minute.

• Scalability testing

To check the scalability of the product required to log all type of users and complete their transactions and record the time duration. Following Table 5.13 shows the analysis of the results for completion of the transaction.

No.	Transaction Type	No of Users	Time Taken to Complete the Txn.	Status
1	Master Data	5	50 S	Good
2	Transaction Data	25	90 S	Average
3	Dashboard	5	25 S	Good
4	Reporting	10	60 S	Good

Table 5.13: Analysis of the results for execute of transaction

5.5 Maintenance Testing

Maintenance testing occurred due to following reasons.

- Software runs many years after their first released.
- New requirement requested from the end-users to update existing software.
- Changes of operating system, database etc.
- New changes in technology and required to update software.

These changes need to be tested thoroughly. The two testing type that is done during this upgrading or enhancing or migration phase is known as maintenance testing.

• Confirmation Testing

During this confirmation testing, all the modifications (either big or small) made in the software thoroughly and make sure that there are no functionality issues and downtime. There is no modification during this implementation stage.

Regression Testing

The need of the regression testing required for whenever there is requirement to change the code and necessary to test whether the modified code affects the other part of software application or not. When this scenario happens no need to test all test cases but need to test selected test cases which required to confirm the solution running without any errors. There is no new requirement or minor changes requested during the implementation stage. Therefore, regression testing not required executing right now.

5.6 User Evaluation

The purpose of project evaluation is to assess the software development methodology that was used throughout the development of the application, assess the usefulness of the technologies, tools, accuracy of the estimations and the usefulness of the reviews. The solution shall be reviewed and evaluated to decide whether it achieves the ideas presented in the initial overview and for the quality of the software application.

Software engineering model used in this project was RAD model. User evaluation for each delivery was obtained by the client at the time the modules were delivered. They were mainly review meetings and the feedback obtained was used in corrective maintenance or change management.

According to the prepared list of criteria and practical experimentation, a software evaluation makes it possible to check whether the project purposes were satisfied. Figure 5.3 was designed to collect feedback from the end users of the system. This was distributed between the users to get their feedback anonymously. The assessor evaluated the returned forms in order to obtain the actual feedback of the users and to assess that the project purposes have been met. Analysing, a measurement against likers scale was used to quantify the feedback and the values allocated parameters are as follows.

- Poor = 1
- Fair = 2
- Satisfactory = 3
- Good =4
- Excellent = 5

	Water Quality Management System for NWSDB Software Evaluation Form	
	Parameter	Rating
Appearance		10
	User Interfaces are attractive	4
	Background colours and colour combination used	2
	Font sizes are compatible and readable	4
Usability		25
	Screens are easy to navigate	5
	Menus are easy to understand	5
	Data validations are satisfied	5
	The requested dashboards/results are successful	10
Functionality		25
	Accuracy of test parameter results	10
	Displaying History water quality data	5
	Displaying unsatisfactory results	5
	Registration of sample in the system	5
Performance		20
	Time taken to retrieve data	10
	Response time for request's events	10
Security		20
•	Date security	10
	User access rights	10
Total		<u>100</u>

Figure 5.3: Software Evaluation Form

5.7 User Evaluation Outcome

According to the feedback results following graphs have been generated and analysed. Important circumstances have been described below with the graphical results of the feedback.

5.7.1 Appearance

Table 5.14 shows evaluation results for the criteria of **Appearance** related to User Interfaces are attractive of water quality management system and graphical view shown in Figure 5.4

Likers Option	Result	Percentage
Excellent	8	27
Good	12	40
Satisfactory	5	17
Fair	3	10
Poor	1	3

Table 5.14: Evaluation Result for Appearance

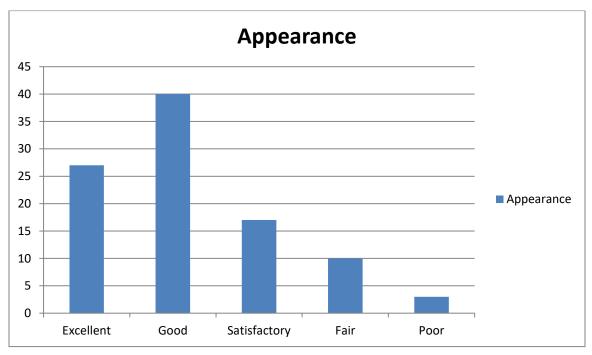


Figure 5.4: Graphical Representation of Evaluation Result for Appearance

According to the Graphical representation most of the users have agreed with the User Interfaces are good-looking of the system. Overall Appearance of the solution is not excellent, but it was not bad according to the results of the feedback. 40% of the results are "Good" while 27% results are "Excellent".

5.7.2 Usability

Table 5.15 shows evaluation results for the criteria of **Usability** related to the "Data validation are satisfied" of the system and graphical view shown in Figure 5.5

Likers Option	Result	Percentage
Excellent	9	30
Good	13	43
Satisfactory	6	20
Fair	2	7
Poor	0	0

 Table 5.15: Evaluation Result for Usability

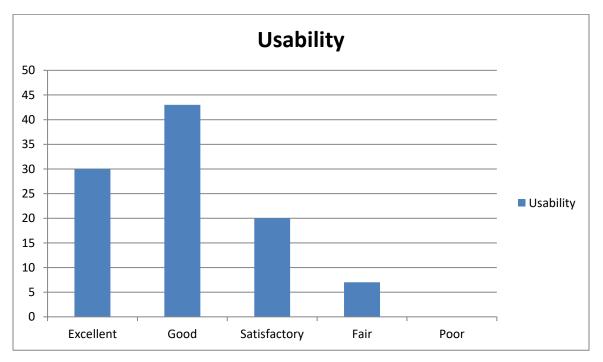


Figure 5.5: Graphical Representation of Evaluation Result for Usability

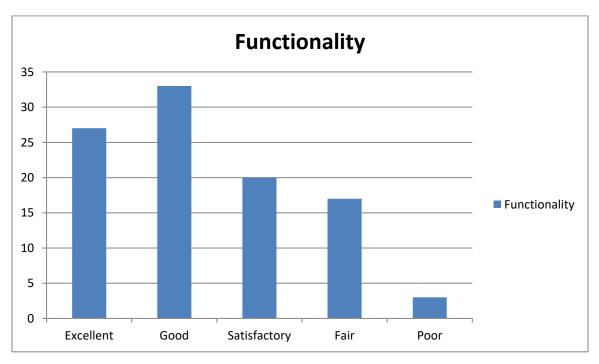
Usability of the system is acceptable level. 43% of the users are provide as system is 'Good' and 30% are commented as 'Excellent'

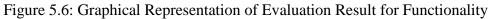
5.7.3 Functionality

Table 5.16 shows evaluation results for the criteria of **Functionality** related to the "water quality data and the testing parameters" of the system and graphical view shown in Figure 5.6

Likers Option	Result	Percentage
Excellent	8	27
Good	10	33
Satisfactory	6	20
Fair	5	17
Poor	1	3

Table 5.16: Evaluation Result for Functionality





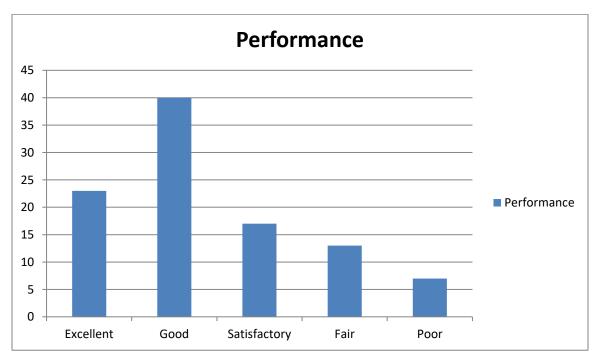
Most of the users are satisfied with the Functionality of the system. There are 27% users marked as 'Excellent' and 33% users given system functionality is 'Good'. Some users are identified the functionality is not good they marked 3% as 'Poor'.

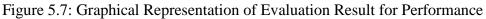
5.7.4 Performance

Table 5.17 shows evaluation results of **performance** of the system. System capability of data retrieval and response time are the key indicators for this question and graphical view shown in Figure 5.7

Likers Option	Result	Percentage
Excellent	7	23
Good	12	40
Satisfactory	5	17
Fair	4	13
Poor	2	7

Table 5.17: Evaluation Result for Performance





According to the analysis more than 80% of the users are accepted as satisfactory performance during the evaluation. At the same time 7% users are not accepted the performance of the system and indicated as 'Poor'.

Chapter 6 - Conclusion

According to the evaluation identified following area should be improved. As per the feedback received from the evaluation of Water Quality Management System.

- The evaluation of the "**Appearance**" has overall **40% "Good**". Therefore, User Interfaces are attractive.
- The "Usability" has 43% "Good" as evaluated. Therefore, input data validations are satisfied for some extend need to improve for better usability of the system.
- The **"Functionality"** has **33% "Good"** for this evaluation. Therefore, online water quality results capturing is important to maintain for NWSDB standard.
- The **"Performance"** has **40% "Good"** as evaluation. Therefor Response time of the system is minimized and acceptable.

The system evaluation was successfully completed with the end users rating the system as being satisfactory level.

The web-based water quality management system has been developed to NWSDB internal users and anyone could access it via VPN which is operated by SLT. Getting the look and feel according to satisfaction of all the users was another challenge successfully faced during design of the screen layouts and themes of the web-based solution.

6.1 Problems Encountered and Lesson learned

During the design, development and implementation process the project face problems which was not solved in long period.

The following problems were encountered during system implementation process as follows.

- There wasn't standard procedure to store water quality data generated from the testing of water in the laboratory. They were use different excel format and procedures in island wide
- Most of laboratory staff refused to give their information during requirement gathering process.

- I have to study and get understand the manual water sample checking process and water quality standards published by WHO and SLS.
- Management required to integrated with the ERP solution which was run as core system in NWSDB. Therefore, I have to use developments patterns, framework of the system, master information maintains by the ERP solution.
- I used this technology and object-oriented concepts, Dot Net frame work version 4, Visual Studio with C#. That was the challenge of this project, I have to learn and complete the project within given time frame
- I have to study to develop Dashboards which required by management for reduce paper work of the organization. They need less printed reports and all reports are in PDF format.

The following lessons were learnt during the projects work.

- Prepared standard procedure to maintain water quality data and the process to display "Unsatisfied" quality of the water which was the key requirement to manage the system and discussing process owners.
- Through the interviewing process it was easy to get necessary details from laboratory staff.
- I have used paper prototype to show the process flow to user, to obtain and stores water quality data and necessary alerts in Dashboard.
- Fast learnt to developed Dashboards during the project life cycle and related sample code using Google search.

The importance of planning and completion work as early as possible was the most important lesson learnt. Initially defined timeline for developing a software project is theoretical aspect. There are deviations from the guideline occur from time to time with the unavoidable circumstances which was happened due to COVID 19. Reviewing project progress often is necessary to ensure that hard work is translated in to meaningful work.

6.2 Future Enhancements

We use this online water quality management system to store water quality data and make decision to developing new water treatment plants around the island. It happens during the process of designing the water treatment plants required to analyses the water quality of the water sources to define their water treatment process.

All laboratories were use manual data storing system and reporting to the higher management as paper-based reports. I have managed to implement Dashboard concept to the management which is overcome the report generating process and further improvement we can implement messaging system to produce online information to attend immediately.

NWSDB was developed and implemented the employee based mobile app with the critical access rights to view important information via mobile interface (monthly water billing, monthly collection, find required items island wide etc.) As an enhancement we can develop the interface to the same mobile app to show water quality data and the remedial action to be taken immediately. NWSDB is the water specialized organization in Sri Lanka. We have provided water quality testing services to the nation for nominal fee. This process was totally manually operated and paper-based result sheet provided to the customers. As an improvement we can design new module to capture water quality test result and produce reports with the integration of SMS and payment collection through the Pay-In voucher integrated to the NWSDB General Ledger.

References

Board, N. W. S. a. D., 2000. organization. [Online] Available at: http://www.waterboard.lk [Accessed 04 09 2020]. Google, 2021. *use-case-narrative*. [Online] Available at: https://sites.google.com/site/hmookna/use-case-narrative [Accessed 18 03 2021]. System, W. -. D. W. Q. M., 2020. *Wsd.gov.hk*. [Online] Available at: https://www.wsd.gov.hk/en/core-businesses/water-quality/drinking-qualitywater/index.html. [Accessed 04 09 2020]. system, W. q. m., 2020. Waternsw.com.au. [Online] Available at: https://www.waternsw.com.au/water-quality/quality/multi-barrier/framework [Accessed 04 09 2020]. Tech, D. W. M. S. S. -. V. W., 2021. Drinking Water Management Software Solution - Verdant *Web Tech.* [Online] Available at: https://www.verdantwebtech.com/ehs-apps/drinking-water-management-app [Accessed 13 02 2021]. Technologies, W. Q. S. f. W. U. J. L., 2021. Water Quality Software for Water Utilities / Locus *Technologies*. [Online] Available at: https://www.locustec.com/applications/industry/water-utilities/ [Accessed 13 02 2021]. Water Quality Management | Laboratories, H.-C. E. L. 2., 2020. Water Quality Management | Laboratories, Hydro-Comp Enterprises Ltd, 2020. [Online] Available at: https://www.edams.com/edams-products/integrated-quality-managementsystem/water-quality-management/ [Accessed 04 09 2020].

Appendix A – System Manual

The web-based system required web server and the client machine to run the solution. NWSDB datacentre maintained by VMware technology to maintain virtual servers to manage systems. Therefore, Water Quality Management System use the virtual machine to install the solution.

Server Installation

Following installations are required to deploy the solution in house datacentre as follows.

• Windows Server 2012 R2

This is the sixth version of the Windows Server operating system by Microsoft, as part of the Windows NT family of operating systems. This product was used to manage web server for the solution.

• IIS Server

Internet Information Services is extensible web server software created by Microsoft for use with the Windows NT family. IIS supports HTTP, HTTP/2, and HTTPS, FTP, FTPS, SMTP and NNTP.

• SQL Server 2014

Microsoft SQL Server is used to maintain water quality database with the integration of HRM system. This product is used throughout the organization as unique database tool.

Client Installation

Web based solutions are not required client machine installation. But web browser is required to navigate the system. The water quality management system was developed under Microsoft environment and uses internet explorer as a web browser. This system can be used within the virtual private network (NWSDB VPN) not espoused to the internet. System users not required internet facility for their machines.

The URL: 10.0.0.200/erpapp

After typing the URL in browser address bar and navigate login screen will appears. User need to enter User ID and Password to navigate the system.

Appendix B – User Manual Login/Home Screen



Figure B.1: Login & Home Page

User login requirement define as valid employee in the NWSDB and employee number used for the user ID. At the point of user creation system check the employee number from the HRM database. Figure B.1 shows the login & Home page when user login to the system.



Master Data Management

Figure B.2: Master Data Management Menu

There are required master data captured to the system using the menu options shown in the figure B.2 Each menu option used to capture the relevant master data to the system.

Scheme Master Data Management process used to describe the create, update and delete data from the system. All other master data input screens follow the same method and same standard throughout the system. When select the scheme menu option, figure B.3 shows the user interface of the system. The top half represent the form to get input from the user to create or update record in the system. Bottom half shows the all schemes define in the system.

Quality Management						RWW NANDATHID	NK [2045508] Head Office 🏠
	nt => Schemes						
me*							
ription*							
ess"							
ct*Select							
Select	~						
onSelect	~						
CenterSelect	~						
ne Details							
scheme	Description	Address	District	RSC	Region	Cost Center	
Yakkala	Yakkala WSS	Yakkala					
			Gampaha	RSC (Western North)	Regional Manager (Gampaha)	Regional Manager (Gampaha)	^
Ambathale	Ambatale WTP	Ambathale	Colombo	Head Office	RSC (Production - Ambatale)	RSC (Production)	
Ambagasdowa	Ambagasdowa WSS	Ambagasdowa	Badulla	RSC (Uva)	Regional Manager (Bandarawela)	OIC (Ambagasduwa)	
Mattakkuliya	Mattakkuliya WSS	Mattakkuliya	Colombo	RSC (Western Central)	Regional Manager (Colombo City N/E)	OIC ((I) Mattakkuliya)	
Boralla Deduru Ova	Boralla WSS Deduru Oya WTP	Boralla Nagollagama Rd. Pothuwewa	Colombo Kurunegala	RSC (Western Central) RSC (North Western)	Regional Manager (Colombo City N/E) Regional Manager (Kurunegala)	OIC ((Iv) Borella) Deduru Ova Water Supply Scheme	
Slave Island	Slave Island WSS	Slave Island	Colombo	RSC (Western Central)	Regional Manager (Kurunegala) Regional Manager (Colombo City S/W)	OIC ((Vii) Slave Island)	
Thimbirigasyaya	Thimbirigasyaya WSS	Thimbirigasyaya	Colombo	RSC (Western Central) RSC (Western Central)	Regional Manager (Colombo City S/W) Regional Manager (Colombo City S/W)	OIC ((VI) Slave Island) OIC ((V) Thimbirigasyaya)	
Pamankada	Pamankada WSS	Pamankada	Colombo	RSC (Western Central)	Regional Manager (Colombo City S/W) Regional Manager (Colombo City S/W)	OIC ((V) Pamankada)	
Battaramulla	Battaramulla WSS	Battaramulla	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Battaramulla)	
Kotte	Kotte WSS	Kotte	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kotte)	
Kolonnawa	Kolonnawa WSS	Kolonnawa	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kolonnawa)	
Kaduwela	Kaduwela WSS	Kaduwela	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kaduwela)	
Palanwatta	Palanwatta WSS	Palanwatta	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Maharagama)	
	Pannipitiya WSS	Pannipitiya	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Pannipitiya)	
			Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Maharagama)	
Pannipitiya Maharagama	Maharagama WSS	Maharagama					

Figure B.3: Scheme Management

When click "New" button, the screen show in the figure B.4 with enabling "Save" button. After input all relevant data, user can save by clicking the button "Save"

<u> </u>	source Planning					RWM NANDATHILAK [2045508] Head Office 🏠 🅻
ter Quality Management =>	Schemes					
heme* New Scheme						
scription* New Scheme De	scriptic					
dress* Address Line						
strict* Galle	~					
C RSC (Southern						
nion Regional Manag						
st CenterSelect						
Regional Manag	er (Galle)					
eme Deta OIC (Wackwell)					
Scheme OIC (Bope-Pod	dala)	Address	District	RSC	Region	Cost Center
Yakkala OIC (Hapugala) OIC (Habaradu	wa)	Yakkala	Gampaha	RSC (Western North)	Regional Manager (Gampaha)	Regional Manager (Gampaha)
Ambath OIC (Ambalang		Ambathale	Colombo	Head Office	RSC (Production - Ambatale)	RSC (Production)
Ambagi OIC (Balapitiya Mattaki OIC (Baddegan	/ Piyagama)	Ambagasdowa	Badulla	RSC (Uva)	Regional Manager (Bandarawela)	OIC (Ambagasduwa)
AE (Galle)		Mattakkuliya Boralla	Colombo	RSC (Western Central) RSC (Western Central)	Regional Manager (Colombo City N/E) Regional Manager (Colombo City N/E)	OIC ((I) Mattakkuliya) OIC ((Iy) Borella)
	a / Dodanduwa)	Nagollagama Rd. Pothuwewa	Kurunegala	RSC (North Western)	Regional Manager (Colombo City N/E)	Deduru Oya Water Supply Scheme
Deduru Slave I: OIC (Fitigala)	00000000	Slave Island	Colombo	RSC (Western Central)	Regional Manager (Colombo City S/W)	OIC ((Vii) Slave Island)
		SS Thimbirigasyaya	Colombo	RSC (Western Central)	Regional Manager (Colombo City S/W)	OIC ((V) Thimbirigasyaya)
Thimbir OIC (Batapola)		Pamankada	Colombo	RSC (Western Central)	Regional Manager (Colombo City S/W)	OIC ((Vi) Pamankada)
Thimbir OIC (Batapola) Pamani OIC (Elpitiya)				RSC (Western Central)	Regional Manager (Kotte)	OIC (Battaramulla)
Pamani OIC (Elpitiya)		Battaramulla	Colombo			
Pamani OIC (Elpitiya) Battara OIC (Galle) OIC (Hapugala	Treatment Plant)		Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Battalandia) OIC (Kotte)
Pamani OIC (Elpitiya) Battara Kotte OIC (Hapugala Kolonna OIC (Hikkaduw	na) a Sewerage)	Battaramulla			Regional Manager (Kotte) Regional Manager (Kotte)	
Pamani OIC (Elpitiya) Battara OIC (Galle) OIC (Hapugala CIC (Akmeema OIC (Akmeema OIC (Hikkaduw Kaduw AE (Ambalango	na) a Sewerage) da)	Battaramulla Kotte	Colombo	RSC (Western Central)		OIC (Kotte)
Pamani Battara Kotte Kolonni OIC (Elpitiya) OIC (Galle) OIC (Hapugala OIC (Akmeema AE (Ambalango OIC (Ahangam) OIC (Ahangam)	na) a Sewerage) da) a)	Battaramulla Kotte Kolonnawa	Colombo Colombo	RSC (Western Central) RSC (Western Central)	Regional Manager (Kotte)	OIC (Kotte) OIC (Kolonnawa)
Pamani Battara Kotte Kolonni Kaduwe AE (Ambalango	na) a Sewerage) da) a)	Battaramulla Kotte Kolonnawa Kaduwela	Colombo Colombo Colombo	RSC (Western Central) RSC (Western Central) RSC (Western Central)	Regional Manager (Kotte) Regional Manager (Kotte)	OIC (Kotte) OIC (Kolonnawa) OIC (Kaduwela)

Figure B.4: Scheme Management Add Record

When selecting the record in the grid, user can have a facility to modify the record and save by clicking "Save" button. This screen shown in figure B.5

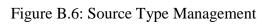
er Quality		ce Planning						4K [2045508] Head Office 🏠 🕻
	y Management => Sche	imes						
heme*	Maharagama							
	Maharagama WSS							
fress*	Maharagama							
trict*	Colombo 🔽							
C	RSC (Western Centr	al) 🔽						
noic	Regional Manager (M	(aharagama)						
	OIC (Maharagama)							
	1 1 0 1	×						
eme Det								
Schem		Description	Address	District	RSC	Region	Cost Center	
Deduru		Deduru Oya WTP	Nagollagama Rd. Pothuwewa	Kurunegala	RSC (North Western)	Regional Manager (Kurunegala)	Deduru Oya Water Supply Scheme	^
Slave I	Island irigasyaya	Slave Island WSS Thimbirigasyaya WSS	Slave Island Thimbirigasyaya	Colombo	RSC (Western Central) RSC (Western Central)	Regional Manager (Colombo City S/W) Regional Manager (Colombo City S/W)	OIC ((Vii) Slave Island) OIC ((V) Thimbirigasyaya)	
Paman		Pamankada WSS	Pamankada	Colombo	RSC (Western Central)	Regional Manager (Colombo City S/W) Regional Manager (Colombo City S/W)	OIC ((V) Pamankada)	
Battara		Battaramulla WSS	Battaramulla	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Battaramulla)	
Kotte	arriuna	Kotte WSS	Kotte	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kotte)	
Kolonn	awa	Kolonnawa WSS	Kolonnawa	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kolonnawa)	
Kaduw		Kaduwela WSS	Kaduwela	Colombo	RSC (Western Central)	Regional Manager (Kotte)	OIC (Kaduwela)	
Palanw	vatta	Palanwatta WSS	Palanwatta	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Maharagama)	
Pannipi	itiya	Pannipitiya WSS	Pannipitiya	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Pannipitiya)	
Mahar	ragama	Maharagama WSS	Maharagama	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Maharagama)	
Homag	gama	Homagama WSS	Homagama	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Homagama)	
Galage		Galagedara WSS	Galagedara	Kandy	RSC (Central)	Regional Manager (Kandy North)	OIC (Galagedera)	
Avissav	wella	Avissawella WSS	Avissawella	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Avissawella)	
Kosgan		Kosgama WSS	Kosgama	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Avissawella)	
		Miriswatta WSS	Miriswatta	Colombo	RSC (Western Central)	Regional Manager (Maharagama)	OIC (Piliyandala/Miriswatta)	
Miriswa Kelaniy		Kelaniya WSS	Kelaniya	Gampaha	RSC (Western North)	Regional Manager (Kelaniya)	OIC (Kelaniya / Paliyagoda)	~

Figure B.5: Scheme Management Modify Record

Same Procedure shall apply for the removing record from the system. There are master data management screens inbuilt to the system which is follow the same procedure. All these screens are listed as follows.

- Source Type Figure B.6
- Source Figure B.7
- Source Used Schemes Figure B.8
- Sample Points Figure B.9
- Testing Parameters
 - Parameters Figure B.10
 - Tolerance Figure B.11
 - Rates Figure B.12
 - Groups Figure B.13

ster quality Hanagement +> Source Types becrifyion	National Water Supply Enterprise Resource Planning	y & Drainage Board	01/09/20. NANDATHILAK [2045508] Head Office 🏠 🛃
Ausrigitation Durb Dirb	r Quality Management => Source Types		
Secret Type Secret Type Note Secret Type Secret Type Secret Type			
Iver Kalvagna Beervidr Kalvagna UPF Beervidr WF Mater Fall WF Water Fall WF Water Fall Water Fall Sender Water Fall Water Fall Sender Water Fall Sender Water Fall <t< th=""><th></th><th></th><th></th></t<>			
Reservir Reservir Reservir Vilar Vilar Vilar Vilar Vilar Savalar Vilar Vilar Savalar Vilar Vilar Savalar Vilar Vilar Savalar Vilar Vilar <th></th> <th></th> <th></th>			
MTP Wafer Flait Meder Fail Wafer Flait Stream Stream Meder Fail Wafer Flait Stream Stream Meder Fail Wafer Flait Stream Stream Meder Fail Stream Method Wafer Flait Stream Open Stream Springs Method Springs			~
Mate Fall Mater Fall Mater Fall Strama Strama Strama Strama Strama Strama Strama Mater Fall Strama Strama Strama Strama			
Stream Stream Stream Will Weil Ora Ora Ora Ora Bore Mole Service Ora Cala Ora Service Service Service Oral Service Oral Cala Oral Service Oral Service<			
Mell Well Op Op Dore koloe Springs Weak Serification Mona Weak Canal Canal Canal Sensitive Well Sensitive Well Sensitive Well Canal Canal Canal Canal Sensitive Well Sensitive Well Canal Canal Canal			
Ora Ora Bordon Ober Hole Bordon Seriopia Springs Seriopia Wena Wena Bordon Cala Bordon Seashare Well Seashare Well Seashare Welle Seasoutball Sea			
Image:			
Springs Springs Springs Wena Wena Isla Isla Canal Canal Seashare Well Seashare Well Seas Outfail Sea Outfail Seas Outfail Sea Outfail Seas Well Seashare Well Seashare Well Seashare Welle <			
Wewa Wewa Wewa Image: Wewa Ba Canal Canal Canal Canal Saware Well Canal Canal Canal Saware Well Canal Canal Canal Saware Well Canal Canal Canal Canal Canal Saware Well Canal Canal <			
Ibi I			
Conal Conal Seador Well Seadorar Well R0 Reverse Osnosis plant Sea Outfall Sea Outfall Guly Bowser Guly Bowser Guly Bowser Factory Industry Redory Industry Factory Industry			
Seabare Well Seabare Well R0 Reverse Samolis plant Sea Outfall Sea Outfall Guly Bowser Guly Bowser Factory Industry Pactory Industry			
R0 Reverse Gronols plant Sao Jufall Sao Jufall Guly Bowser Guly Bowser Factory Industry Factory Industry			
See Outfall See Outfall Gully Bowser Gully Bowser Gully Bowser Factory Industry Pactory Industry Pactory Industry			
Gully Bowser Gully Bowser Factory Industry Factory Industry			
Factory Industry Factory Industry			
New Cancel Cancel Conce			~
0 🛠 😰 🖳 🧍 🥨			2



	Enterprise Researcher						RWM NANDATHILAK [20-	43300j Nead Oli	
	r Quality Management => 5	ources							
	ce Type*Select er Type*Select	~							
	ce Name*								
c	ription*								
	ess*	_							
	ict*Select ting Date* 01/01/0001								
	X Coordinate	0.00							
	Y Coordinate	0.00							
•	ce Details								
	Source Type	Water Type	Source Name	Description	Address	District	Starting Date	GPS X C	oordinate
	WTP	FullyTreatedWater	Ranpokunawatta WTP I	Ranpokunawatta WSS	Ranpokunawatta	Gampaha	01/01/2021 00:00:00	0.00	0
	Bore Hole	RawWater	BH Galgamuwa	Galgamuwa Distribution	At Sathipola Galgamuwa	Kurunegala	25/03/2021 00:00:00	0.00	0
	WTP	FullyTreatedWater	Ambathale WTP	AWTP Sumps	Ambathale	Colombo	08/07/2021 00:00:00	0.00	0
		FullyTreatedWater	Ellakanda Reservoir	Horana WSS	Horana	Kalutara	01/01/2021 00:00:00	0.00	0
	Distribution	,			Araly South Araly	Jaffna	10/12/2020	0.00	
	Distribution	RawWater	Araly WSS- Dug Well I Bottom	Araly WSS	Araiy South Araiy	Jamna	00:00:00	0.00	0
			Araly WSS- Dug Well I Bottom Perera Hotel Kandy Rd Rikillagaskada	Araly WSS Rikillagaskada distribution	Perera Hotel Kandy Rd	NuwaraEliya		0.00	
	Well	RawWater					00:00:00 21/05/2021 00:00:00 10/12/2020		0.
	Well Oya	RawWater FullyTreatedWater	Perera Hotel Kandy Rd Rikillagaskada	Rikillagaskada distribution	Perera Hotel Kandy Rd	NuwaraEliya	00:00:00 21/05/2021 00:00:00	0.00	0. 0. 0.

Figure B.7: Source Management

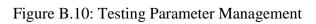
Enterprise Resource Pla	unning			RWM NANDATHILAK [2045508] Head Off
/ater Quality Management => Source Use				ווט שאח (סטכניוע) אינווח ואנווישיו יוווא
Source Name* Select	o schemes	~		
Scheme*Select	~	•		
	•			
Description*				
Starting Date*				
Water Usage 0.00				
Source Used Schemes Details			and the second s	
Sno. Source Name	Scheme	Description		ter age
749 Yakkala	Yakkala	Yakkala	25/03/2021 0	0
813 Aththanagalu Oya	Yakkala	Raw water	30/03/2021 0	0
203 Bomuruella	Ambagasdowa	Raw water gravity line	05/02/2021 0	0
1334 Ambagasdowa Stock Tank	Ambagasdowa	Distribution	20/07/2021 0	0
1127 Maligakanda Reservoir	Boralla	Borella Distribution	14/05/2018 0	0
1307 Deduru Oya Reservoir	Deduru Oya	Intake Deduru Oya WTP	10/06/2021 0	0
592 Sump Deduru Oya WTP	Deduru Oya	Deduru Oya WTP	11/03/2021 0	
137 Ranpokunawatta WTP I	Deduru Oya	Hulftsdorf Area	01/01/2021 0	
595 OHT Maho	Deduru Oya	Site Office Maho	11/03/2021 0	
597 CKD Tank, Maho.	Deduru Oya	Site Office Maho Site Office	11/03/2021 0	
1335 Over Head Tank Polphithigama	Deduru Oya	Polphithigama	15/07/2021 0	0
187 Ranpokunawatta WTP I	Slave Island	Maligakanda Reservoir		
760 Maligakanda Reservoir	Slave Island	Slave Island Area	25/03/2019 0	
761 Maligakanda Reservoir	Thimbirigasyaya		25/03/2019 0	
762 Jubilie Reservoir 1355 Dehiwala Reservior	Thimbirigasyaya Thimbirigasyaya		25/03/2019 0 23/05/2021 0	
40 Rannokunawatta WTD I	Thimbirinaevava		23/05/2021 0	

Figure B.8: Source Used Scheme Management

	ational wa	ter Supply & Drain	аде воаго		
🥑 Ent	terprise Resour	e Planning			RWM NANDATHILAK [2045508] Head Office 🏠 (
ter Quality Man	nagement => Samp	le Points			
•		RSC (Central)	~		
on*		Regional Manager (Kandy Ea	st) 🗸		
eme*		Balagolla 🗸			
rce*		Mahaweli River		×	
er Type		RawWater		Source Type River	
ce Address		Balagolla. Haragama		Source District Kandy	
ple Point De					
ple Point No		04138-SP-3			
ple Point Nan	me	Treated water			
ple Point Add	dress	Balagolla WTP Sump		District* Kandy	
X Position		0.00000		GPS Y Position 0.00000	
ing Date*		02/03/2021			
ng Date*					
ing butte		1			
	st for Scheme				
ple Point Lis		Sample Point Address* Starting	g Date* Ending Date*		
ple Point Lis ple Point No 38-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021		
ple Point Lis ple Point No 38-SP-2	Sample Point Nam	Sample Point Address* Startin	2021	^	
ple Point Lis ple Point No 38-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	^	
ple Point Lis ple Point No 38-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	^	
ple Point Lis ple Point No 18-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	^	
ple Point Lis ple Point No 18-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	^	
ple Point Lis ple Point No 38-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	^	
ple Point Lis ple Point No 18-SP-2	Sample Point Nam Raw Water	Balagolla WTP Intake 03/03/	2021	*	
ple Point Lis ple Point No 18-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	Sample Point Address [®] Startin Ralagolla WTP Intake 0.3/03/ Balagolla WTP Sump 02/03	2021	^	
ple Point Lis ple Point No 38-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	Balagolla WTP Intake 03/03/	2021	Î	
ple Point Lis ple Point No 18-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	a Sample Point Address* Startin (Balagolla WTP Intaka 0.3/02/ Balagolla WTP Sump 02/03	2021		
ple Point Lis ple Point No 38-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	Sample Point Address [®] Startin Ralagolla WTP Intake 0.3/03/ Balagolla WTP Sump 02/03	2021	Î	
ple Point Lis ple Point No 38-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	a Sample Point Address* Startin (Balagolla WTP Intaka 0.3/02/ Balagolla WTP Sump 02/03	2021		
ple Point Lis ple Point No 18-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	a Sample Point Address* Startin (Balagolla WTP Intaka 0.3/02/ Balagolla WTP Sump 02/03	2021		5
ple Point Lis sple Point No 38-SP-2 38-SP-3	Sample Point Nam Raw Water Treated water	a Sample Point Address* Startin (Balagolla WTP Intaka 0.3/02/ Balagolla WTP Sump 02/03	2021		•

Figure B.9: Sample Point Management

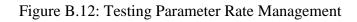
ater Quality Management => Testing Pa	rameters => Parameters				RWM NANDATHILAK [2045508] Head Office 🗌
	annecers - 2 - andimeters				
nalysis Type*Select	~				
est Parameter Name*					
escription*					
nit					
est Method					
st Parameter Details					
no. Analysis Type		Description	Unit	Test Method	
PhysicalNOrganolepticRequirements		Colour		APHA 2120 B	
PhysicalNOrganolepticRequirements		Turbidity	NTU	APHA 2130 B	
PhysicalNOrganolepticRequirements		pН		APHA 4500 H B	
ChemicalRequirements		Aluminium		APHA 3113 B	
ChemicalRequirements		Free Ammonia	mg/l	Appendix A	
ChemicalRequirements		Albuminoid Ammonia	mg/l	Appendix A	
ChemicalRequirements		Calcium		APHA 3500 Ca B	
ChemicalRequirements		Chloride		APHA 4500 CI B/APHA 4110	
ChemicalRequirements		Chemical Oxygen Demand		APHA 5220 B	
ChemicalRequirements		Copper		APHA 3111 B/ICPMS APHA	
ChemicalRequirements ChemicalRequirements		Fluoride Free Residual Chlorine	mg/l	APHA 4500 F C/ APHA4110B APHA 4500 Cl G	
		Iron		APHA 3500 EF B	
ChemicalRequirements			mg/l		
ChemicalRequirements		Magnesium	mg/l	APHA 3500 Mg B	
ChemicalRequirements ChemicalRequirements		Manganese		APHA 3111 B/ICPMS APHA APHA 4500 NO3 E/APHA 4110	
ChemicalRequirements ChemicalRequirements		Nitrate Nitrite	mg/l mg/l	APHA 4500 NO3 E/APHA 4110 APHA 4500 NO2 B/APHA4110B	
ChemicalRequirements	Nitrite	Nitrite	mg/i	APHA 4500 NO2 B/APHA4110B *	



Vater Quality Management => Te: Water Type*Select	-			
water typeSelect				
	~			
Test ParameterSelect	~			
Description*				
Minimum Value*	0.00			
Maximum Value*	0.00			
est Parameter Tolerance Deta	lle			
		Description	Minimum Valu	e Maximum Value
		Colour	0.00	15.00
		Colour	0.00	100.00
108 ChlorineOnlyTreatedWater		Colour	0.00	15.00
		Colour	0.00	15.00
		Turbidity	0.00	2.00
111 ChlorineOnlyTreatedWater		Turbidity	0.00	2.00
		Turbidity	0.00	2.00
		pH	6.50	8.50
		pH	6.00	9.00
112 ChlorineOnlyTreatedWater		pH	6.50	8.50
		Inland Surface water	6.00	8.50
		рН	6.50	8.50
		Aluminium	0.00	0.20
113 ChlorineOnlyTreatedWater	Aluminium	Aluminium	0.00	0.20
5 FullyTreatedWater	Aluminium	Aluminium	0.00	0.20
7 FullyTreatedWater	Free Ammonia	Free Ammonia	0.00	0.06
114 ChlorineOnlyTreatedWater	Free Ammonia	Free Ammonia	0.00	0.06

Figure B.11: Testing Parameter Tolerance Management

Enterprise Reso	ater Supply & Draina			
🖅 Enterprise Reso		oard		
	urce Planning			RWM NANDATHILAK [2045508] Head Office 🏠
er Quality Management => Te	esting Parameters => Rates			
t ParameterSelect	V			
st"	0.00			
ective Date*				
d Date* 🛛 🔯				
t Parameter Rate Details				
. Test Parameter	Cost Effective Date End Date			
Colour	60.00 16/02/2021 31/12/2025			
Turbidity	60.00 16/02/2021 31/12/2025			
pH	60.00 16/02/2021 31/12/2025			
Aluminium	2600.00 16/02/2021 31/12/2025			
Free Ammonia	330.00 16/02/2021 31/12/2025			
Calcium	1300.00 16/02/2021 31/12/2025			
Chloride	330.00 16/02/2021 31/12/2025			
Chemical Oxygen Demand	1300.00 16/02/2021 31/12/2025			
Copper Fluoride	1300.00 16/02/2021 31/12/2025			
Free Residual Chlorine	260.00 16/02/2021 31/12/2025 60.00 16/02/2021 31/12/2025			
Iron	500.00 16/02/2021 31/12/2023			
Magnesium	260.00 16/02/2021 31/12/2025			
Manganese	1300.00 16/02/2021 31/12/2023			
Nitrate	260.00 16/02/2021 31/12/2025			
Nitrite	260.00 16/02/2021 31/12/2025			
Nickel	2600.00 16/02/2021 31/12/2025			
New 💾 Save 🔕 C	ancel 🔀 Remove 🗙 Close			
	? 🛠 📝 🖳	9		



	Resource Planning				1 NANDATHILAK [2045508] Head Of
	=> Testing Parameters => Groups				
rest Parameter Group Name	Metal and Toxic Central Lab	~			
-			~		
Description			\sim		
Test Parameter Group Del					
Analysis Type	Test Parameter	Unit	Estimated Cost	~	
ChemicalRequirements	Calcium	mg/l	1300.00 📑 🦉		
ChemicalRequirements	Magnesium	mg/l	260.00 📑 🦉		
ChemicalRequirements	Copper	mg/l	1300.00 📑 🖉		
ChemicalRequirements	Manganese	mq/l	1300.00 📑 🦉		
ChemicalRequirements	Zinc	mg/l	1300.00 📑 🦉		
ChemicalRequirements	Aluminium	mg/l	2600.00 📑 🦉		
ChemicalRequirements	Sodium	mg/l	1300.00 📑 🖉		
ChemicalRequirements	Nickel	mq/l	2600.00 📑 🦉		
ToxicRequirements	Arsenic	mg/l	2600.00 📑 🦉		
ToxicRequirements	Cadmium	mg/l	2600.00		
ToxicRequirements	Lead	mq/l	2600.00 📑 🦉		
ToxicRequirements	Mercury	mg/l			
ToxicRequirements	Selenium	mg/l	2600.00 📑 🦉		
ToxicRequirements	Chromium	mg/l	2600.00		

Figure B.13: Testing Parameter Group Management



Transaction Data Management

Figure B.14: Transaction Data Management Menu

Sample testing process conducted by laboratories island wide. Their test results are required to captured to the system using the menu options shown in the figure B.14 Each menu option used to Register, Capture Results and Approve Result are the relevant transaction data to the system.

When Samples are received to the laboratory, they have to register in the system with the required data. System shall generate the sample no and continue as unique no for the laboratory. This process incorporated screen is shown in figure B.15.

	-
Song State (S	- C) Search ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・ ・
National Water Supply & Drainage Board	01/09/2021
Enterprise Resource Planning	RWM NANDATHILAK (2045508) Head Office 🏠 😃
Water Quality Data => Sample Registration	
Sample No. Prepare D	te"
RSC*Select	
Region*Select V	
Scheme*Select	
Source*Select V	
Water Type Source Ty Source Address Source Di	
	nnc Address
Sample Pair Raine Sample Pair	
Sample Volume (ml) 0.00 Wheather	
	lector Designation
References	
Document Control Record	
	~
🕞 Register 🦻 View 📮 Change 💾 Save 🔕 Cancel 🔀 Close 🚋 Print	
🙂 🛛 🛇 🛠 🖉 🖳 🏅 🥬	un de la companya de
🗉 🔎 Type here to search 🛛 🔿 🛱 🧟	📲 📧 😰 🕲 🖄 👯 😗 👔 👘 🕄 🖏 👘 👘 🕅 🖏 👘 👘

Figure B.15: Sample Registration Form

This screen facilitates to view existing sample details by entering sample no or searching through the separate search screen by entering the input criteria and viewing. This search provide user to find the sample no and retrieve from the database. This screen is shown in figure B.16 with the search window.

C () (200/ErpA	hpp/WQM/InHouseWaterQuality/WQSampleRegi	stration.aspx					≁ C Search			P- @☆@ [®]
	Water Supply & Drai	nage Board								01/09/2021
Enterprise Re	esource Planning									l Office 🕋 😃
Water Quality Data => Sampl	le Registration									
Sample No.	٩		Prepa	re Date*	1					~
RSC*	Select		~							
Region*	Select V									
Scheme	Select V									
Source*	Select V	Sample Number Search	Webpage Dialog					×		
Water Type	Select +	http://10.0.0.200/ErpApp	p/WQM/InHouseWaterQu	ality/WQSearch.aspx?id=ctI00_Co	ontentPlaceHolder1_fvWater	Quality_txtSampleN	Vo&ispopup=true&Value=			
Source Address		Sample Number Search	h							
Sample Point Name*	Select V			-						
Sample Date*		RSC*	RSC (Central)	<u> </u>						
Sample Volume (ml)	0.00	Region	Select	>						
	0.00	Scheme	Select 🗸							
Sample Collector Name		Source	Select V							
References		Sample Point Name	Select V							
Document Control Record		From Date*	01/08/2021		To Date* 01/09/2021					
		Source		Sample Point Name		Sample Date	Sample No.	~		
		BOI Security Room		BOI Security Room		09/08/2021	04138-2021-WQD-134			
		Food City Kandy Rd Na		Food City Kandy Rd Na		09/08/2021	04138-2021-WQD-138			
		Madapola Hotel Kandy	Rd Theldeniya	Madapola Hotel Kandy	Rd Theldeniya	09/08/2021	04127-2021-WQD-45			
		Peopel s Bank Digana		Peopel s Bank Digana		09/08/2021	04138-2021-WQD-139			
		Kahalla Distributions Wegiriya Distributions		Distribution 1 Distribution 1		11/08/2021 20/08/2021	04339-2021-WQD-100 04312-2021-WQD-92			
		Wegiriya Distributions Wegiriya Distributions		Distribution 1 Distribution 5		20/08/2021	04312-2021-WQD-92 04312-2021-WQD-93			
		Yatihalagala Distributio	ons	Distribution 2		20/08/2021	04312-2021-WQD-98	~		
		Toonalayora Disarbaa	0110			20,00,2022	CIGAR ROLL INQUISO			
				🕒 Vie	w 🗙 Close					~
Register 🦻 View	Change 💾 Save 🚫 Cancel	http://10.0.0.200/ErpApp/W0	QM/InHouseWaterQuality	WQSearch.aspx?id=ctl00_Conter	ntPlaceHolder1_fvWate 😜 Ir	ternet Protected P	Mode: On			
	0 🛠 🖄 🖳	l 🤰 💖 👘								
										~
Type here to search	h O H	: 💽 🗖 🚔	o 📫 🧉		S S	5		2 81	"F Rain showers 🔨 😳 🐔 🛥 🚯 ዕ) Er	NG 6:57 AM
s spende to search		· · · · ·			· · ·	~~				01/09/2021 🔞

Figure B.16: Sample Registration View with Search Option

After completing the sample testing at laboratory, chemist should input the test results by inputting sample no directly or search and retrieve the relevant sample no using sample no search screen. This process is shown in the figure B.17.

	water	Supply & Draina	ge board							
Enterprise R	esource Pl	anning								RWM NANDATHILAK [2045508] Head Office 🏠 🌾
ater Quality Data => Captu	re Result									
cheme*	Polgolla	\sim								
ource*	Kahalla D	Distributions 💙								
ater Type	FullyTreate				Source Type		Distribution			
ource Address	Kahalla Ar				Source District		Kandy			
ample Point Name*	Distributi				Sample Point A	dress	Mr.Fernando,No:14,Kahalla			
imple Date*	11/08/202				Sample Time		14:36			
ample Volume (ml)		1000.00			Wheather Cond	tion	Dry 💙			
mple Collector Name	Mr. Kanish	nka Prasanna			Sample Collecto	r Designation	Lab Attendant			
est Parameter Group Name	Regional	Laboratory	~	1	References					
st Parameters										
alysis Type		Test Parameter	Value Obtain		Estimated					
ysicalNOrganolepticRequire	ements	pH	6.9300			0.00 📑 🦉				
ysicalNOrganolepticRequire	ements	Turbidity	0.3300	NTU		0.00 📑 🦉				
ysicalNOrganolepticRequire	ements	Colour	0.0000	Hazen Units		0.00 📑 🦉				
emicalRequirements		Total Dissolved Solids	27.1000	mg/l		0.00 📑 🦉	1			
emicalRequirements		Free Residual Chlorine	0.9000	mg/l		0.00 🔜 🛒				
croBiologicalRequirements		Total Coliform	0.0000	100ml	50	0.00 🕞 🦉	-			
croBiologicalRequirements		E Coli	0.0000	100ml		0.00			~	
<									>	
ocument Control Record		-								
		Designation	Name	TAWALA	Sta		temarks	E	^	
		CHEMIST/BACTERIOLOGIST - CHEMIST/BACTERIOLOGIST -				pted			_	
						pted				
prove 25/08/2021 834		CHEMIST/BACTERIOLOGIST -			Acc	pted		2		
View 📮 Capture Re	esults 📙	Save 🚫 Cancel 🗙 Clo	se 📥 Print							
		0 쑱 📝 🛄	<u></u>							_

Figure B.17: Enter Test Results for Selected Sample Registration No.

Final Stage of the test results to be approved for confirmation of the test result. Head of the laboratory should input the sample no and view the result entered sample or using sample no search screen to find the sample for approval. This process was incorporated in figure B.18.

	esource Planning				RWM NANDATHILAK [2045508] Head Office 🏠 🌔
Vater Quality Data => Appro	ve Result				
Sample No.	11112-2021-WQD-251		Prepare Date*	03/08/2021	
RSC*	RSC (Production - Ambatale)		\checkmark		
Region	RSC (Production - Ambatale) ¥				
5cheme*	Ambathale WTP 💙				
Source*	Ambathale 💙				
Vater Type	FullyTreatedWater		Source Type	WTP	
ource Address	Ambathale Kubota Sump		Source District Sample Point Address	Colombo	
Sample Point Name* Sample Date*	03/08/2021		Sample Time	AWTP 02:40	
Sample Volume (ml)	500.00		Sample Time Wheather Condition	Dry Y	
ample Collector Name	Kasuni Damayanthi		Sample Collector Designatio		
est Parameter Group Name		~	References	Contract	
est Parameters	regional caporatory renoutine				
Analysis Type	Test Parameter	Value Obtain Unit	Estimated Cost		
hysicalNOrganolepticRequire		0.7800 NTU	60.00 📑 💈	^	
hysicalNOrganolepticRequire	ements pH	6.9000	60.00 📑 🖁		
hysicalNOrganolepticRequire	ements RCL	0.8000	0.00 📑 📲		
	Free Ammonia	0.0600 mg/l	330.00 🔜 関		
hemicalRequirements					
	Residual Alum	0.0500 mg/l	0.00 📑 🦉		
ChemicalRequirements ChemicalRequirements ficroBiologicalRequirements	Residual Alum E Coli	0.0500 mg/l 0.0000 100ml	500.00		

Figure B.18: Approve the Test Results Enter by Chemist Using Sample No.

Dashboard



Figure B.19: Dashboards for Water Quality Management System

This concept was introduced to the NWSDB to operate paperless system to manage water quality of the water production and distribution. These dashboards are processed based on the user given criteria which is filtering the requirement needed by the end-user shown in figure B.19

Detail Analysis

This dashboard based on the water quality test results recorded by each laboratory in NWSDB. Users have a facility to filter required information according to the criteria built by their input values. Input RSC as "RSC North", From Date as 01/05/2021 and To Date as 31/05/2021 other options are kept as 'No Selection'. After completing the input criteria, system process the data and display the dashboard. Input fields labelled as "*" indicated required field other are selectable. This concept applied to all dashboards in the system. The results shown in figure B.20.

NHibernate in Details Part 1 en U	Jpdated list of locked do	🚯 Welcome To Samp	ath Vis 😁 Water (Quality Manageme 🕜 W	ater Quality Software	. 🔀 Water Quali	ty Manageme	Water Quality Software fo D Hibe	emate With One-To-N	L. (J) Hibernate One-to-Many X 🍕	httpsnhibernate.info	-do	
National Wa		rainage Board										03/07/] Head Office 🏠	
ashBoard => Water Quality	Management=> D	etail Analysis											
sc	RSC (North)			\sim									1
egion	Select	~											
cheme*	Select 🗸												
ource*	Select 🗸												
/ater Type ource Address				Source Type Source District									
ample Point Name*	Select V			Sample Point Add	lress								
rom Date *	01/05/2021			To Date *	31/05/2021								
est Parameters													
nalysis Type Test	Parameter	Unit		~									
			🕞 🦉										
			+										
				~									
< nalytical Data				>									
	-	Pandiyankulam					-		-		-		
egional Manager (Jaffna)	Pandiyankulam	WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	рН	7.5600		60.00	^	
egional Manager (Jaffna)	Pandiyankulam	Pandiyankulam WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	Total Dissolved Solids	477.0000	mg/I	60.00		
egional Manager (Jaffna)	Pandiyankulam	Pandiyankulam WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	Chloride	57.0000	mg/l	330.00		
egional Manager (Jaffna)	Pandiyankulam	Pandiyankulam WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	Total Alkalnity	247.0000	mg/l UnSatisfie	230.00		
egional Manager (Jaffna)	Pandiyankulam	Pandiyankulam WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	Nitrate	0.1000	mg/l	260.00		
egional Manager (Jaffna)	Pandiyankulam	Pandiyankulam WSS Borehole III	Bore hole III	RawWater	03	/05/2021	12:45	Nitrite	0.0120	mg/l	260.00	~	
<			1	1	1		1	1	1	1		>	
					👎 View 🛛	🔇 Cancel 🕽	Close						
		🛠 🖻 🛛	😐 🤱 I	S)								7	1

Figure B.20: Detail Analysis Dashboard

Summary Analysis

In this dashboard shows analytical data and the graphical view of the analysis. All inputs are in same standard define in detail analysis dashboard. Analytical data shown in figure B.21 and graphical view shown in figure B.22.

Fintern		ater Supply &	Dramaye	DUaru										01/09/2
Enterp	orise Resou	irce Planning										RWM NANDAT	'HILAK [2045508] He	ad Office 🏫 🌘
ashBoard => Water	Quality Mana	gement => Summary Ana	lysis											
ISC	RSC (Nort	th) 🗸	Region	Se	lect	~	Scheme	Se	elect	~	•			
	RawWa	ter .	1											
/ater Type		eatedWater												
ater rype		~												
	Partially	yTreatedWater												
nalysis Type	Select	~	Analysis By	• Sa	mple Scheme	Region								
rom Date*	01/08/202	1 🔟	To Date*	01/0	9/2021 🔟									
	4					-1								
rocess Data =>	🚮 🛛 RSC V	Vise 🚮 Region Wise	Scheme W	se 🚫 Can	cel 🗙	Close			-					
			No. of Complete	No of	Datia Dhusical	No of		No of		No of	Datia	No. of Complex	Sample	~
gion		Scheme	No of Samples Tested	Unsatisfied Physical N	Ratio Physical N Organoleptic	Unsatisfied	Ratio Chemical	Unsatisfied	Ratio Toxic	Unsatisfied	Ratio MicroBiological	No of Samples Unsatisfied	Unsatisfied	
			restea	Organoleptic	in organoicpeic	Chemical		Toxic		MicroBiological	rinerobiological	onsatistica	Ratio	
gional Manager (Jafi	ffna)	Analaithivu	3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	
gional Manager (Jafi	ffna)	Araly	6	2	33.33	6	100.00	0	0.00	0	0.00	6	100.00	
gional Manager (Jafi	ffna)	Chunnakam	7	0	0.00	7	100.00	0	0.00	0	0.00	7	100.00	
		0.10	5	0	0.00	3	60.00	0	0.00	0	0.00	3	60.00	
gional Manager (Jafi	ffna)	Delft												
		Eluvaithivu	3	0	0.00	0	0.00	0	0.00	0	0.00	0	0.00	
gional Manager (Jaf	ffna)					0	0.00 66.67	0	0.00	0	0.00	0	0.00 66.67	
gional Manager (Jafi gional Manager (Jafi	ffna) ffna)	Eluvaithivu	3	0	0.00					-				
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna)	Eluvalthivu Kaithady	3	0	0.00	2	66.67	0	0.00	0	0.00	2	66.67	
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna)	Eluvaithivu Kaithady Karainagar	3 3 9	0 0 3	0.00 0.00 33.33	2	66.67 100.00	0	0.00	0	0.00	2	66.67 100.00	
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna) ffna)	Eluvaithivu Kaithady Karainagar Karaveddy	3 3 9 2	0 0 3 0	0.00 0.00 33.33 0.00	2 9 2	66.67 100.00 100.00	0	0.00 0.00 0.00	0	0.00 0.00 0.00	2 9 2	66.67 100.00 100.00	
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna) ffna) ffna)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts	3 3 9 2 21	0 0 3 0 8	0.00 0.00 33.33 0.00 38.10	2 9 2 9	66.67 100.00 100.00 42.86	0 0 0 0	0.00 0.00 0.00 0.00	0 0 0	0.00 0.00 0.00 0.00	2 9 2 12	66.67 100.00 100.00 57.14	
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Vav	ffna) ffna) ffna) ffna) ffna) ffna) vvuniya)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts Kilinochchi	3 3 9 2 21 7	0 0 3 0 8 2	0.00 0.00 33.33 0.00 38.10 28.57	2 9 2 9 0	66.67 100.00 100.00 42.86 0.00	0 0 0 0 0	0.00 0.00 0.00 0.00 0.00	0 0 0 0 1	0.00 0.00 0.00 0.00 14.29	2 9 2 12 3	66.67 100.00 100.00 57.14 42.86	
egional Manager (Jafi egional Manager (Jafi egional Manager (Jafi egional Manager (Jafi egional Manager (Jafi egional Manager (Jafi egional Manager (Vat egional Manager (Jafi egional Manager (Jafi egional Manager (Jafi	ffna) ffna) ffna) ffna) ffna) ffna) vvuniya) ffna)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts Kilinochchi Madhu	3 3 9 2 21 7 8	0 0 3 0 8 2 0	0.00 0.00 33.33 0.00 38.10 28.57 0.00	2 9 2 9 0 3	66.67 100.00 100.00 42.86 0.00 37.50	0 0 0 0 0 0	0.00 0.00 0.00 0.00 0.00 0.00	0 0 0 0 1 0	0.00 0.00 0.00 14.29 0.00	2 9 2 12 3 3	66.67 100.00 100.00 57.14 42.86 37.50	
gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Jafi gional Manager (Vav gional Manager (Jafi	ffna) ffna) ffna) ffna) ffna) ffna) ivuniya) ffna) ffna)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts Kilinochchi Madhu Mallavi	3 3 9 2 21 7 8 10	0 0 3 0 8 2 0 0	0.00 0.00 33.33 0.00 38.10 28.57 0.00 0.00	2 9 2 9 0 3 3	66.67 100.00 100.00 42.86 0.00 37.50 30.00	0 0 0 0 0 0 0 0	0.00 0.00 0.00 0.00 0.00 0.00 0.00	0 0 0 1 0 0	0.00 0.00 0.00 14.29 0.00 0.00	2 9 2 12 3 3 3 3	66.67 100.00 100.00 57.14 42.86 37.50 30.00	
gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna) ffna) ffna) ivuniya) ffna) ivuniya)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts Kilinochchi Madhu Mallavi Mandaithivu	3 3 9 2 21 7 8 10 4	0 0 3 0 8 2 0 0 0 3	0.00 0.00 33.33 0.00 38.10 28.57 0.00 0.00 75.00	2 9 2 9 0 3 3 4	66.67 100.00 100.00 42.86 0.00 37.50 30.00 100.00	0 0 0 0 0 0 0 0 0	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0 0 0 1 0 0 0	0.00 0.00 0.00 14.29 0.00 0.00 0.00	2 9 2 12 3 3 3 4	66.67 100.00 57.14 42.86 37.50 30.00 100.00	
gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna) ffna) ffna) ffna) ffna) vuniya) ffna) vuniya) ffna)	Eluvaithivu Kaithady Karainagar Karaveddy Kayts Kilinochhi Madhu Mallavi Mandaithivu Mannar	3 3 9 2 21 7 8 10 4 37	0 0 3 0 8 2 0 0 0 3 3	0.00 0.00 33.33 0.00 38.10 28.57 0.00 0.00 75.00 0.00	2 9 2 9 0 3 3 3 4 28	66.67 100.00 42.86 0.00 37.50 30.00 100.00 75.68	0 0 0 0 0 0 0 0 0 0 0	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0 0 0 1 0 0 0 0 0	0.00 0.00 0.00 14.29 0.00 0.00 0.00 0.00	2 9 22 3 3 3 3 4 28	66.67 100.00 57.14 42.86 37.50 30.00 100.00 75.68	
gional Manager (Jafi gional Manager (Jafi	ffna) ffna) ffna) ffna) ifna) ifna) ifna) ifna) ifna) ifna) ifna) ffna) ffna)	Eluvaithivu Kariinagar Karaveddy Kayts Kilinochchi Madhu Mallavi Mandaithivu Mannar Nainathivu	3 3 9 2 21 7 8 10 4 37 10	0 0 3 0 8 2 0 0 0 3 0 1	0.00 0.00 33.33 0.00 38.10 28.57 0.00 0.00 75.00 0.00 10.00	2 9 2 9 0 3 3 4 28 5	66.67 100.00 42.86 0.00 37.50 30.00 100.00 75.68 50.00	0 0 0 0 0 0 0 0 0 0 0 0 0	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0 0 0 0 1 0 0 0 0 0 0	0.00 0.00 0.00 14.29 0.00 0.00 0.00 0.00 0.00	2 9 2 12 3 3 3 4 28 5	66.67 100.00 100.00 57.14 42.86 37.50 30.00 100.00 75.68 50.00	ļ

Figure B.21: Summary Analysis Analytical Data

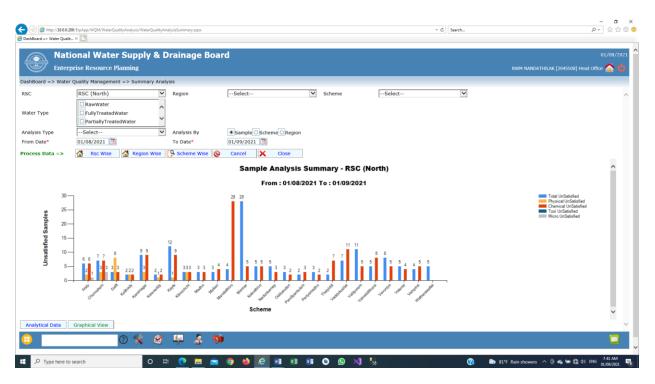


Figure B.22: Summary Analysis Graphical View

Source Type Analysis

In this dashboard provide user to analyse water sources based on the type. This dashboard shows analytical data in figure B.23 and graphical view in B.24.

	urce Planning												e 🏠
shBoard => Water Quality Man	agement => Source Typ	e Analysis											
SC R	SC (North)	~											
gion	Select	~											
-	Select 🗸												
	TP	\sim											
	Select												
		Ŷ											
om Date* 01	/08/2021		To Date* 31/08/	2021									
Analytical Data Graphical \	ïew												
egion	Scheme	Source Type	No of Samples Tested	No of Unsatisfied Physical N Organoleptic	Ratio Physical N Organoleptic	No of Unsatisfied Chemical	Ratio Chemical	No of Unsatisfied Toxic	Ratio Toxic	No of Unsatisfied MicroBiological	Ratio MicroBiological	No of Samples Unsatisfied	S ^ Uns
gional Manager (Jaffna)	Analaithivu	WTP	3	0	0.00	0	0.00	0	0.00	0	0.00	0	
gional Manager (Jaffna)	Chunnakam	WTP	3	0	0.00	3	100.00	0	0.00	0	0.00	3	1
gional Manager (Jaffna)	Delft	WTP	1	0	0.00	1	100.00	0	0.00	0	0.00	1	1
gional Manager (Jaffna)	Kayts	WTP	3	3	100.00	3	100.00	0	0.00	0	0.00	3	1
gional Manager (Jaffna)	Kilinochchi	WTP	2	1	50.00	0	0.00	0	0.00	0	0.00	1	5
gional Manager (Jaffna)	Mandaithivu	WTP	2	2	100.00	2	100.00	0	0.00	0	0.00	2	1
gional Manager (Vavuniya)	Mannar	WTP	1	0	0.00	1	100.00	0	0.00	0	0.00	1	1
gional Manager (Jaffna)	Nainathivu	WTP	1	0	0.00	0	0.00 62.50	0	0.00	0	0.00	0	
greener rearreger (serring)	Analytical Totals		16	6	37.50	10		0	0.00	0	0.00	11	6

Figure B.23: Source Type Analysis Analytical Data

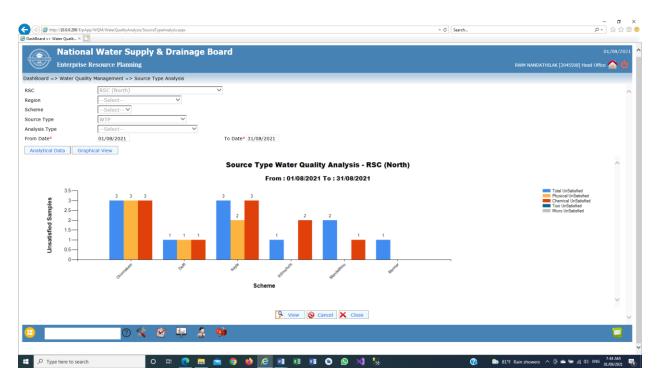


Figure B.24: Source Type Analysis Graphical View



Appendix C – Management Reports Reports

Figure C.1: Reports for Water Quality Management System

Management reports are developed in two ways in the system. Dashboards and the MIS Reports. Most of the dashboards are described in user manual. Management required reports are shown in figure C.1 and requirement are as follows;

- Water Quality Monitoring Summary report required to presented at progress review meeting
- Island wide monitoring and the information reported to the ministry by this report
- Remedial action taken based on the water quality of the source compared with previous month

In my project identified important report for water quality analysis summary define as follows. Input RSC as "RSC North", From Date as 01/08/2021 and To Date as 31/08/2021 other options are kept as 'No Selection'. After completing the input criteria, system process the data and display on the popup screen in pdf format. User can have a facility to print report in pdf format. The output and the input screen shown in figure C.2.

😑 (=) 🧟 http://10.0.0.200/ErpApp/WQM/MIS	SReports/SampleAnalysis 💋 htt	p://10.0.0.200/ErpApp/WQM/MISReports/ReportView	r.aspx							, O -	6 🕁 🕮
Report => Water Quality = × []	Fle	Home Comment View Form	Protect Share				Tind Find	P	3•0 D	۵	
Enterprise Resou	arce Planning	Cinhoard - C Et Width	Rotate Right Typewrite	er Highlight ment PDF Sign Protect	Bookmark	File Attachment Image Annotatio Audio & Video Insert	m			01/ VANDATHILAK [2045508] Head Office	09/2021
eport => Water Quality => Sample	Analysis Summar									•	
SCSe	lect	- Nations	W- t 0		Duct		D				~
egionSe	lect V	🛛 👔 👔 Nationa	l Water Sı	ирріу 8	Drair	nage I	Boai	ra			
hemeSe	lect 🗸 👔	Laboratory	Services								
nalysis TypeSe	lect 🥩	SRILANKA									
rom Date* 01/08	8/2021										\sim
🔍 View 🚫 Cancel 🗶 C	P		Island Wide Water	Quality Mon	itoring Sun	nmary					
🦻 View 🚫 Cancel 🗙 C	lose		A	s per the SLS 614							
	0 🛠 🎽					Pri	int Date :	01/09/	2021		
	- · · · 6	Rsc All Rscs									
	10	Region : All Regions									
	^ R	Scheme : All Scheme	i								
		Analysis Trans. All Analysis									
		Analysis Type : All Analysis	Types								
		From Date : 01/08/2021	Types			т	o Date :	31/08/2	021		
			Scheme	No of No o		To No of Un Sati			1021		
		From Date : 01/08/2021		No of No o Sample Sampl Prog. Teste	es Physical	No of Un Sati	sfactory San		1021 Total		
		From Date : 01/08/2021		Sample Sample	es Physical	No of Un Sati	sfactory San	mples			
		From Date : 01/08/2021 Bas Region	Scheme	Sample Sampl Prog. Teste	es Physical d	No of Un Sati	sfactory Sar Toxic	mples Micro	Total		
		From Date : 01/08/2021 Region RSC (Central)	Scheme Araththana	Sample Sampl Prog. Teste	es Physical d	No of Un Sati Chemical	sfactory Sar Toxic	mples Micro 0.00	Total		
		From Date : 01/08/2021 Region RSC (Central)	Scheme	Sample Sampl Prog. Teste	es Physical d 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00	sfactory Sar Toxic 0.00 0.00	mples Micro 0.00 0.00	Total 0.00 0.00		
		From Date : 01/08/2021 Region RSC (Central)	Scheme Araththana Balagolla	Sample Sample Prog. Teste	es Physical d	No of Un Sati Chemical	sfactory Sar Toxic	mples Micro 0.00	Total		
		From Date : 01/08/2021 Bits Region <u>RSC (Central)</u> Regional Manager (Kandy East)	Scheme Arahthana Balagolla Madadumbara Haarispaththuwa	Sample Sampl Prog. Teste 1. 2. 1. 3.	es Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00	mples Micro 0.00 0.00 0.00 0.00	Total 0.00 0.00 0.00 0.00		
		From Date : 01/08/2021 Bits Region <u>RSC (Central)</u> Regional Manager (Kandy East)	Scheme Araththana Balagolla Madadumbara	Sample Sampl Prog. Teste 1. 2. 1. 3.	es Physical 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00	mples Micro 0.00 0.00 0.00	Total 0.00 0.00 0.00		
		From Date 01/08/2021 Stie Region RSC (Central) Regional Manager (Kandy East) Regional Manager (Kandy North) RSC (East)	Scheme Arahthana Balagolla Madadumbara Haarispaththuwa	Sample Sampl Prog. Teste 1. 2. 1. 3.	es Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00	mples Micro 0.00 0.00 0.00 0.00	Total 0.00 0.00 0.00 0.00		
		From Date : 01/08/2021 Bas Region RS <u>C (Central)</u> Regional Manager (Kandy East) Regional Manager (Kandy North)	Araththana Balagolla Madadumbara Haarispaththuwa Polgolla	Sample Prog. Tests 1 2 1 3 3 1	ss Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00 0.00 0.00	Micro 0.00 0.00 0.00 0.00 0.00 0.00	Total 0.00 0.00 0.00 0.00 0.00		
		From Date 01/08/2021 Stie Region RSC (Central) Regional Manager (Kandy East) Regional Manager (Kandy North) RSC (East)	Scheme Arahthana Balagolla Madadumbara Haarispaththuwa	Sample Sample Prog. Teste	ss Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00	mples Micro 0.00 0.00 0.00 0.00	Total 0.00 0.00 0.00 0.00		
		From Date 01/08/2021 Bise Region RSC (Central) Regional Manager (Kandy East) Regional Manager (Kandy North) RSC (East) RSC (East) Regional Manager (Akkaraipattu)	Araththana Balagola Madadumbara Haarispaththuwa Polgola	Sample Sample Prog. Teste	es Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00 0.00 0.00	mples Micro 0.00 0.00 0.00 0.00 0.00 0.00	Total 0.00 0.00 0.00 0.00 0.00		
		From Date 01/08/2021 Stie Region RSC (Central) Regional Manager (Kandy East) Regional Manager (Kandy North) RSC (East)	Araththana Balagola Madadumbara Haarispaththuwa Polgola	Sample Sample Tester	s Physical 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00 00 0.00	No of Un Sati Chemical 0.00 0.00 0.00 0.00 0.00 0.00	sfactory Sar Toxic 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	mples Micro 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.	Total 0.00 0.00 0.00 0.00 0.00	v	

Figure C.2: Water Quality Monitoring Summary