Micro-controller based Water Level Sensing System

Tinotenda Nyamukuwa

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By

TINOTENDA NYAMUKUWA

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ABSTRACT

The Micro-controller based water level sensing system is an Arduino based project that was designed to capture water level distances using micro-controllers as the tank fills up or as it is emptied. The system will be used for monitoring the daily operations which involve the filling up of the tanks that feed water to the main boilers which generate electricity. Information about the current system was obtained using questionnaires, interviews and observations. Previously, during each daily shift, water readings were manually measured using a vertical rod and then recorded. When the tank became empty or full, the foreperson would then switch on or of the pumps respectively. Upon doing research there was a need for a system that would perform these repetitive tasks that are boring and monotonous such that forepersons may simultaneously perform other tasks as the system automatically manages the start or stop of pumps. Tank readings captured into the system will presented as reports to the section head of operations which could not be done before hand. Tests including black and white box, unit and acceptance testing were done. Verification and validation of the system was done to ensure that it is functioning as stated in objectives. After all tests were done various maintenance techniques were agreed on such as corrective, adaptive and perfective maintenance. The tools used to develop this system were Arduino, PHP and MySQL database.

DECLARATION

I, **Tinotenda Nyamukuwa R,** hereby declare that I am the sole author of this dissertation with help from several sources. I authorize the Midlands State University to lend this dissertation to other institutions or individuals for the purpose of scholarly research.

Signature ________________________________ Date ____________________________

APPROVAL

This dissertation entitled “Micro-controller based water level sensing system” by Tinotenda Nyamukuwa meets the policy governing the award of the degree of Bsc Information Systems Honours Degree of the Midlands State University, and has been approved for its contribution to knowledge and literal presentation.

Supervisor: ________________________________

Date: __________________________________

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DEDICATION

To my parents, Mr. and Mrs. Nyamukuwa and my sister Caryl, who exceedingly added to the establishment of the framework on which I stand and whose motivation is my source of inspiration. May the Lord keep on blessing you.

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CHAPTER ONE: INTRODUCTION

1.1 Introduction

The initial chapter informs us about Zimbabwe Power Company (ZPC). Facts and history about the organisation will be given so as to shed more light on its reason for existence and why there was a need for a power generation company to be started. Insight on the current systems functionality and limitations will be given followed by a proposed solution to address the problems mentioned

1.2 Organisational Background

According to ("Our Background") The ZESA family was initially formed in the year 1985. Due to the electricity act, five preceding companies were born from it namely Zimbabwe Electricity Transmission Company, Powertel Communications, ZESA Enterprises, Zimbabwe Power Company (ZPC) and Zimbabwe Electricity Distribution Company. In 1996 Zimbabwe Power Company was formed to be a driving tool in the generation of electricity and became when 1999 came it was functional. The company was approved to build, possess, work and keep up power generating stations for the supply of electric power. ZPC generates electricity through thermal energy. Water is warmed, transformed into steam and turns a steam turbine which drives an electrical generator. After it goes through the turbine, the steam is consolidated in a condenser and reused to where it was warmed steam hitting the turbine blades. The water for turning the turbines is pumped from Dutchman's pool then stored in tanks which are close to the boilers. The overall report could only be done once the shift foreperson and other departments have submitted their compilation. It was noted that the shift forepersons report delayed the compilation process as he would have to travel 27 kilometres to and from Dutchman's pool to start and stop the water pumps and record the time taken to fill the pumps. Sometimes they would submit their report after hours or the next day hence the paper would be lost before results were recorded. If these pumps could be automatically started and stopped it would save the company on fuel and time.

1.2.1 Organisational Structure

The organisational structure describes how exercises, for example, errand distribution, synchronization, administration, are matched toward accomplishing organisational aims (Pugh, 2007). The structure is developed to establish how organisations work and assists them in getting its objectives to accommodate future improvements. (Lucy, 2017) postulates that the organisational structure sets out each person's role, job and position in the organisation. All exercises at ZPC are controlled by the Power Plant Manager with the help of section heads of departments who have proficient subordinates to give brilliant administration. The hierarchical structure of ZPC is presented as follows.

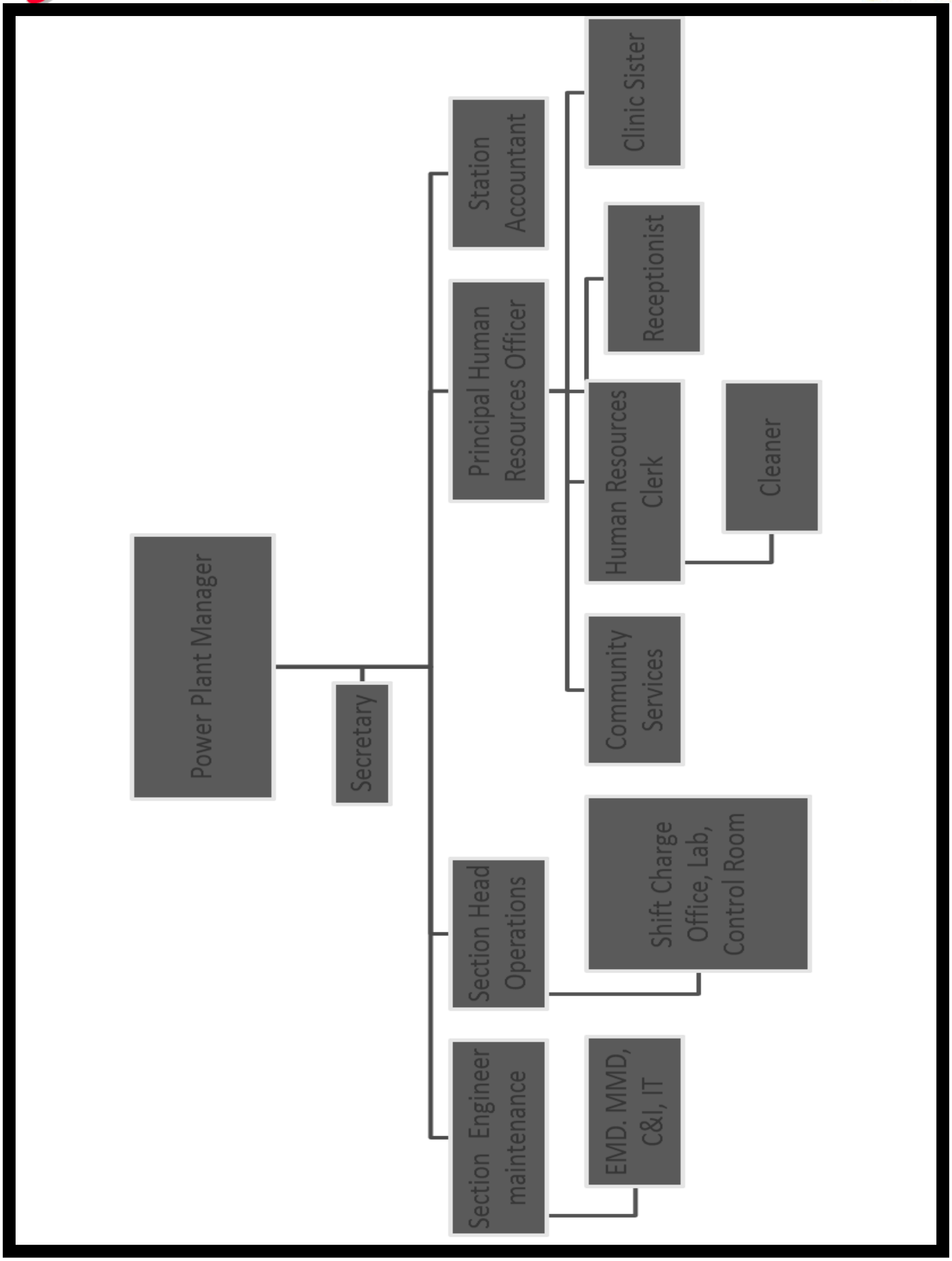


Figure 1.1 Organisational Structure

Key:

EMD- Electrical Maintenance Department

MMD- Mechanical Maintenance Department

C & I- Control and Instrumentation

I.T- Information Technology

From the above diagram, the Power Plant Manager heads Munyati Power Station. Under him are four departments which are headed by the Section Engineer Maintenance, Operations Engineer, Principal Human Resource Officer, and the Station Accountant. The I.T department is headed by Systems Administrator who reports to the Section Engineer Maintenance. The System Administrator has subordinates who are either Under Graduate Attachees or Post Graduate Trainees.

1.2.2 Vision

A vision as defined by (Kantabutra, 2010) is an assertion of an organisation's goals in light of financial foreknowledge, planned to guide its inner choice making. The vision is defined below.

Vision statement:

To be the leading supplier of energy and related services in the region

To be the most preferred supplier of peaking capacity by maintaining competitiveness in efficiency, quality, and cost, reliability and response time.

1.2.3 Mission Statement

The mission statement according to (Kelly, 2007) is a short articulation of an organisations reason for existence, distinguishing the extent of its operations, what sort of item or administration it gives, its essential clients or market, and its land district of operation.

Mission statement:

To generate electricity and supply energy related products through use of environmentally friendly technologies.

1.3 Problem Definition

Without a micro-controller based water level sensing system there will be **damage to water pumps if they are left to run until there is no water being pumped.** The damage and cost resulting from running these pumps without water is such that the electricity production process being the core activity will come to a halt. These pumps are responsible for pumping water to the boilers which is then heated to turn the turbines thus generating electricity. Stopping the power generating process means a shortage of electricity on the national grid and less revenue to the company. Less revenue may affect the salaries of employees hence reducing their morale and zeal to come to work. Low employee morale effects to less carefulness on the job which may also mean accidents occurring. These pumps should always be inundated in water to avoid damage as they are very expensive to replace or repair hence there should be someone physically there to switch it on or off.

1.4 Aim

The aim is to develop or implement a micro-controller based water level sensing system that will alert the operators when the water tanks are full and they can start pumping water to the boilers. The system will also alert the operators when the water level is low so as to stop the pump and allow the tank to be refilled again. It will be used by the operators to monitor and maintain the water levels within the given range hence starting or stopping the pump whenever water levels reach the minimum or maximum levels respectively.

1.5 Objectives

Objectives are the issues the developed system is meant to address and provide a solution for:

- To develop a system for sensing the maximum and minimum water levels in the water treatment tanks.
- To develop a system which will request the foreperson to start or stop the pumps upon getting feedback from water sensors on the current water level.
- To develop a system which updates employees on the current activity and daily functionality of the pumps.

- To develop a system which can be operated by different users of various shifts through user accounts for accountability.
- To develop a system which allows ZPC IT to manage the forepersons with access to the system as per instruction from the section head of operations.
- To develop a system allowing management to view daily readings taken from the tanks and stored the electronic database.
- To develop a system which generates reports and shows graphical statistics on time taken to refill water tanks.

1.6 Instruments

This section will give a list of all the tools and instruments to be used throughout the research process of the project and a brief description of each tool will be given.

Listed below are all the tools to be used in designing and developing the micro-controller based water level sensing system:

- Arduino
- MySQL
- PHP

Android Studio – the integrated development environment (IDE) for developing on the Android platform (Philips, 2013)

Arduino - (Kushner, 2011) defines Arduino as an open source, PC equipment and programming organization, venture, and client group that outlines and produces Single-board microcontrollers and microcontroller packs for building computerized gadgets and intuitive items that can detect and control items in the physical world.

PHP – a programming language supporting interactive platforms with a robust database.

1.7 Justification

The proposed system will eliminate the risks of damaging the water pumps by allowing the operators to be notified of the water level before it reaches either the minimum level or the maximum level. This will save the company on the costs of repairing and replacing the pumps.

The micro-controller based water level sensing system will ensure a smooth running of operations and increasing revenues as all customers are given service at the right time. This means that Zimbabwe Power Company is able to award its employees bonuses to motivate them to work harder to improve the service rendered to customers. Increased employee morale will ensure that they are more attentive and careful when working thus avoid life threatening accidents related with the working with electricity. The operators will be able to keep a record of the daily readings and activities happening with the pumps. This will ensure for proper planning of how to improve the system and further evaluate the effect on the production of electricity. Management will be able to check the system for an update to see the statistics and previous readings at any point and time hence operators will always do their work on time.

1.8 Conclusion

This chapter focused on presenting the topic and giving a background of the problem. The problem was also identified and described and how it is intended to be addressed. Chapter one has stated the proposed system's objectives and there is need to further go on to draft the actual route to be taken towards developing and implementing the system. Apart from benefiting the operators only, the whole organisation will benefit from lower costs of production. At the point when the system is implemented, it should meet the above objectives. The next chapter includes the planning stage.

CHAPTER TWO: PLANNING PHASE

2.1 Introduction

The main aim of the planning phase is to highlight why the proposed solution is the best alternative among others to solve the problem identified. In this chapter the business value will be identified and evaluated. A feasibility study will be done with the hope of ensuring that the project to be undertaken is achievable and can be practically implemented. Technical feasibility will measure whether there is enough technical proficiency to implement the project from start to end. An assessment of the effects of the system implementation on the social lives surrounding people will be carried out. The major area of concern being the economic feasibility will determine whether the project will be taken up or not as it directly affects Zimbabwe Power Company's finances directly. Through the work plan, the time needed to needed to complete the whole system from development to implementation will be shown.

2.2 Reasons for developing the new system

This stage identifies need for developing a new system and reasons why the old one must be replaced. The major objective of this system is to reduce and avoid damage to the water pumps which may result if they are left to run when the tanks are empty. The pumps are very expensive hence they must be preserved well. In addition to the main reason, below are stated other few reasons to develop the proposed system:

- To improve information flow between shift forepersons, operators and management through the use of a database system which stores daily readings and allows management to view and analyse the readings
- To enhance the operators' involvement and participation through the use of a notification system that alerts them whenever the water level reaches a maximum or minimum level.
- To enable accountability of any faults associated with the pump by enabling forepersons to login during their shifts.
- To improve on cost savings of electricity used in pumping water by switching them off when they are not in use

2.3 Business Value

This part of the research helps to shed light on the advantages of the system and the value of those advantages to Zimbabwe Power Company. The business value is the return the ZPC will get from implementing the new system in the long run (Sliger et al, 2008) which can be customer, supplier or employee value. In the long run, the micro-controller based water level sensing system will bring the following benefits:

- Reduced aggregate water and electricity bill due to efficient monitoring of the pumps such that when the tanks are full, the pumps will be switched off thus avoiding wasting electricity and water.
- Increased supply of electricity on the national grid hence over time ZPC may export bringing foreign currency.
- Forepersons and operators will be more time productive as they can wait for a notification signal of the tanks water level whilst performing other tasks as compared to waiting for the tanks to fill whilst seated idle.
- Managers can make decisions and see real time changes in daily operations through accessing information from the database system

2.4 Feasibility Analysis

A feasibility study aims to check for the practicality of executing the proposed project. This can be determined by checking for a number of requirements to kick start the project (Blanchard, 2011). A feasibility study is an investigation of how effectively a project can be completed, representing elements that influence it, for example, economic, technological, legal and scheduling factors. Project supervisors utilize feasibility studies to decide potential positive and negative results of a venture before contributing a lot of time and cash into it. The information to make decisions as to whether the project is viable or not is gathered through research methods such as questionnaires and interviews. The overall study will weigh the cost against the gains and whether to continue or stop the proposed project.

2.4.1 Technical feasibility

The technical aspects of any project are what will help in the implementation of the project. This entails assessing the system requirements to see whether ZPC has the adequate technical stuff to manage to project from start to completion (O'Brien & Marakas, 2011). The project developer must have knowledge about the proposed system and they must gather both the hardware and software needed throughout the implementation phase. (Georgakellos and Marcis, 2009) over emphasize that this feasibility study can only take place once a project has been identified and has shown the need for technical expertise to be key members of the project team. Before starting the project, there must be clarity on the type of labor to be used and whether there's room for improvement and future changes with the new system.

2.4.1.1 Hardware requirements:

Hardware requirements are the minimum specifications a system or computer in terms of hardware in order to run a specific software version (System Requirements Definition, 2004). There is need to round up all the necessary hardware and software requirements before starting to avoid stopping the project once it has started. The necessary requirements

Table 2.1 Hardware Requirements

Item	Quantity	Description
Laptop	1	4Gb RAM 2.40Ghz, 500Gb HDD
Arduino UNO Micro-controllers	1	Microcontroller ATmega328, Architecture AVR, Operating Voltage 5 V, Flash Memory 32 KB, SRAM 2 KB, Clock Speed 16 MHz
Arduino Ethernet Shield	1	Ethernet W5100, ATmega328, 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a RJ45 connection, a power jack, an ICSP header
Arduino Ultrasonic sensors HC-SR202 Sensor	1	Power Supply : 5V DC, Quiescent Current : <2mA, Effectual angle : <15°, Ranging distance : 2cm – 500 cm, Resolution : 1 cm, Ultrasonic Frequency : 40kHz

2.4.1.2 Software requirements

These are the application requirements that are necessary to run control the hardware (System Requirements Definition, 2004)

Table 2.2 Software Requirements

Software	**Edition**	**Available/Required**
Arduino	UNO R3	Available
Java Development Kit	v8	Available
Operating System	Windows 7 Professional	Available
360 Antivirus	v1.9.0	Available

2.4.2 Economic Feasibility

According to (Marakas, 2011) the official decision to put resources to a proposed system is done upon performing an economic feasibility which reflects that costs incurred towards developing the system are reconciled. The decision to make the system is based on whether it is worthwhile investing in the proposed project, if the benefits will outweigh the costs and the availability of resources to develop the system.

2.4.2.1 Costs

Costs are incurred each time a project is being carried out and a system is being developed. These are costs that are unavoidable hence much effort must be put to try to reduce the costs to be experienced. These costs are classified into operational and developmental costs (McEachern, 2012).

2.4.2.1.1 Development costs

(Ison and Stuart Wall, 2007) describe these costs as all the expenses suffered during the designing and coming up with the system. These costs mainly include the equipment needed when developing the system from the first day to the last day. The project will require that certain hardware items needed for development are bought. Below is a list of the costs that will be in incurred when developing the system.

Table 2.3: Development costs

Item	**Description**	**Unit Cost ($)**	
Laptop	4 GB Ram 2.50 Ghz 500 HDD	450	
Arduino Board	UNO R3	50	
Ethernet Shield	W5100	25	
Ultra sonic sensors	hc-sr04	15	
Total Costs		**540**	

2.4.2.1.2 Operational Costs

These are costs incurred daily as the system is being used (Ison and Stuart Wall, 2007). There are two categories of cost namely variable and fixed costs.

Table 2.4 Operational Costs

ITEM	**Year 1**	**Year 2**	**Year 3**	**Total**
	$	**$**	**$**	**$**
Installation	380	-	-	380
System maintenance	500	350	250	1100
Network Infrastructure	200	150	100	450
Total	**1080**	**500**	**350**	**1930**

2.4.2.2 Benefits

These are the gains the organization will get from implementing the system (O'Brien & Marakas, 2011). Among many reasons for a company rolling out a project, one of the major reasons would be to realize profits and benefits. Below are the benefits that will accrue to the firm upon implementing the proposed system.

2.4.2.2.1 Tangible benefits

These are profits that can be quantifiable in the form of dollars and cents and normally have a bearing on the invoice price. This area attracts investors as they normally focus their interests there.

Some of the benefits include reduced travel costs to and from the pumps and reduced costs of repairs.

Table 2.5 Tangible benefits

Item	**Year 1**	**Year 2**	**Year 3**	**Total**
	(US$)	**(US$)**	**(US$)**	**(US$)**
Improved staff productivity	5500	6000	6500	18000
Reduced pump repairs	1300	1400	1500	4200
Reduction in Transport Costs	850	900	950	2700
Total	**7650**	**8300**	**8950**	**24900**

2.4.2.2.2 Intangible benefits

They are those positive outcomes which come with using the system such as better employee attitude and job satisfaction at work (O'Brien & Marakas, 2011). These cannot necessarily be converted into monetary value but are realized as part of the positive effects of a new implementation.

- Less delays in submitting reports by forepersons as it will be done online as long as you have internet access.
- Constant supply of electricity to customers as there will be less chances of broken down pumps.
- Forepersons in charge of monitoring the pumps will welcome the system as it will lessen their burden of manually checking the water level in the tanks before stopping or starting the pumps.

2.4.3 Investment appraisal

This accounts for the assumed costs that may be accrued during the development of the system as well as the income that may arise from implementing the micro-controller based water level sensing system (Sheffrin, 2005).

2.4.3.1 Cost benefit analysis

According to (Laudon & Laudon, 2006) this section aims to show to show the total costs as a proportion of the total benefits hence it is a comparison of costs versus benefits. The table below shows the tangible benefits weighed against the operational costs:

Table 2.6 Cost Benefit Analysis

Type of Cost	Year 1	Year 2	Year 3
Benefits	**USD**	**USD**	**USD**
Tangible	**7650**	**8300**	**8950**
Costs			
Development Costs	540		
Operational Costs	1080	500	350
Total Cost	**1620**	**500**	**350**
Net Benefits	**6030**	**7800**	**8600**

2.4.3.2 Payback period

According to (Lucy, 2002) payback period is the time period taken to pay off the first amount invested in the project. ZPC will look at multiple options of implementing the system and asses the method that will return their invested money quicker and in what quantities. Calculations to determine this are usually done in the format below:

Pay back = investment (after deducting tax)

Table 2.8 Payback period

Year	Net Cash flows $	Balance $
0	**(1620)**	(1620)
1	**7650**	6030
2		

4350 * 12 = 3 months

5350

Comments:

As shown above, if ZPC invests $1620 at start, the project will reimburse their capital figure after 3 months. The project is realistic to take on as the initial outlay is returned in a short space of time.

2.4.3.3 Return on investments (ROI)

It refers to a performance tool which can be used in assessing the effectiveness of multiple investments (Lucy, 2002). It helps calculate the value of earnings on a venture in relation to the venture cost. ZPC will implement the new system if the return on investment is attractive.

The formula for calculating the return on investment is as follows:

[(Aggregate rewards after removing total expenses) / aggregate expenses] as a percentage=

Aggregate expenses = development expenses + operating expenses

= $540 + $1080

= 1620

Therefore ROI = (7650 – 1620) / 7650

= 78.8%

R.O.I = (Total Benefits – Total Costs)*100

Total Benefits

The project shows that it will give a positive return on investment meaning that it will be able to give profits from the first amount invested. ZPC will benefit if they take on this project.

2.4.3.4 Net Present Value

(Lucy, 2002) goes on to say that the Net Present Value (NPV) assists with calculating the current value of cash outflows and present value of probable cash inflows. It is therefore a measure of profitability by weighing the cash inflows against the cash outflows and Randall (2001) supports this notion. NPV is calculated for the preceding financial periods using the formulae below:

NPV = a – {c * [1/ (1+r)] ^n}

a = initial investment

c = cash flow

r = interest

n = time period (years)

2.4.3.5 Choosing the appropriate discounting rate

According to (Laudon & Laudon, 2006) a discounting rate is the percentage by which any business intends to grow its initial investment annually so as to return a reasonable amount on its investment after a certain number of years. This means that depending on the amount ZPC expects to receive after 3 years a discounting rate will be chosen. Choosing a high discount rate means ZPC is expecting a high rate of return on their investment whilst a lower discounting rate means they are more interested in the getting back their investments and achieving their major objectives such as improved employee productivity.

The table below illustrates how to calculate the present value for three years making use of a 10% discounting factor of:

Table 2.7 Net Present Value

Year	Net cash flows $	10% Discounting factor	Current value $
0	(1620)	1	(1620)
1	6030	0.909	5481.3
2	7800	0.826	6442.8
3	8600	0.751	6458.6
Net Present Value			116763

Comments:

The above results illustrate a positive Net Present Value suggesting that the project yields great returns since benefits are more than costs. Due to the positive NPV of $16763, the assumption is that the project can be implemented.

2.4.4 Social feasibility

The social feasibility aims to identify the effects of the community and people within the surrounding area (Bently & Whitten, 2007). Every project that is undertaken has got impacts on the society surrounding it which may be positive or negative. A project may result in cost savings and profitability for ZPC but if does not benefit the Munyati society then it ceases to be socially feasible. A system may be resisted if it cause people to be jobless or harm the environment around. The micro controller based water level sensing system benefits the community by reducing the chances of spillages of chemicalised water overflowing from tanks. The implementation of the new system will enhance coordination between forepersons as they can easily giving see updates of the water level, time taken to fill tanks and the challenges of the day.

2.4.5 Operational feasibility

According to Rosenblatt (2012) operational feasibility attentions we be used, developed and also implemented. The ease of managing operations should also be noted and this is listed below:

- The system should at a certain level stop the pump or start the pump thus allowing the water pumps to be always submersed in water to avoid damage.
- The new system should trigger a start or stop command upon receiving a notification of the current water level.
- Operators of the system should be aware of the tank readings by accessing the system.

2.5 Develop a work plan

A work plan is a set path of the steps to be taken towards the completion of the project. A timeline must be put in place to allow for tracking and gauging project progress. The work plan table below will act as a guide to track progress of the project and will be used to make decisions as to whether to whether to abort or continue with the project (Project Management Institute, 2013).

Table 2.9 Work plan

STAGE	START	END	PERIOD (weeks)
Proposal	22/01/17	28/01/17	**1**
Planning	29/01/17	25/02/17	**4**
Examining	12/03/17	31/03/17	**3**
Designing	09/05/17	29/07/17	**2**
Testing	06/08/17	26/08/17	**1**
Installation	03/09/17	16/09/17	**2**
Maintenance	11/10/17	**-**	**Ongoing**

2.6 Gantt chart

Russell (2007) postulates that a Gantt chart is a diagrammatic illustration showing the schedule in which the project will follow. It describes the stages the project should follow and the time spans each stage should be completed in:

PHASE	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Introduction								
Planning								
Examining								
Designing								
Installation								
Maintenance								
Documentation								

Figure 2.10: Gantt chart

2.7 Conclusion

This chapter was focusing on planning for the development process. After considering the benefits and costs related with building and maintaining of the proposed system, the business value was made clear. A feasibility study was done on the system with the aim of seeing the practicality of such an implementation. The economic feasibility identified the costs and benefits associated with implementing the project. The social feasibility showed that the proposed system has minimal negative effects on the surrounding community making it environmentally friendly. The next chapter being the analysis phase will give a detailed analysis of the system currently in use. An evaluation of the pros and cons, inputs processes and outputs, data gathering techniques, evaluation of alternatives and requirements analysis.

Chapter 3: Analysis Phase

3.1 Introduction

This stage in project development mainly looks at inspecting, transforming and modelling data in an attempt to gather appropriate information for use in the system development (Dittman, 2004). The major goal of the chapter is to scrutinise the existing system. This entails taking note of the information flow from process to process, evaluating the alternative systems available to solve the same problem and analysis of the requirements that should be met by the system. Such information is obtainable through using various forms of methodologies to gather data.

3.2 Data Gathering Methodologies

These are the tools and skills used to gather valuable information from people directly impacted by the system implementation. (Ainley, 2004) describes tools as the enablers for the researcher to attain knowledge on the environment and how best to fit the system. It is also a method of collecting data necessary when the forepersons at ZPC who monitor the water levels and lab technicians are the main stakeholders and the following information gathering tools was used (Ainsley, 2014).

- Interviews
- Questionnaires
- Observations

3.2.1 Questionnaires

Refers to a form of information gathering tool that asks the stakeholder a set of questions that assist us in assessing the public's view towards the implementation of the new system (Saris and Gallhofer, 2014). Structured and unstructured questionnaires were used, unstructured ones giving room for the employee to express their full thoughts. (Saris and Revilla, 2015) also define it as a list of written questions that with choices of answers that are related to the area under research. These questions were prepared then given to ZPC employees and lab technicians to answer honestly. To ensure that the answers given were as honest as possible, the employees did not write their names and also tried to change their handwriting specifically for the exercise. The steps by (Burns and Bush, 2010) taken to conduct the information gathering exercise were as follows.

- Identify the people to answer the questionnaire(Lab technicians and forepersons)
- List questions specific to the lab technicians and forepersons.
- Give the respondents about four days to answer the questionnaires.
- Collect and scrutinise the feedback given by employees.

The time period of four days given to employees to give feedback was to allow them to accurately and thoughtfully answer them.

3.2.1.2 Advantages of Questionnaires

Questionnaires resulted in good responses mainly due to the time given to the respondents to answer the questions.

- Open and honest responses were given due to anonymity maintained and the time frame of four days given to the respondents.
- Accurate and contextual answers were given due to the structured questioning technique
- This method was less distracting and time consuming as employees could answer them in their own time.
- Questionnaires allowed the respondent time to think of the best answer to give allowing for accurate feedback.
- They provided hard evidence that can be later used for similar projects or as reference when further developing the system.

3.2.1.3 Disadvantages of questionnaires

Employees had to be visited at their various work stations to convince them to give us information. Some of them were uneasy when they were handed the questionnaire as they assumed a possibility of their handwriting being recognized on the papers. As a result here are some of the issues that hindered accurate results;

- Respondents may not have been completely honest when answering the questionnaire due to fear of disclosing ZPC information which may have reparations.
- Some of the responses were totally different resulting in failure to bridge the two different answers, there was need to keep the questions simple and short.

- Some answers may have been misinterpreted as the respondent could not express their actual feelings and emotions in their explanations.
- Some respondents returned the questionnaires without answering all questions
- The responses given may be biased towards a certain thought. Companies hardly disclose the weaknesses and failures hence employees may have discussed and agreed on having uniform responses.

3.2.2 Observations

This entails going into the natural working environment and observing the employees daily activities (Peter, 2011). The observation was done during the normal shift, ZPC forepersons were observed as they monitored the water level, communicated with the man in the office who was recording the levels at regular intervals and traveled to the Dutchman's pool. By seeing how the forepersons were going about their daily tasks (Julia, 2016), it was noted that employees have a way of performing tasks differently from others.

3.2.2.1 Advantages of Observations

These were the benefits that were realized from this information gathering methodology

- The method gave a clearer picture of the actual situation on the ground and how it can best be addressed.
- Data captured was highly reliable as the activities were recorded as they happened thus there was no room for bias.
- Observations are less costly unlike questionnaires which require printing.
- There was room to move around from point A to B to fully explore and clarify the details needed

3.2.2.2 Disadvantages of Observations

- The observer was limited on what they could see and capture as certain areas were prohibited unless one is an authorised official.
- Employees were uncomfortable with being observed as they worked resulting in distorted results from observations. Forepersons and lab technicians were extra careful with their actions whilst some were very shy.

- Observations were limited to the day shifts due to company policies hence the data gathered was limited.
- Transport costs were incurred from visiting one site to another.

3.2.3 Interviews

These were done both in the laboratories and in the field with the forepersons at Dutchman's pool. This was the third method used to obtain data from the employees. In preparation for the interviews certain steps were followed (Shahani-Denning, 2012).

- Selecting the interviewees
- Drafting of the interview questions
- Sitting down with the selected few to run the interviews

3.2.3.1 Advantages of interviews

- Interviews allowed for full expressing of oneself through emotions and body gestures hence there was less bias and misinterpretation of answers,
- There was first-hand information given hence answers were less prone to bias.
- Data needed was collected instantly unlike waiting four days for a questionnaire.
- There was room to ask for clarifications and develop conversations allowing for a good and balanced survey.

3.2.3.2 Disadvantages of interviews

- Interviewees had little time to think about their answers hence they were inaccurate and unrefined
- Employees were busy hence they had very little time to answer.
- Some questions were left unanswered as forepersons feared disclosing private information.

3.3 Systems Analysis of the existing system

This stage looks at the existing system in detail, its functionality and also looking into the inputs, the processes and the outputs. The present system is manually operated by forepersons who switch on and off the pumps. The forepersons also sign for the vehicle to be used, airtime and for fuel. The details sent to the control room are the start time of pumps, stop time, date, foreperson on shift and the shift their own. All these processes are done manually. There is need to computerize them and integrate them into one system.

3.3.1 Inputs

- Forepersons name and surname
- Work ID number

3.3.2 Processes

- Add start time
- Add stop time
- Sign in and out a vehicle
- Request for fuel
- Request for airtime

3.3.3 Output

- Shift fill out form

3.4 Process Analysis

This refers to the scrutiny of order and links between the system and its functions. The aim is to understand how the data that comes in as input is then processed into output that is meaningful.

3.4.1 Activity diagram of the current system

This diagram illustrate the activities happening within the company. It shows the flow of information and parallel activities running concurrently. The diagram below shows the activity diagram for Zimbabwe Power Company (Adamski, 2014). These are referred to as the graphical symbols of workflow.

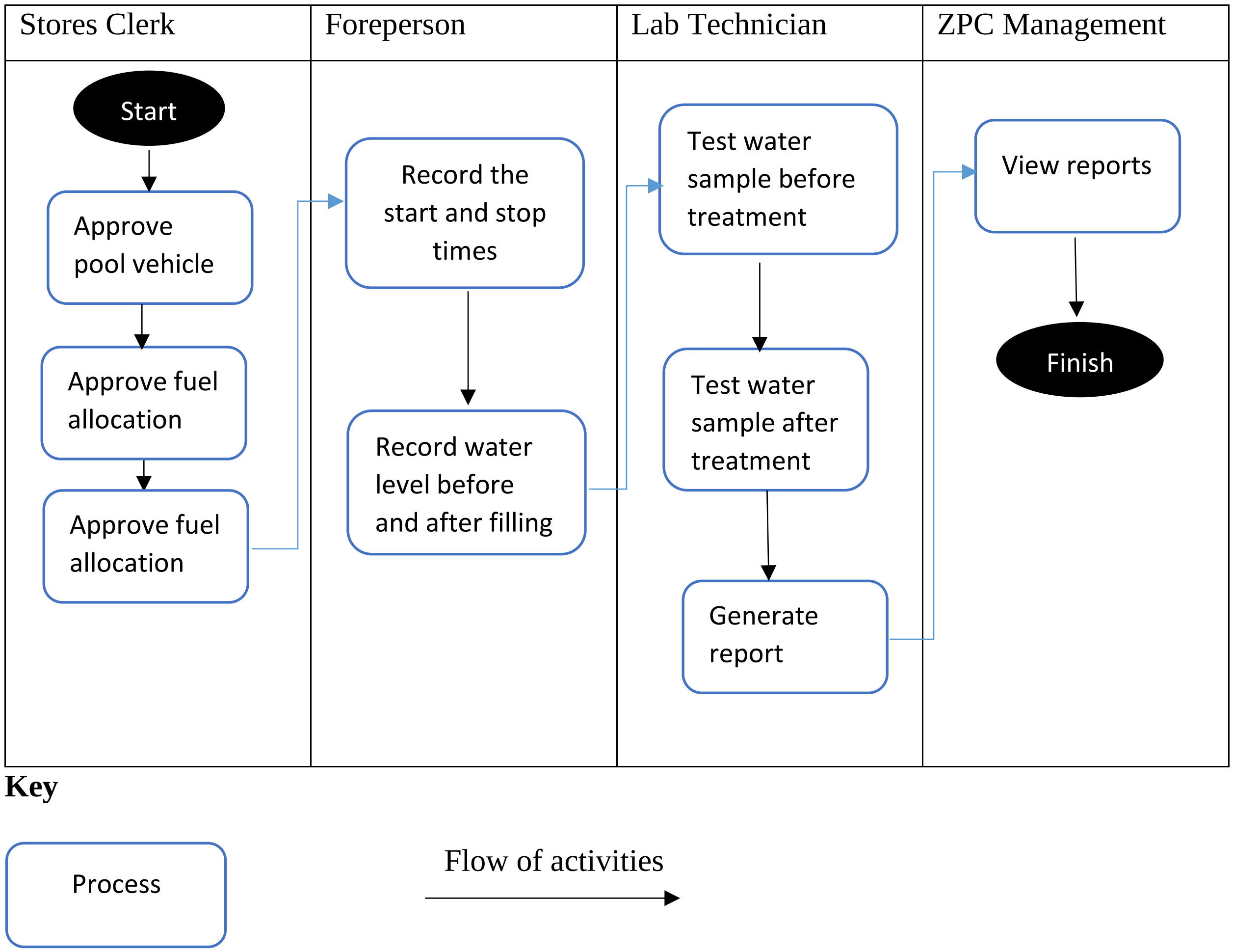


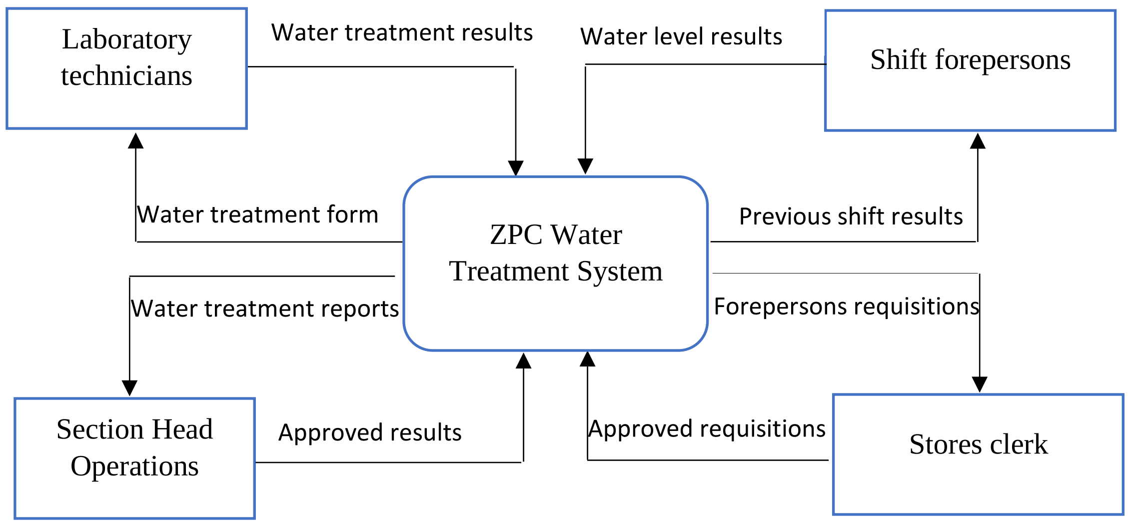
Figure 3.1 ZPC Activity Diagram

3.5 Data Analysis

This shows how data moves from department to department at ZPC. To illustrate this, context diagrams and data flow diagrams are used.

3.5.1 Context Diagram

(Choubey, 2012) defines a context diagram as a simplified depiction of the movement of data through the various structures of information systems in organisations. Below is the context diagram for ZPC.



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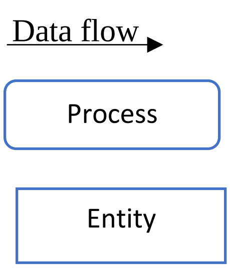


Figure 3.2 Context diagram

3.5.2 Dataflow diagram

This diagram shows how data and the systems components interact. The diagram below shows the movement of data within ZPC from the foreperson to the section head of operations.

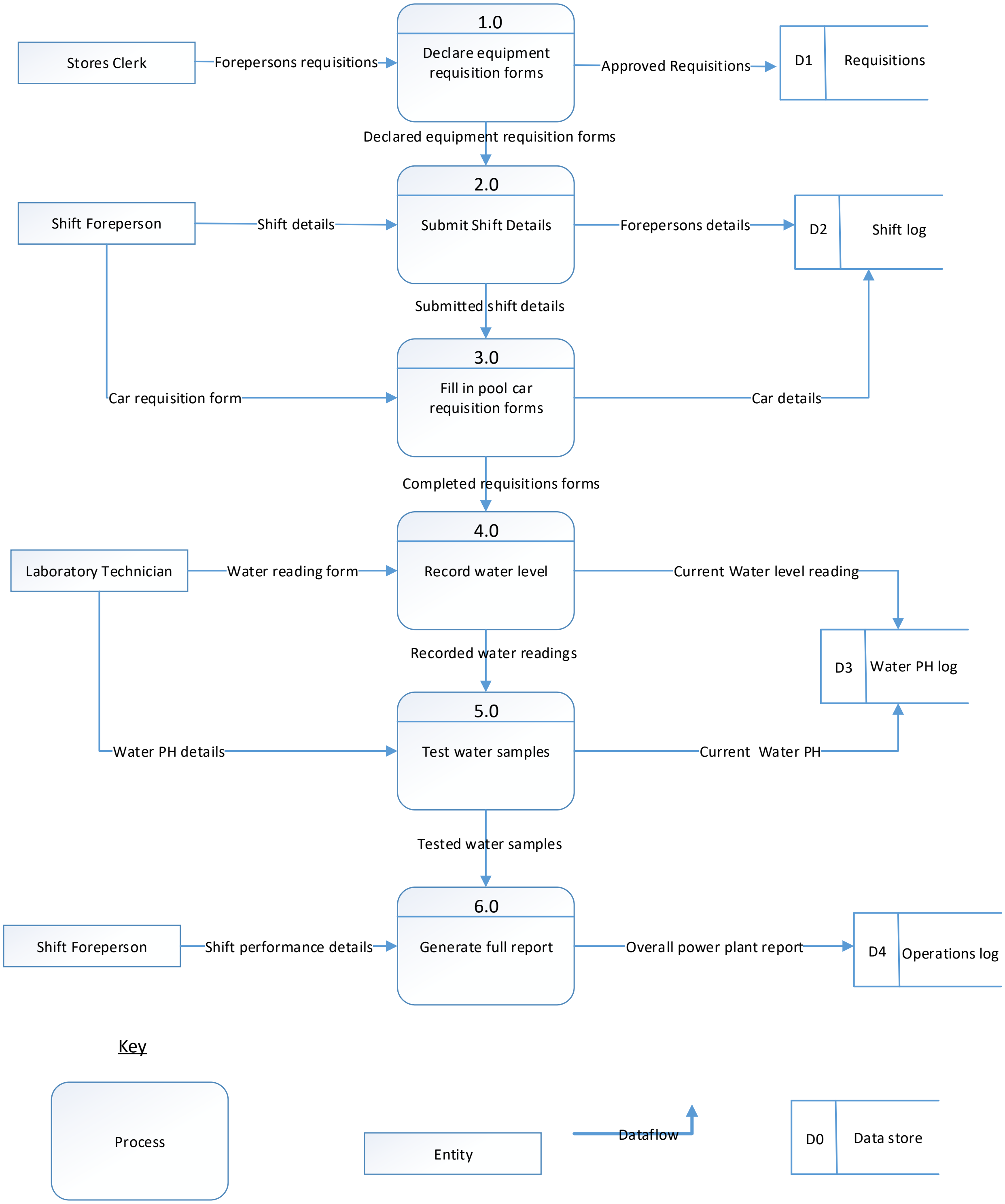


Figure 3.3 Data flow diagram

3.6 Weaknesses of the current system

- All results are recorded on paper hence they can be lost in the event of a fire.
- Failure to automatically start the pump once it the water level has reduced.
- Checking water levels is a monotonous task such that the foreperson on duty may simply record any figure based on their knowledge of the average water level.
- Poor communication structure between forepersons on duty hence there lack of continuity from one shift to another.
- The section head may take time before they are have approved the request.

3.7 Evaluation of alternative sources of system development

There is need to look at other options that can assist in rectifying the current problem at hand. Evaluation of alternatives are other routes that can be taken to reach the destination or provide a solution. There are several methods that can be used to develop a solution to solve the current problem. We can either choose to outsource for a solution, develop a system internally or simply find a way to modify the existing system to solve the problem.

3.7.1 Outsourcing

According to (Marian, 2011) this involves contracting an external developer to handle the project or lead the internal team in developing the system. Costs of hiring are developer may discourage ZPC from hiring externally.

3.7.1.1 Advantages of outsourcing

- External developers usually provide service in a shorter space of time due to experience.
- They can be less costly than in-house developers depending on preparedness to tackle the project. Their experience allows them to specify before-hand a budget for resources, labor costs and a more accurate schedule for fully implementing the system.
- User requests can be attended to as ZPC will have a paid for a license, it becomes easier to dictate and make changes as the development progresses.
- Accountability can be attached to the licensed developer in the event of a system or software malfunction.

3.7.1.2 Disadvantages of outsourcing

- External developers may leave loopholes in the system creating recurrent jobs for themselves in the future on the same system.
- External developers may not contextualize the problem well hence may fail to address the problem well.
- ZPC may not afford the high costs of hiring an external developer.

3.7.2 Improving the existing System

Improving the existing system means adding features to the already standing water treatment plant (Alex, 2007). Arduino components will have to be integrated with the existing GSM system such that whenever the water level is reaching minimum stage, messages will be sent to the shift forepersons mobile phones. This will mean real time updates on the water level hence real time updates can be done. Research will need to be done to find out the user requirements of the shift forepersons and the Lab technicians in order for the improvement process to be a success. These users need to be involved in much of the improvement process. Improvements will be done by the local IT department and developers may be taken from Harare Power station to assist with the improvements.

3.7.2.2 Advantages of improving the existing system

- There will be less training costs as the forepersons and technicians are involved in the improvement process.
- There is less risk of information publicity as the improvement will be done by the local IT department and developers from Harare or Hwange Power Station.
- The improvements to the existing system are more likely to be embraced by the forepersons and lab technicians as developers constantly refer to them for confirmation on any changes to the existing system. This makes the users feel important hence the change will be smooth.
- The idea of adding ultrasonic sensors was welcomed by the staff as it meant they can control the water levels from the comfort of the office unlike being out in the cold with a torch checking for the water level.

3.7.2.2 Disadvantages of improving the existing system

- There may be need for constant upgrades to the existing system which may due to the ever changing technology making it more costly in the future.
- Some of the features needed cannot be incorporated in the existing system unless a separate one is built from start. There will be need for an internet connection between the tanks and the control room which may be an almost impossible task to achieve.

3.7.2 In-house development

In-house development is normally the first choice when there is need for privacy and confidentiality of information associated with the development of the new system. It is also appropriate when the team of developers are internal employees and development and designing of new systems is part of their routine tasks.

3.7.2.1 Advantages of in-house development

- The local IT department was very keen to take on the task as it would change their daily routine from attending to general networking and troubleshooting tasks, as well as hardware problems.
- This option will be cheaper as there are no extra costs of hiring external developers. IT employees are permanent staff hence it is part of their duties to attend to any jobs assigned to them.
- The IT department is in a better position to better contextualize the problem as they are part of the normal running of the company operations.
- Development process can become a continuous process which may lead to the best solution being discovered.

3.7.2.2 Disadvantages of in-house development

- The local IT staff will take longer to come up with an implementable solution due to lack of experience.
- The local IT staff can take long in debugging a normal issue. This may not be permissible with management as they work with targets.

Selection of alternative sources of the system

In-house development turned out to be the most favorable option after putting into account the type of project and its project scope. The combination of the system administrator with various programming certifications, graduate trainees and interns will bring forth a potentially strong team to take on the task. The team will have access to research through the use of the internet and the support of developers from other power stations like Hwange and Kariba.

Table 3.1: Costs of each alternative

Alternative option	Cost($)
In house development	1,620
Improvement the existing system	2,600
Outsourcing	3,200

3.8 Requirements analysis

Requirements analysis takes at what is required by the system for it to be fully functional and working up to the standards set by the objectives (Kotonya & Sommerville, 1998). This phase takes into account the factors that affect the implementation of the system which include conflicting stakeholder motives and goals. This stage also determines whether the developer will be able to meet the end users requirements. These requirements are categorised into functional and non-functional requirements.

3.8.1 Functional requirements

These requirements emphasize on the way the system will behave and respond to different user requests under given conditions, the goal being to test whether the system brings a solution to the users problems stated (Robertson & Robertson, 2012).

- The proposed system must store data in a secure database and manipulate the data such that it presents meaningful information.

- Employee information and daily operation details must be stored for future reference and used for managerial decision making.
- Reports showing daily operations, water levels, start and stop times must be printable and viewable such that the section head of operations may attend to any noticeable changes in operations that may affect generation of electricity.
- The system must allow employees to monitor the current water level through a readings that are sent to a webserver.

3.8.2 Non-functional requirements

These describes how a system works and the procedures involved in the system for getting things done (Robertson & Robertson, 2012). Non-functional requirements also relate to the quality of results produced by the system, whether it crashes during operations or whether it accurately keeps data in a consistent state.

All the requirements that are not covered by the functional requirement s are considered as part of non-functional requirements.

3.8.2.1 Security

All unauthorized users must not have access to the system or its data unless given access by the system administrator. Only users with a username and password must be allowed access and only existing employees must have access.

3.8.2.2 Performance

Forepersons must be able to login to the system at any time and it must allow for many concurrent users at the same time. Management must be able to do their meetings to discuss the daily readings whilst all logged in at the same time.

3.8.2.3 Reliability

The water readings stored in the system must be accurate. The aggregate readings must be the same as the readings on paper and the system must be able to keep the date of readings. The system data must be consistent and have integrity such that if the readings are updated from Dutchman's pool, management at the power station can instantly see the updated information.

3.8.2.4 Backup

Water readings and test samples must be stored online and offline for future reference.

3.8.2.5 Interface

The system must be user friendly and welcoming to forepersons and laboratory technicians. The interface must be simple such that anyone can easily navigate to view either water readings or PH levels.

3.9 Conclusion

Having looked at the current system and its processes, there is need to come up with a better solution to meet the user requirements hence enhancing power generation. The next chapter aims to further look at ways to overcome the challenges posed by the current system. Many solutions will be generated and the resolution best meeting the problem will be implemented.

Chapter 4: Design phase

4.1 Introduction

The design phase as (Rudolph, 2010) postulates, will generate specifications that highlight the actual solution. The system specifications that were stated in chapter 3 will be further improved and allocated into the system and database design specifications. Parts of the system such as the login page must be functional (David, 2009). The users, developers and other stakeholders must be well versed with the systems functionality. The proposed system must be secure yet still easy for the stipulated users to access. Shift forepersons must be able to read data stored in the database and generate reports that will show different interpretations of the system as and when management requires them.

4.2 System Design

The system design refers to the system functionality and how it operates (Springer, 2015). It also entails putting the theoretically designed system into a visual and practical system that can be implemented at ZPC. This crucial stage requires the developers to contextualize the environment in which the system will function which means developers will need to visit Dutchman's pool to see the water tanks in use. There is need to identify the sources of data that ZPC will be using to feed into the system.

The system according to (Whitten et al, 2004) must be flexible enough to be altered if the need arises to add features such as remote water pump control. This water based micro-controller system must be efficient enough to provide output such as water level reports that are required by the section head of operations. Data that is logged in must be saved to a database and must be retrievable at any point in time. Its design interface must be aesthetically pleasing yet simple to use such that forepersons are willing to embrace the new technology. Such a system requires maintenance as postulated by (Post & Anderson, 2006) hence the maintenance process must be affordable and easy to do such that the system is available as and when there is a need to read water levels.

4.1.1 Description of the proposed system

When water is pumped into the tank, readings of the water level are taken and automatically sent to the foreperson's computer on duty. Upon reaching maximum capacity level, a red light in the control room will switch on alerting the foreperson that the tank is full and pumps need to be switched off. The same process will happen when water is being pumped out from the tank into the plant, as the water level lowers the readings are sent to the forepersons computer and upon reaching the minimum level, a green light switches on signaling the need for a refill. These readings are stored in the database for future reference. Management is able to log into the system and see the records.

4.2.1.1 Inputs

- Water level readings
- PH sample tests from laboratory

4.2.1.2 System processes

- Send water readings from the tanks to the control room
- Capture PH sample tests from the laboratory
- Request for pool car and fuel
- Email reports to the section head of operations
- Update database with most current readings

4.2.1.3 System outputs

- Updated Water results in the database
- Daily water reading reports
- Collaboration of technicians and forepersons

4.2.2 Context diagram of the proposed system

This illustration outlines the confines of the system and its surrounding environment (Choubey, 2012). The diagram below shows the communication and information flow between different entities of the system.

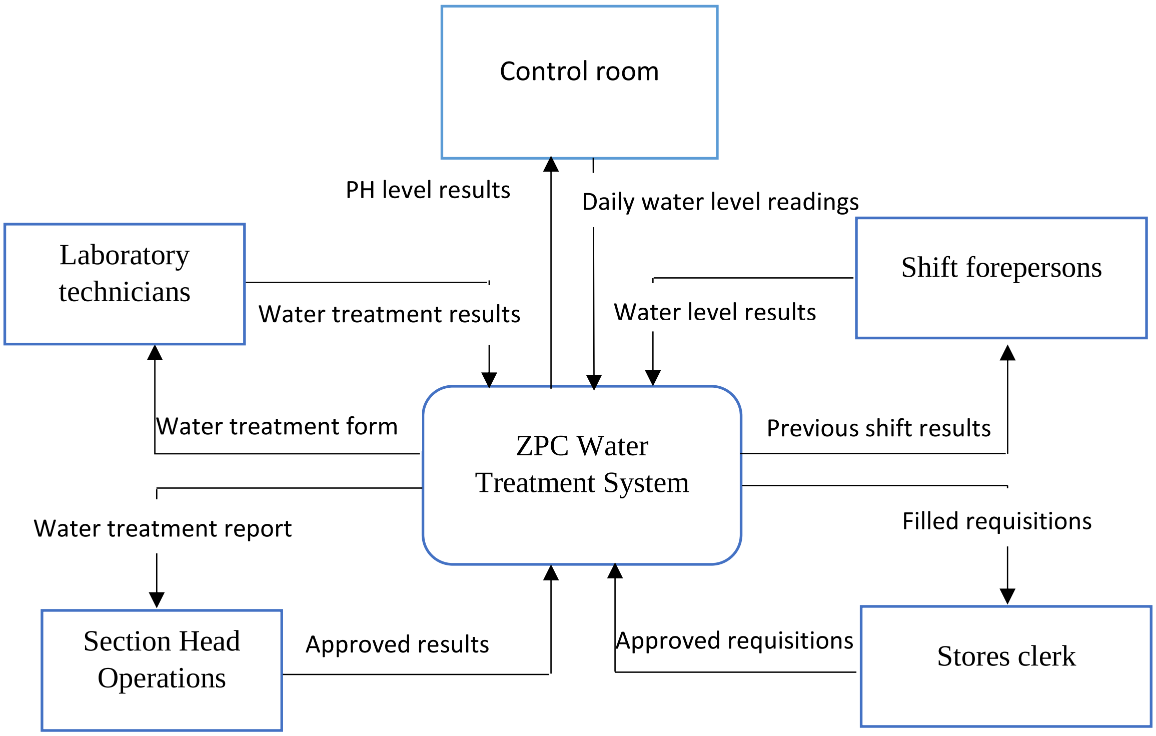
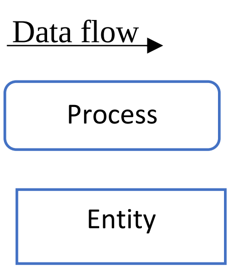


Figure 4.1 Context diagram of the proposed system

Key

KEY



4.2.3 Data flow diagram of the proposed system

This is a diagrammatic representation of the flow of data within the system from the laboratory technician to the section head of operations. An overview of the system and its functionalities is given however without getting into much detail (Workinger, 2014). A data flow diagram must give a clear picture of the system functionality and processes. Problem resolution becomes easy as all steps have been stated out hence the section head is able to call the appropriate person for accountability suppose there is need to for clarity on readings for the day. The IT department may use the diagram when doing data backups as it shows the different data stores.

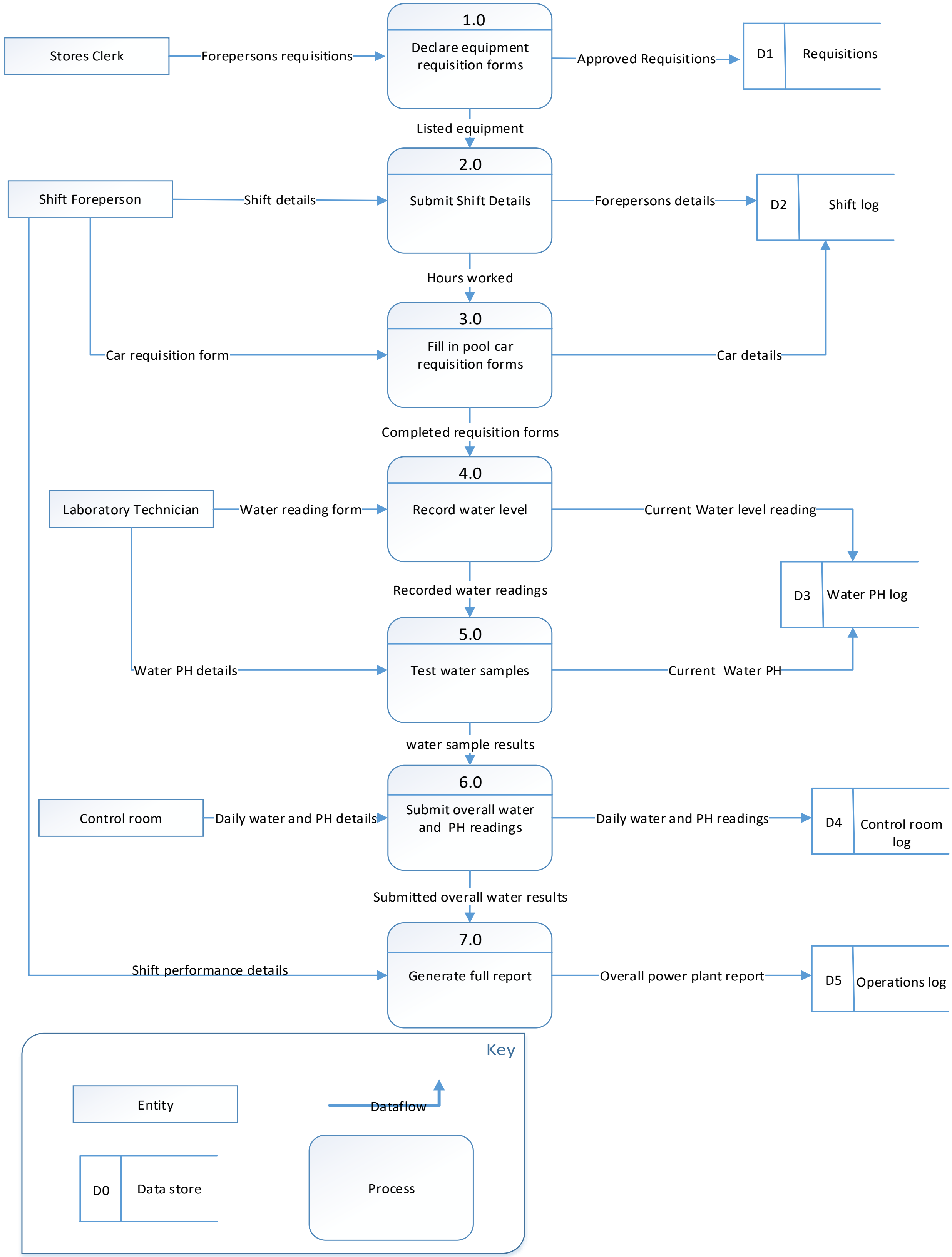


Figure 4.2 Data flow diagram of the proposed system

4.3 Architectural design

The diagram below shows a conceptual model defining how the system is structured and how it will behave (Thalheim, 2001). As explained by (Firesmith et al, 2008), this architectural design aims to reduce the difficulties of understanding complex system designs. The architectural design is a primary outline from which a software can be developed for the end users. The Ethernet Arduino server will collect readings from its surrounding environment and then send them to a webserver through a router where laboratory technicians, shift forepersons and the section head of operations may view the readings.

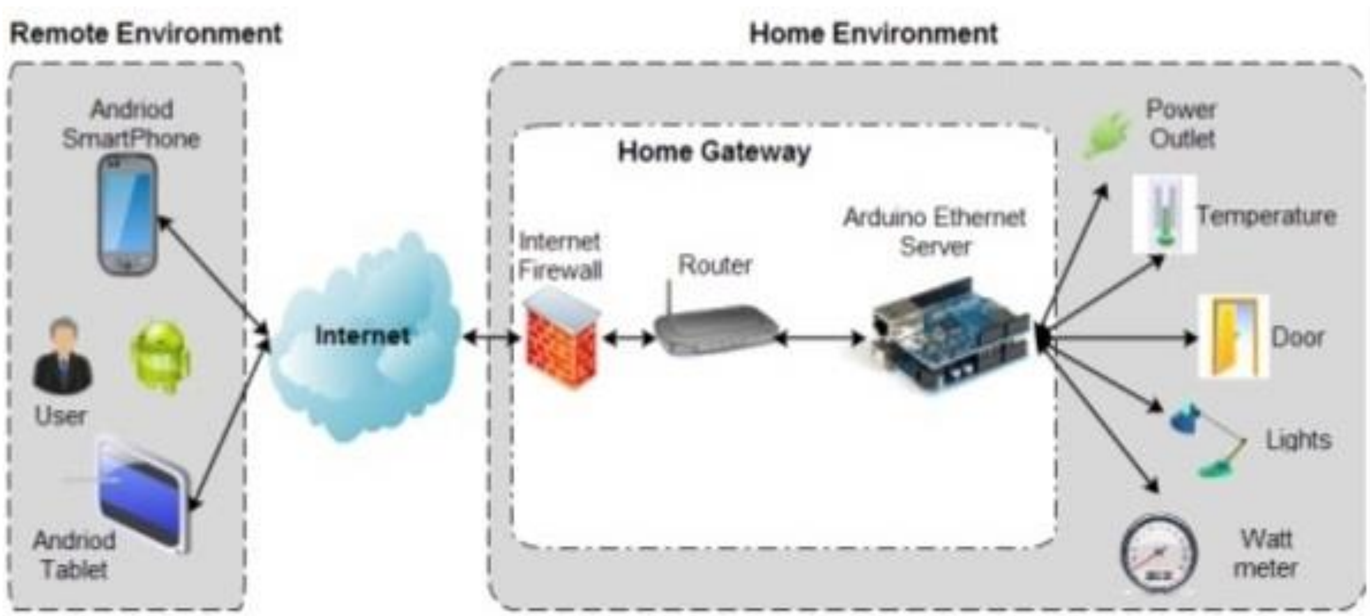


Figure 4.3 System architecture design

4.4 Physical design

This design graphically represents the system so that it illustrates both internal and external entities (Levin, 2015). This design shows the relationship between entities and the data flow into and out of the systems entities.

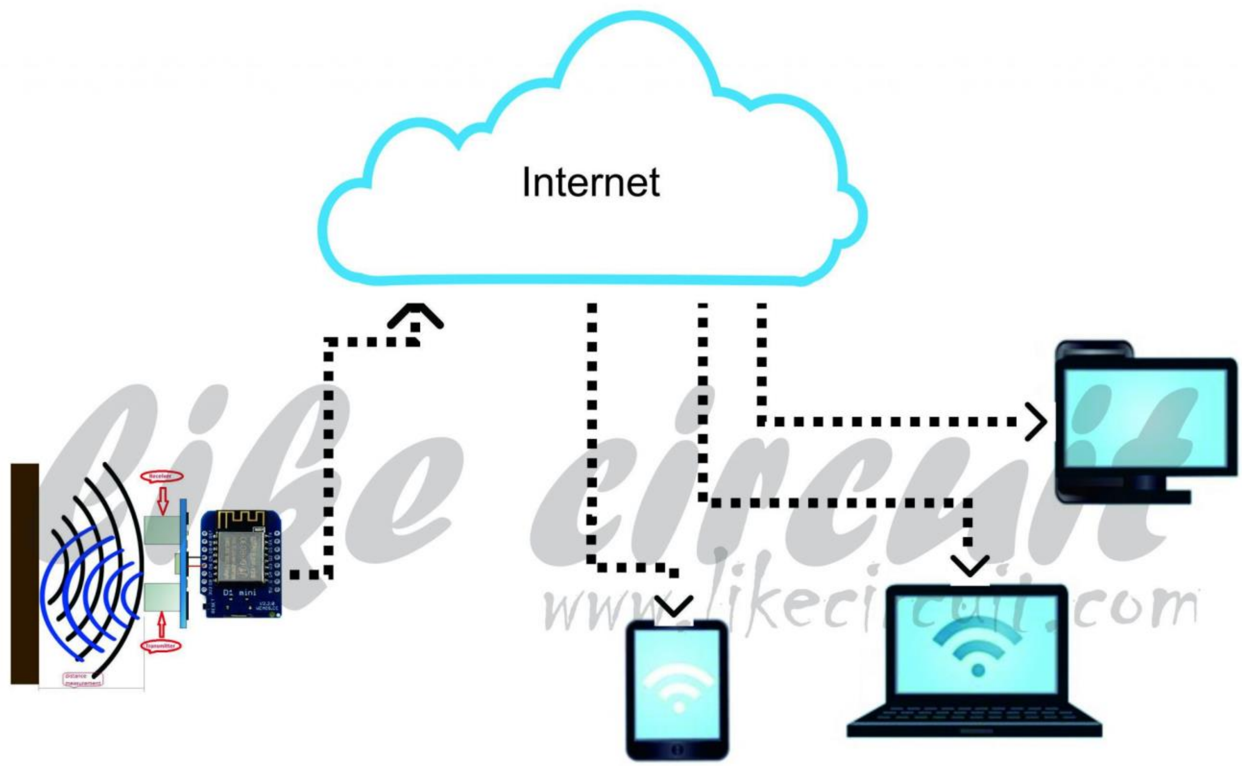


Figure 4.4 System physical design

4.5 Database design

A database is a group of data that is organised into meaningful information such that it can be manipulated, retrieved and stored for future reference. Information in the database may be represented graphically and reports may be generated. This will help management at Zimbabwe Power Company make decisions based on the information they have retrieved from it (Linders, 2016). ZPC may decide to have data marts for all their power stations that store their water readings which will then feed into the main database. This will allow easy storage and retrieval of information whenever it is needed at a local power station.

4.5.1 Data Architectural design

The data architecture design is made up of standards policies and models that govern the data to be collected, its arrangement and integration into the system (Prashant, 2009). It is a method used to logically represent data hence storing them in layers know as schemas. The design architecture will identify all the schemas, name all the components, define the use of each component and how they are all integrated to function for one purpose. The ansi-sparc architecture will be used to define the proposed system's database management system.

Three level ANSI-SPARC architecture

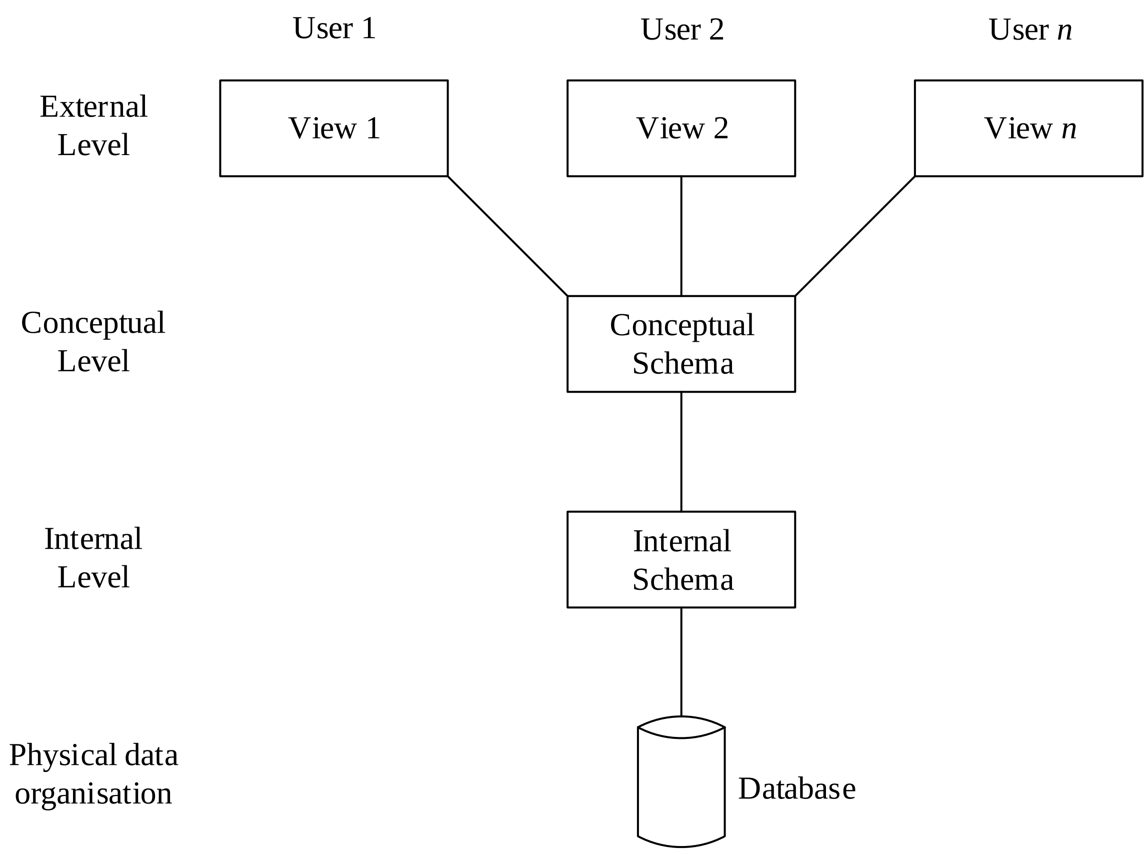


Figure 4.5 Three level Ansi-Sparc Architecture

External level

At this level there is high level abstraction. Information requested by the user will only be displayed and used at this level and the rest of the data remains concealed (Storey, 2006). The external or logical level directly interacts with the user and as such, it is mainly concerned with the presentation of information to users upon. The records in the external view are defined by the external schema which also gives the procedures of showing conceptual level objects to the external level.

Conceptual level

This also known as the community view of the database. The relationship between the database entities are explained and the conceptual schema also describes the conceptual view not only represents the whole database but continuously checks for integrity and consistency in the whole database (Aït-Ameur, 2007).

Internal level

This is the storage level of the database showing the physical representation of the data in the database and how it is represented on the hardware and software. This level goes hand in hand with the internal view and the internal schema which shows all records in the database. The internal schema describes the representation of attributes and how to access them in the database (Fankam, 2008).

4.5.2 Entity relationship (E.R) diagram

An entity-relationship shows information in a system represented in a graphical format and how entities are related to the whole information system (Paul, 2004). It is developed for database design in which entities show which data is stored in the database and how they are all interrelated. The components in an entity relationship diagram are entities. The proposed system entities are the laboratory technician, shift forepersons and section head of operations.

Table design

Table 4.1 Laboratory technician login table

Field Name	**Data Type**	**Description**
Username	Varchar	Lab tech Username
Password	Varchar	Lab tech Password

Table 4.2 Shift forepersons login table

Field Name	Data Type	Description
Username	Varchar	Foreperson's username
Password	Varchar	Foreperson's password

Table 4.3 Water level results table

Field Name	Data Type	Description
Water level	Integer	Unique Average value
Date taken	Varchar	Name of the equipment
Description	Varchar	Environment description

Table 4.4 Shift details table

Field Name	Data Type	Description
Email	Varchar	Unique identity of the foreperson
Name	Varchar	Foreperson's name
Time in	Varchar	Check in time
Time out	Varchar	Time out to the control room

4.5.3 Enhanced entity-relationship diagram

This type of model is also called the extended entity-relationship model. It is a conceptual data model which extends from the primary entity relationship model (Shamkant, 2011). It is mainly used to construct accurate database schemas and hence gives a better reflection of data properties and constraints. On top of the normal elements that an entity relationship diagram has, it has, relationship inheritance super types and subtypes, attribute, generalization or specialization (Peter, 2011). Super type entities have relationships with at least one sub entities whilst a subtype defines a subcategory of entities with attributes that uniquely identify them. Subtypes can inherit all attributes of the super type.

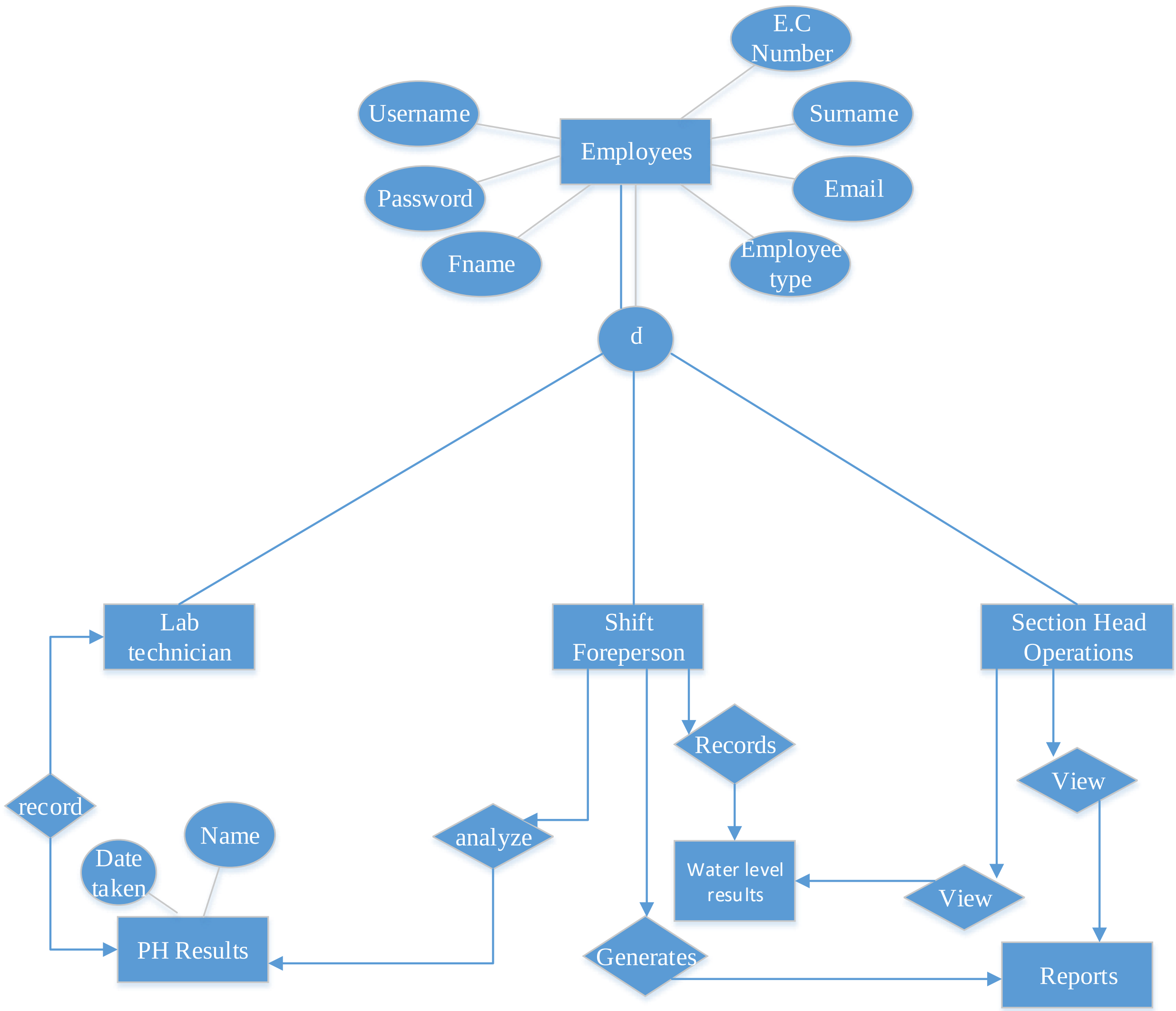


Figure 4.6 Enhanced Entity-Relationship diagram

4.6 Program design

Program design gives emphasis on individually designing the system modules and then illustrating how all of them will be integrated to work together as one unit. Once the individual modules are functional when separate, the next goal is for them to work together and synchronise with each other such that all modules are representing data consistently. A complete program design comprises a class diagram, package diagram and a sequence diagram.

4.6.1 Package diagram

This illustration may be called a Unified Modeling Language (UML) structure diagram showing the system's packages and dependencies between the packages. A package or namespace clusters semantically related elements which are likely to change together (Sparks, 2011). Package diagrams are constructed in order to easily see the groups of packages and how they are linked. (Goodwin, 2015).

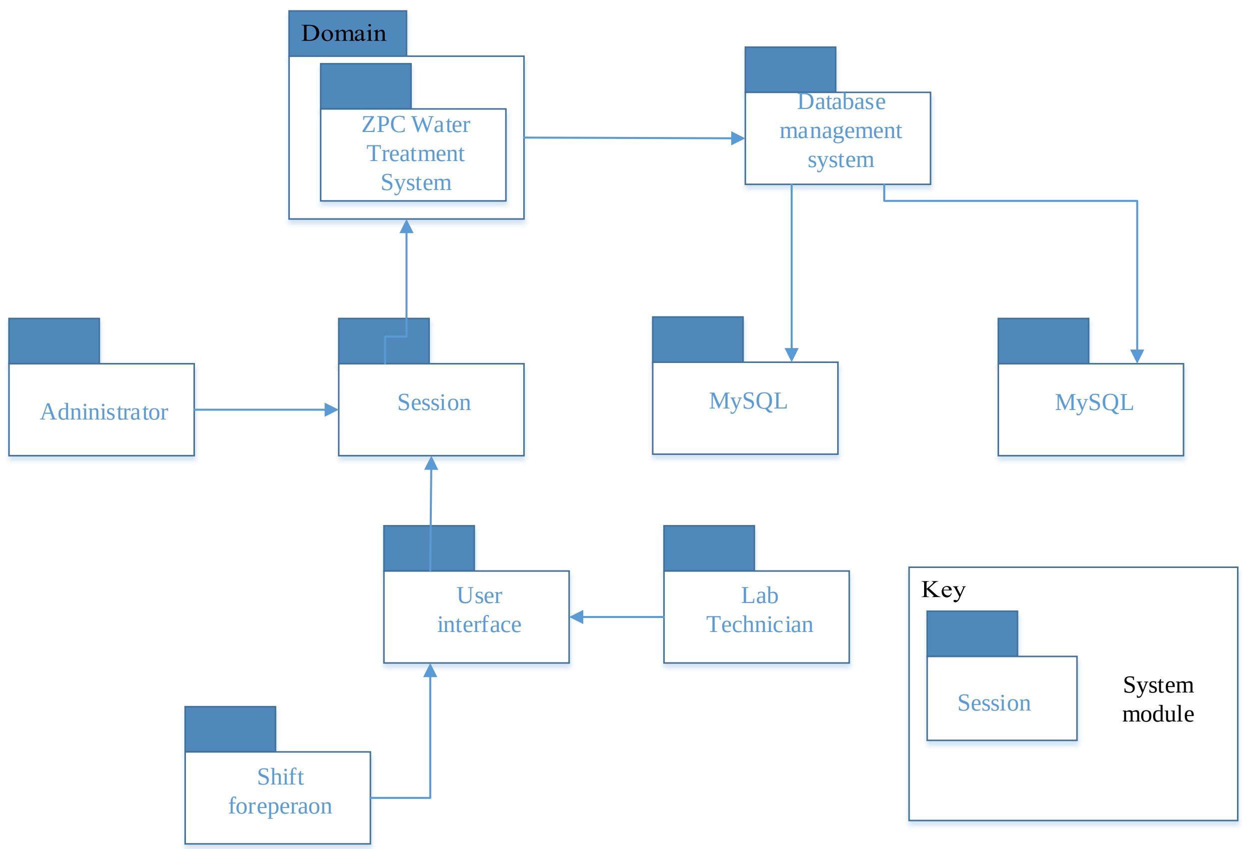


Figure 4.7 Package diagram

4.6.2 Class diagram

A class diagram within the Unified Modeling Language (UML) describes a static type structure diagram showing a system's attributes, operations and relationships between methods (Geoffrey, 2011). Class diagrams also show how classes are linked and related together. The diagrams are used in conceptual and detailed modelling which then deciphers the model into programmable code (Fowler, 2003). The diagram provides an outline of the system's responsibilities.

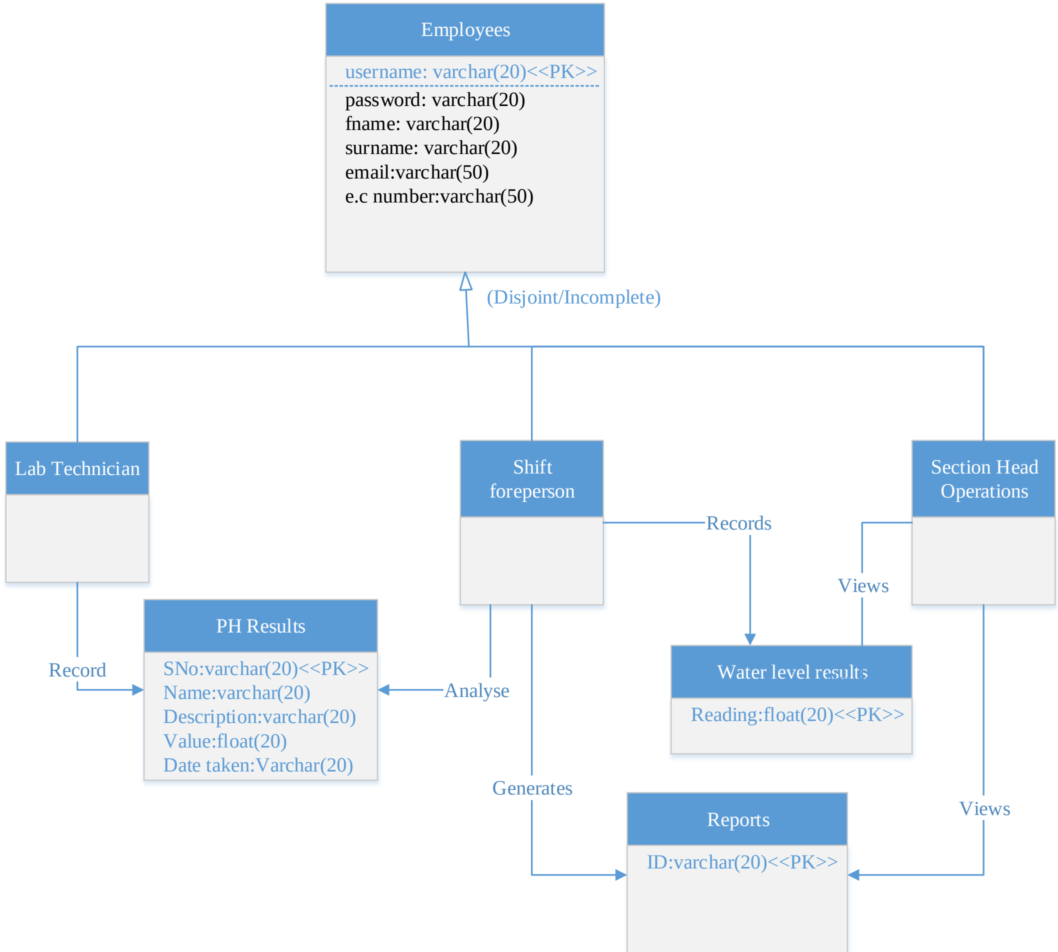


Figure 4.8 Class diagram

4.6.3 Sequence diagram

This diagram illustrates how methods function together and how they work together (Martin, 2003). This diagram shows how objects can live simultaneously and how information is passed between them which allows for simple runtime0020situations shown graphically.

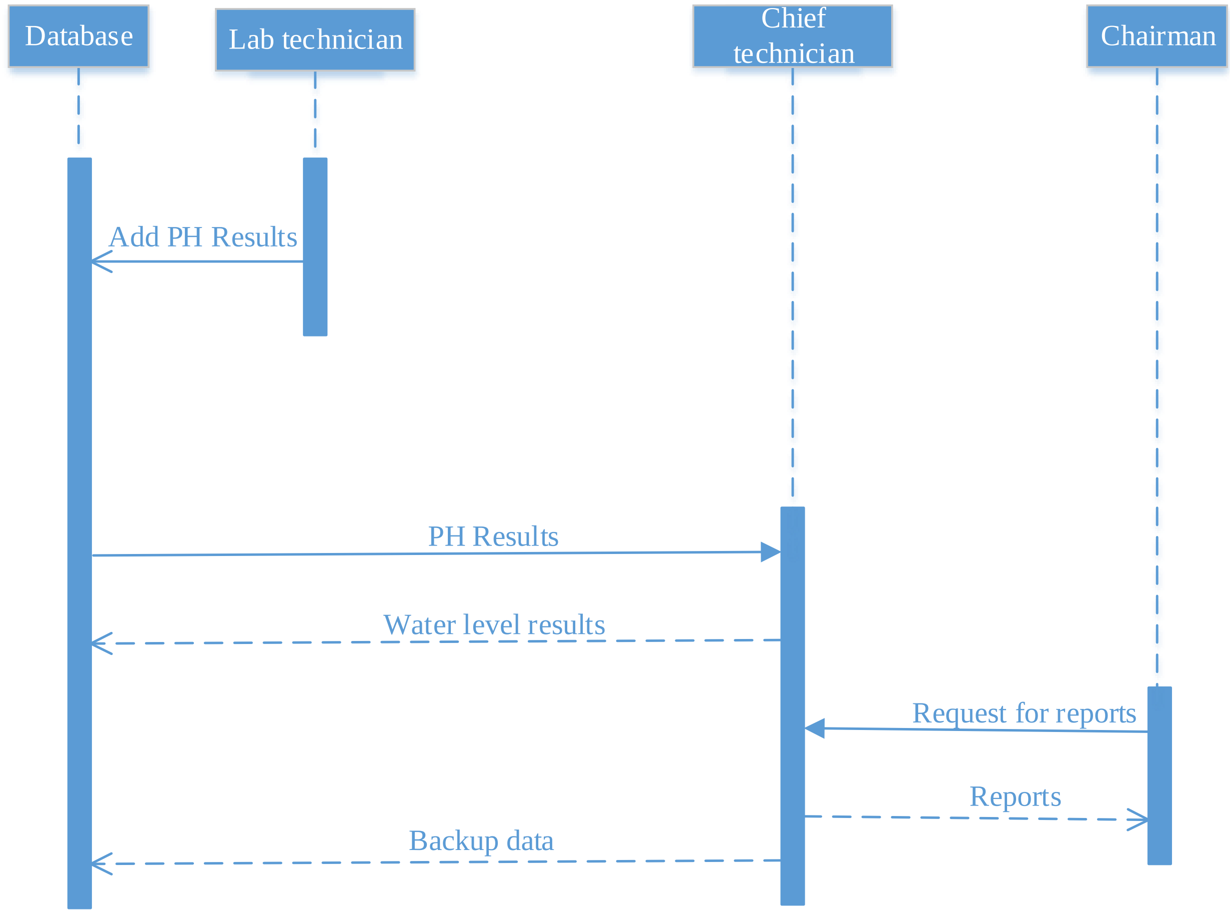


Figure 4.9 Sequence diagram

4.7 Interface design

Interface design aims to improve the outlook of the system thus improving the user's experience when maneuvering around as well as the systems ease of use. The user requests must be executed such that when a user changes the background theme, the system will not crash but show the changes done by the user (Norman, 2002). In order for the developer to design user interfaces that are attractive and welcoming, there is need for an understanding of the system functionality and the environment it will be used in. the type of daily activities associated with the system and the type of data to be stored also determines the colors and themes that will be used to design the system (Wolf, 2012). User interfaces must appeal to the users and the environment in which they are working in.

4.7.1 Menu design

A menu, is a rundown of options which are composed such that the user can without much of a stretch make choices and navigate to the intended page or interface (Dix, 1998). A menu can be an interface of a system or a sub part of the whole system.

4.7.1.1 Main menu

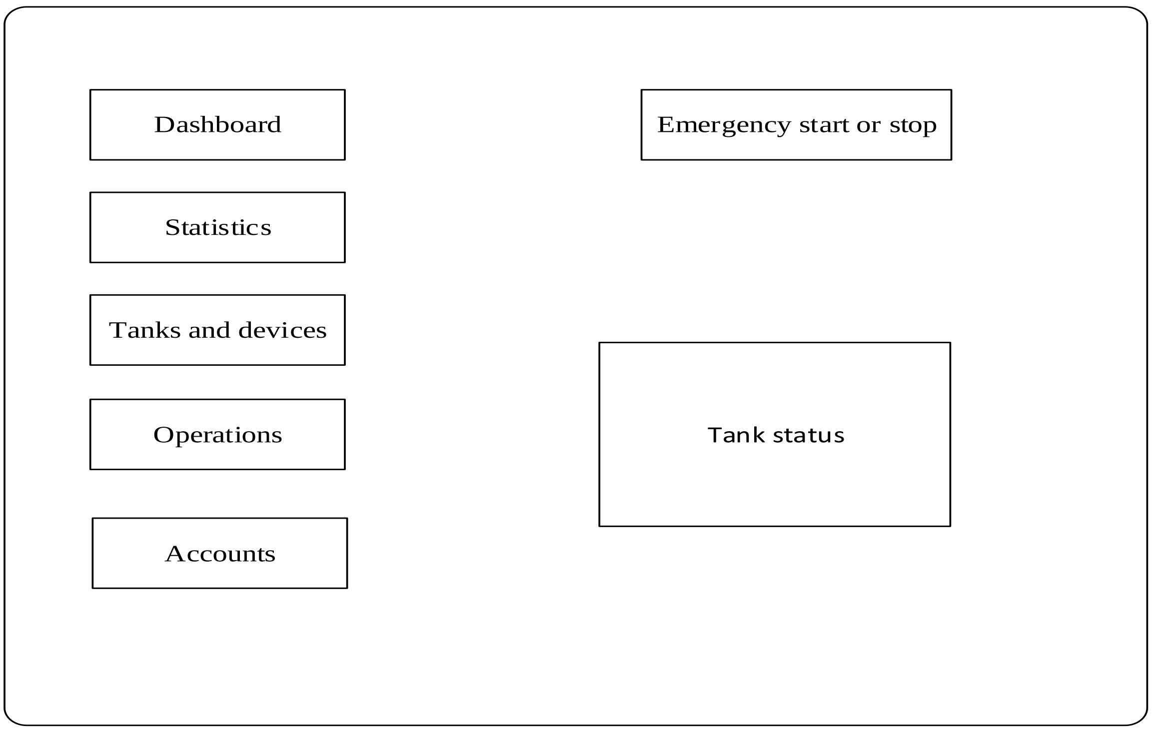


Figure 4.10 Main menu

4.7.1.2 Sub menus

These appear as one navigates deeper into the system after the main menu page. The shift foreperson has sub menus which they can access which may be different from those of the laboratory technician and the system administrator.

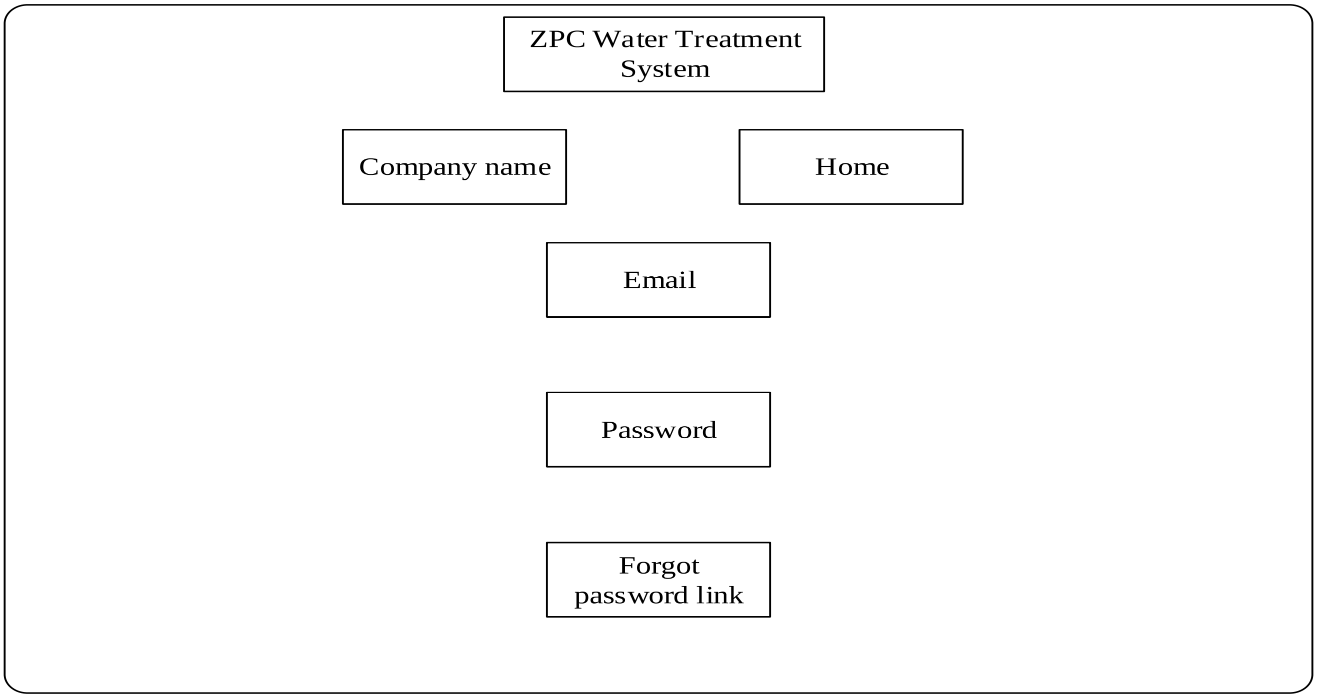


Figure 4.11: Log in page

4.7.2 Input design

The input design shows the appearance of the pages that will be used to feed data into the system. The operator will add a new tank to the system which will be used in addition to existing tanks and each user will input their log in credentials for verification and validation each time they need to access the platform. Input pages include login forms, registration forms data entering forms.

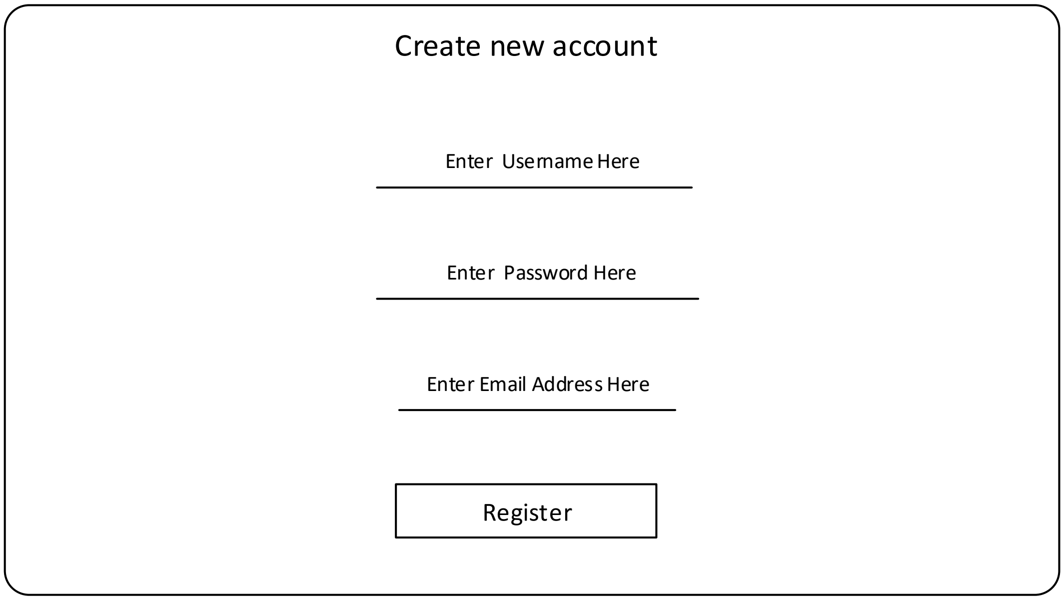


Figure 4.15 Create new account

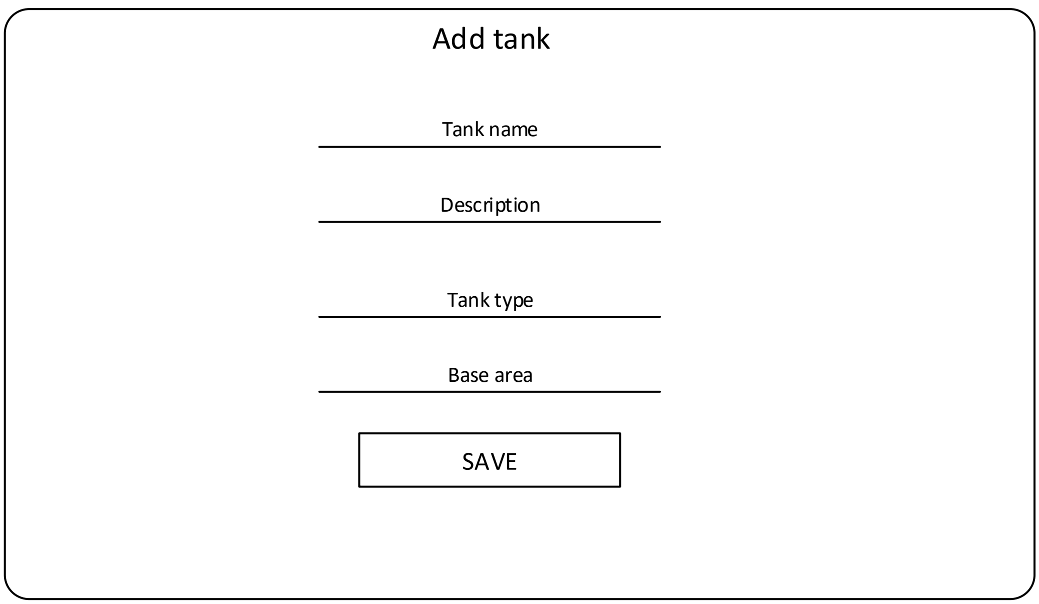


Figure 4.16 Add new tank

4.7.3 Output design

These forms illustrate the information stored in the system. These includes records of added tanks, water level results and the shift forepersons that have logged in that week or month (Norman, 2002). In this way the designed output of a system must be well ready to display data to the end user of the system in a clear and understandable way. Design output is a way of speaking with user the after the system has handled information. It will also show the representation of data in the system, how it is saved and any changes made to the data.

The following factors are considered before creating output pages:

- The output forms must display information in a neat and presentable way such that any technician or shift foreperson is able to interpret the information with much ease.
- The requested data must be easy to manipulate such that it can be seen in graphical or report format (Wolf, 2012).

Table 4.5 Added equipment

Date Taken	Name	Description	Value(cm)
01/02/17	Water level	There were no damages to pumps	154.35
01/02/17	Tank name	Uno Tank 1	8

4.8 Pseudo code

Pseudo code is a simpler format of representing the actual code that has been used in developing the system (Zobel, 2013). It makes use of the actual coding structure however the lines are readable as they are closer to the human understanding than the machine language. Pseudo code does not include any of the programming specific signs and symbols pertaining to any particular programming language such as assignment operators and termination signs. Such type of code is used when presenting the system functionality to laymen.

ZPC Employee login process

Click on the sign in page

Fill in your username and password

Click on the login button

If The username and password are correct as recorded in the database Then

Your login was successful

The employee is directed to the account they were registered as

Else

Username or password incorrect

Try to reenter your username and password correctly

End If

Create a new account

Enter name, surname, username and password

Click save and wait for account approval from system administrator

If details supplied by new user match the required criteria Then

Approve request

The new user may now login to their account

Else

Account is not authorised

End If

Add Tank procedure

Enter login credentials

Click the tanks and devices button

Add the details required

If details supplied are correct and comply with the fields required Then

Click the add tank button to save the tank details

Else

Fill in all necessary fields

Employee remains on the add tank page

End If

Changing user password

Click the change password button

Fill in old and new password

If old password entered matches current password and new password meets criteria Then

Password changed successfully

Else

Please fill in fields correctly!

End If

4.9 Security design

This approach is predominantly used for developing a more secure system. In this way it means to create a software which completely ensure its safety. The security of the software is a key feature for that should be thought about when building up a product (Daniel, 2014).

4.9.1 Physical security

This ensures that all the hardware components associated with the system are stationed in a location that is theft free and free from damage by nature or the surrounding (Jannsen, 2014). This will avoid physical damage to the system components, cables hence there will be less maintenance issues. The Arduino Ethernet shield should be housed with a water proof case such to protect it in the rain season. The Hr-sc04 distance ultrasonic sensor must be kept far away from the maximum point of water level as they are easily affected by the humidity. All cables running from the bread board to the Arduino components must be insulated to avoid electrocution.

4.9.2 Network security

This aims to ensure that both software and hardware associated with the networking of the system is secured to avoid access to information to data shared over the network. The Arduino Ethernet shield has an Ethernet port which must be deactivated when inactive or unplugged from a recognized mac or IP address (Wright & Harmening, 2009). The webserver must be protected using either an HTTPS socket or log in credentials preventing unauthorized access to information. The network administrator must trace all IP addresses that access the webserver for accountability purposes. The network administrator must also use access modifiers to control access to information in the system, the laboratory having least access while the section head of operations have ultimate access to information.

4.9.3 Operational Security

Operational security guarantees that data stored within the system is safe from unsafe and unauthorised hands which may be potential threats to the information (Andrew, 2009). The data must also be safe from misuse by the actual laboratory technicians and shift foreperson. Once data is entered into the system, it must be kept consistent and free from alterations. The time data is entered must be recorded.

4.10 Conclusion

This research section was fundamentally centered on the design of the software product. It clarified in detail how the proposed system will function, along these lines its information sources and procedures. Diagrammatic perspective of information streams were illustrated. The systems database was likewise portrayed using database tables, the enhanced entity-relationship diagram. The system can now be implemented and installed into the working environment.

CHAPTER 5: IMPEMENTATION PHASE

5.1 Introduction

This stage in the system development life cycle entails integrating the system with the environment and users so as to see the practical side of the system (Burd, 2007). The micro controller based water level sensing system will be installed on the tank receiving water from Dutchman's. This will allow to test if it will signal whenever the tank is empty or full. There is need to check if readings recorded as the tank is filled of emptied are sent to the control room or not. The shift forepersons and laboratory technicians will need to be trained to effectively and efficiently use the system (Kerzner, 2006).

5.2 Coding

Computer code are the instructions that are used to design and create user applications as solutions to real world problems (Bebbington, 2014). ZPC IT department must be trained computer programming/coding as it will allow them to alter the system functionality and maintain the system in case it develops bugs. Data captured from the readings must be stored in a database for future reference. The system to be installed will use a MySQL database to store its data (Hartmann, 2009).

5.3 Testing

Testing is a method of verifying and validating whether a system is properly functional and that all the modules integrate with each other well. This test will determine whether the system can be presented to the shift forepersons and laboratory technicians (Prasad, 2008). The objectives are matched with the systems functionality when installed. Any errors that come up during the testing are then rectified immediately such that the system is released to the end users without any bugs. Below is a diagram showing the stages undergone during system testing (Black and Rex, 2002).

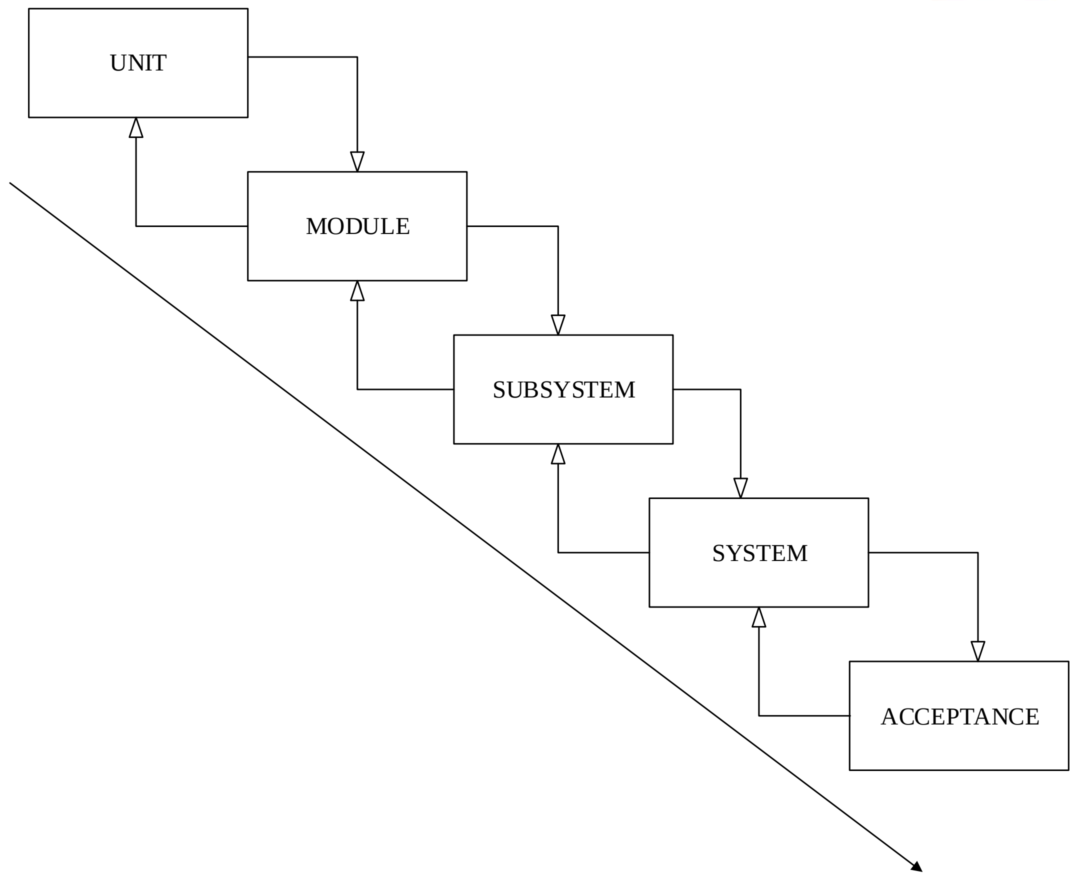


Figure 5.1 System testing stages

5.3.1 Unit testing

Unit testing is testing of the systems individual facets to check if they are fit for the intended use (Noel, 2015). There is need to thoroughly test each facet on its intended use and finally on whether it meets the purposes intended. Below are the types of tests that will be done on the system.

- Grey box testing
- White box testing
- Black box testing

5.3.1.1 White box testing

According to (Chauhun, 2010) this type of testing is done to test the core functionality of the system, testing to check if small changes on one facet of the system have an impact on the other modules e.g. if the back ground colour of the application is changed then all other modules should also show the changes done. Once readings are updated to the database, the Section Head of

Operations must be able to see the updated results from his office without physically logging on to the machine on which the results were being stored as they were being read. Software code must be tested to equal a described design, the systems weaknesses must be addressed unraveled and dealt with until no bugs are found. Below is a diagram showing white box testing approach.

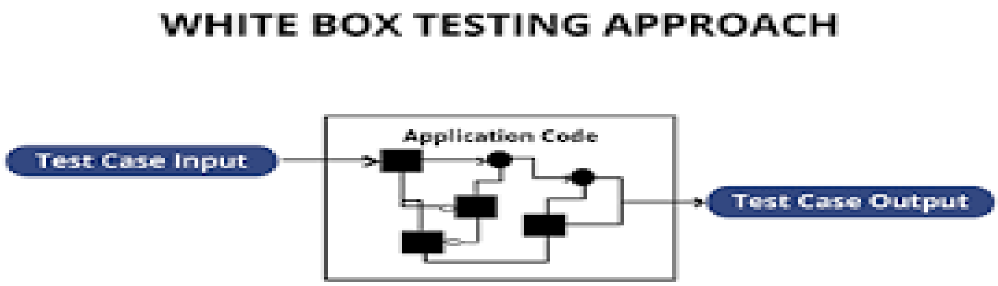


Figure 5.2 White box testing

5.3.1.1.1 Advantages of White box testing

- This analysis unveils deep errors and bugs as the developers are part of the testing.
- Developers are able to find better ways of writing code making it the code syntax and logic theoretically correct.
- Repeated and unnecessary code is removed.
- Since the developers are present during the test, introspection is applied hence the system is made to better present a solution to the needs of the employees.

5.3.1.1.2 Disadvantages of White box testing

- The cost of hiring experts and professional developers may be costly to ZPC.
- Too much code publicity is needed in order for the developers to effectively scrutinise the system.

5.3.1.2 Black box testing

This testing looks concentrates on product usefulness as opposed to its inward structure. As such, black box testing focusses on what the program does rather than program structure hence it is also called functional testing (Saleh, 2009). It looks at how practical a product is, depending on the expressed objectives. The operations team in charge of completing the testing procedure has no knowledge of the information of the interior system or product structure at test. Information pertaining to the systems inputs and outputs is known however how it arrives at an outcome remains unknown.

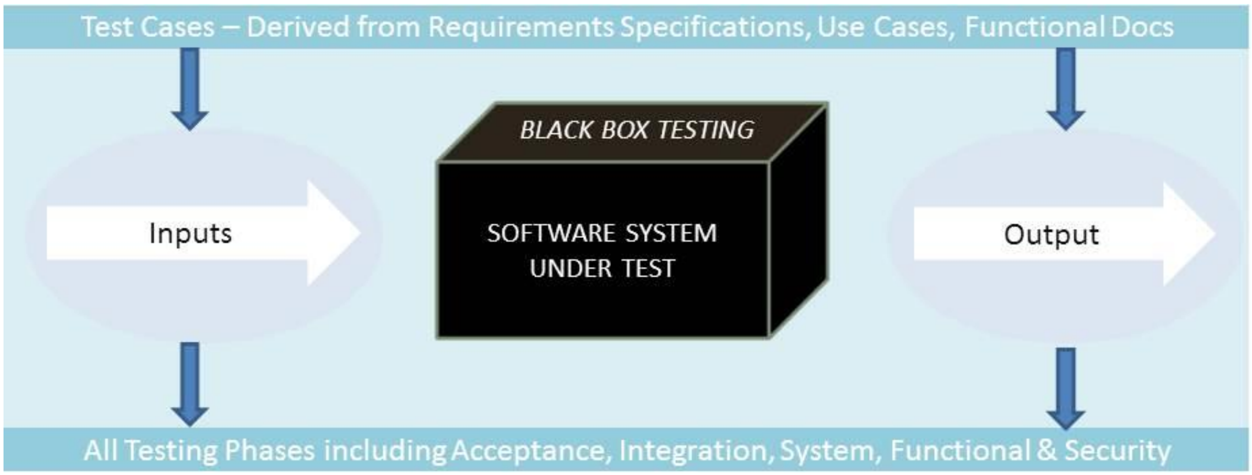


Figure 5.3 Black box testing

a) Advantages of black box testing

- It is a simple method of systems testing.
- It allows for high level design complex softwares.
- It is flexible as it does not require any programming knowledge to perform the test hence anyone can run the test.
- Testing of the system carried out from the users' viewing point rather tha the programmers' viewing point.
- Black-box testing is ideal for large systems hence it will be good for ZPC as the system will cover all the power stations.

b) Disadvantages of black box testing

- Test redundancy may arise if other tests have been run by the software designer.
- Overestimation of the test outcomes is a common temptation for the evaluating team.
- May only used in scenarios where there is need for simple and shallow tests to be done.

5.3.1.3 Grey box testing

It is a hybrid version as it encompasses both black and white box testing. Grey box means that one gets to see the systems contents in partiality (Rogers, 2016). One does not need to have much skill on programming however they get to test both the source code side and the presentation layer which is the interfaces.

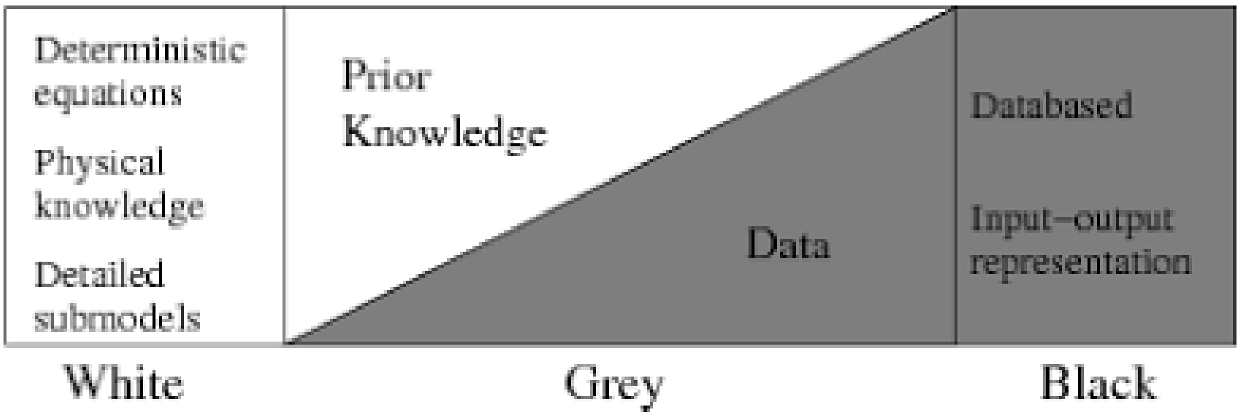


Figure 5.4 Grey box testing

a) Advantages of grey box testing

- Grey box testing combines the positive elements of both the black box and white box testing which brings out a strong and robust system.
- This testing technique gives a window period for rectifying elements of the system that may have bugs or errors.
- The shift forepersons and technicians are involved in the testing process hence they can give their input on any changes they would like done to the system.
- This type of testing allows for a clear separation of the developers and the testers.

b) Disadvantages of Grey box testing

- The source code is not accessible in this type of test hence minimal changes can be done to correct and better the system.
- It is difficult to design test cases.

5.3.2 Module testing

This is done after modules have been individually tested (Aditya, 2008). All modules are then tested as one integrated system to see whether each module corresponds with the preceding one and that changes done to one part of the system are updated throughout the system. Certain changes may be intentionally done to the system so as to check if the modules are linked and working as proposed.

5.3.3 Subsystem testing

This involves testing the individual modules that make up separate subsystems which when combined will become the full system. Developers may choose to test subsystems for bugs and errors before integrating the whole system (Rex, 2002). One common error usually found at this stage of testing is failure of interfaces to properly link and failure of pages to communicate with each other by passing commands and requests which require systems response through change. In order to prove that all interfaces are communicating well with each other, the system must be used by different users under different conditions so as to have a thorough check on all the interfaces.

5.3.4 System testing

Once the modules are seen to be functional and working well together, the whole system will now be checked for process errors such as updating water level results and viewing the output. This testing focuses on finding those mistakes which come because of unexpected interactions between the modules and sub modules of the system. The system should also be meeting the functional and non-functional requirements of the system.

5.3.5 Acceptance testing

Acceptance testing is done when the system has been tried and tested and now meets all the user requirements (Tannenbaum, 1990). After the developers test the system they ten hand over to the users to give their final thoughts and suggestions on the system. This final testing is done in two phases which is alpha and beta testing.

5.3.6 System objectives versus system solutions

In this section, there will be an analysis of how much the proposed system manages to meet the end users requirements

Objective 1

To develop a system for sensing the maximum and minimum water levels in the water treatment tanks.

System solution

When the Arduino and Ethernet shield devices are connected to the tank, the user will start the pump using the start button, when it becomes full, it will be stopped using the same button.

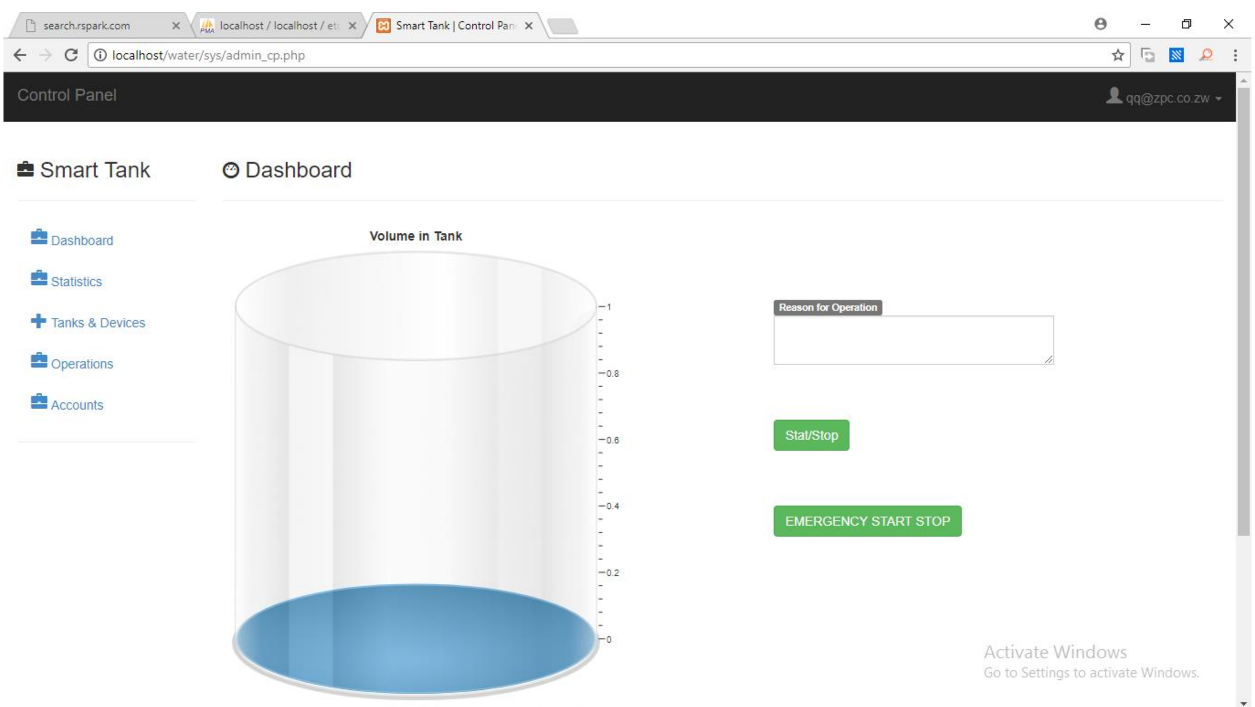


Figure 5.5 Starting or stopping the pump

Objective 2

To develop a system which allows collaboration between operators updating them on the current activity and daily functionality of the pumps.

System solution

The diagram below illustrates the tank activities page which can be seen by the different users of the system. The shift foreperson is able to login and see the current level of the pump and previous readings taken.

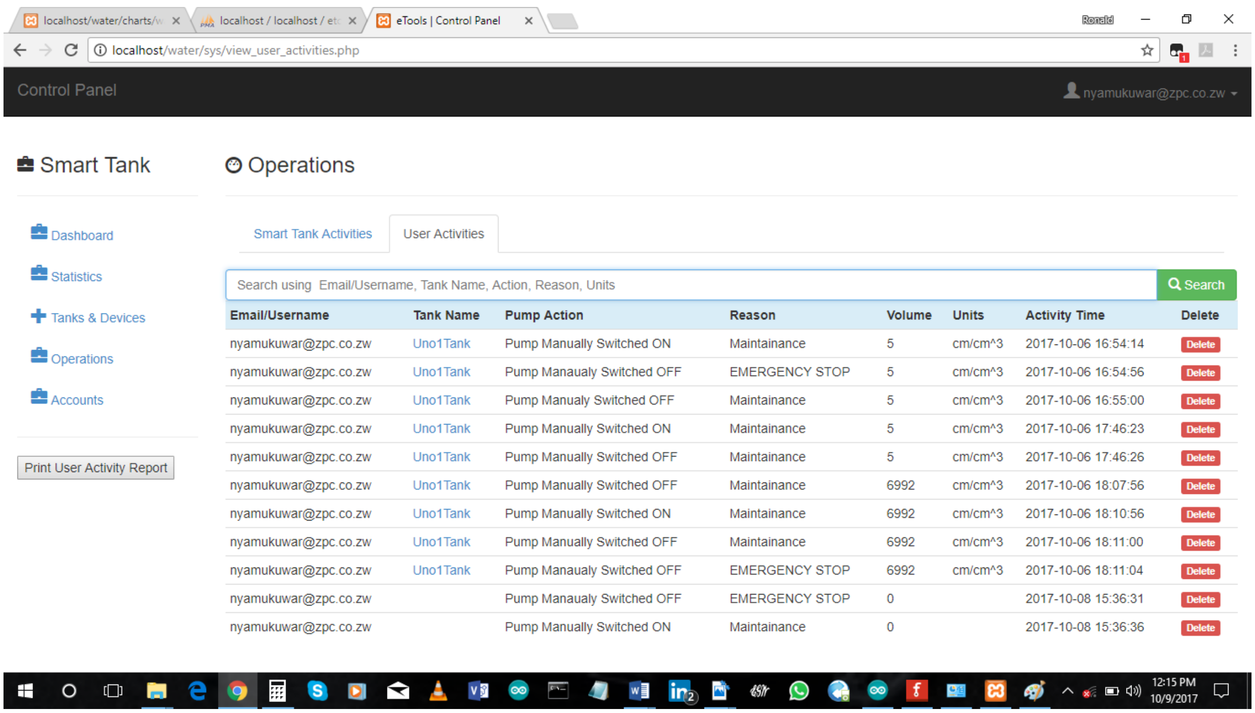


Figure 5.6 User Activities

Objective 3

To develop a system which can be operated by different users of various shifts through user accounts for accountability.

System solution

In the accounts section the administrator is able to view all user activity, the log in and log out date and time as well as the duration spent in the system. Reports can also be printed and sent to the section head of operations.

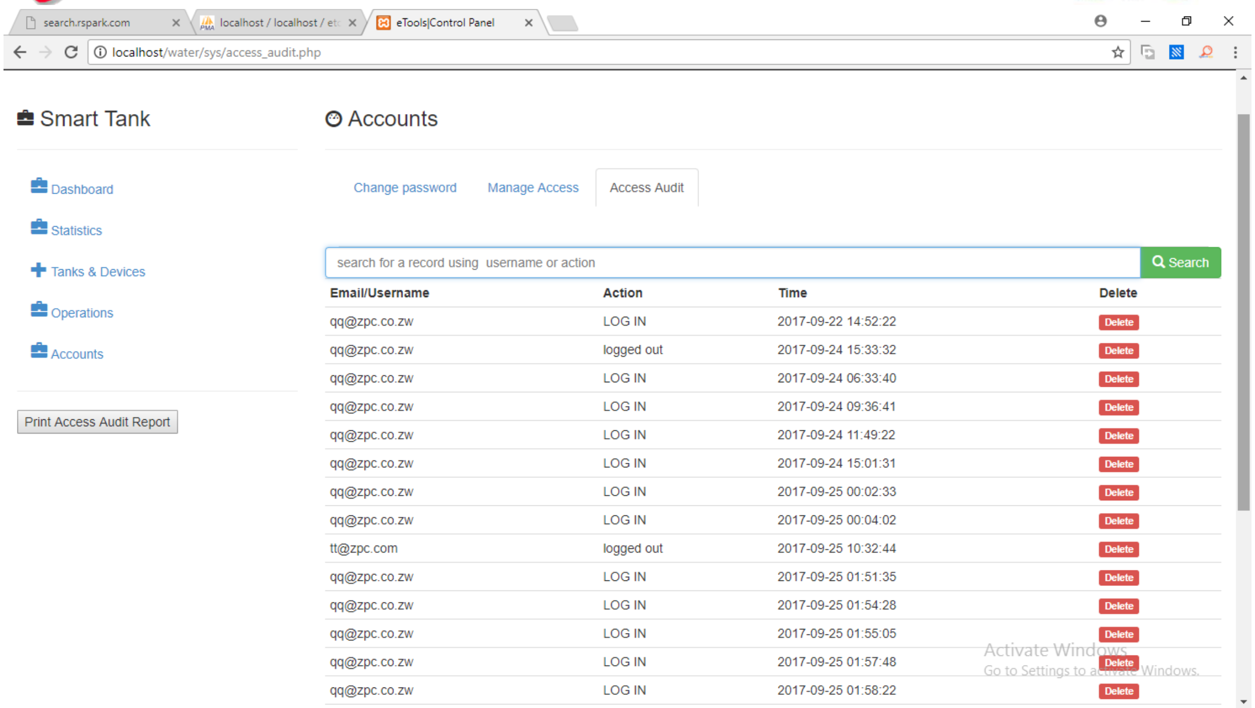


Figure 5.7 View active users

Objective 4

To develop a system allowing management to view daily readings taken from the tanks and stored the electronic database.

System solution

The section head of operations is able to view activities done in the system and make managerial decisions or take necessary measures that may aid better performance and generation of electricity.

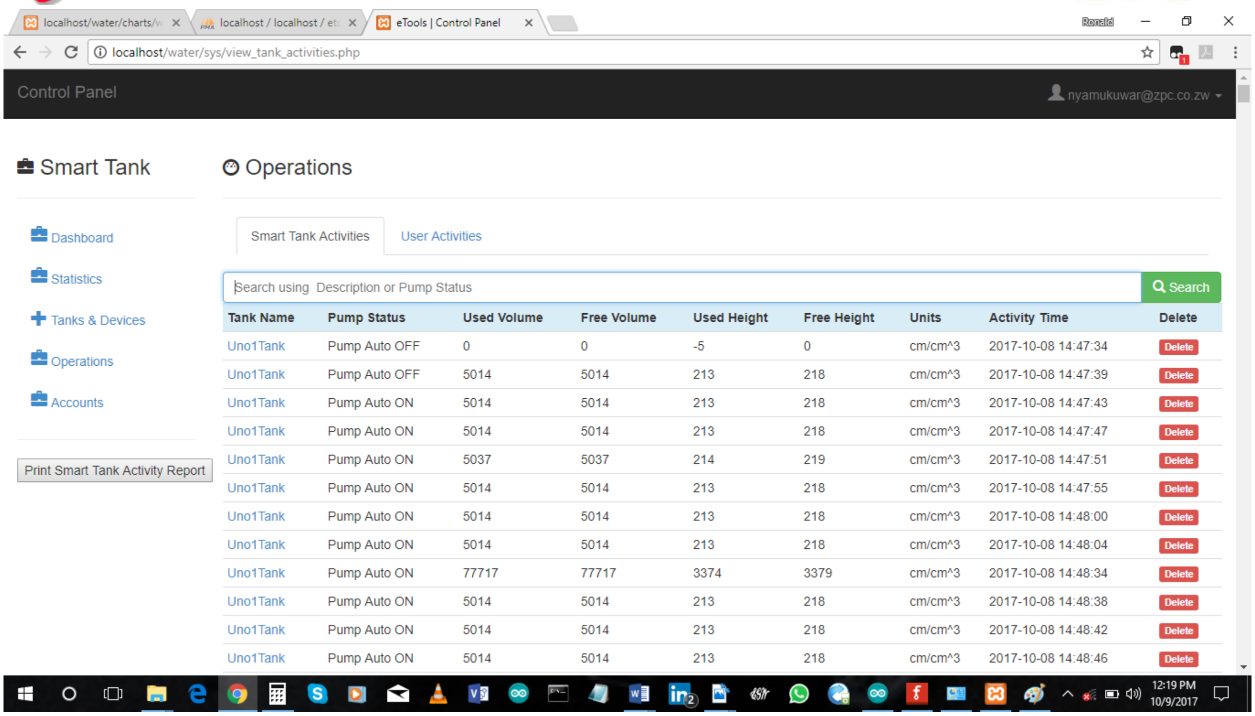


Figure 5.8 Managerial view of the tank activities

Objective 5

To develop a system which generates reports and shows graphical statistics on time taken to refill water tanks

System solution

The system allows the users to view and print reports showing the activities done in the system. These can be filed and used for future reference.

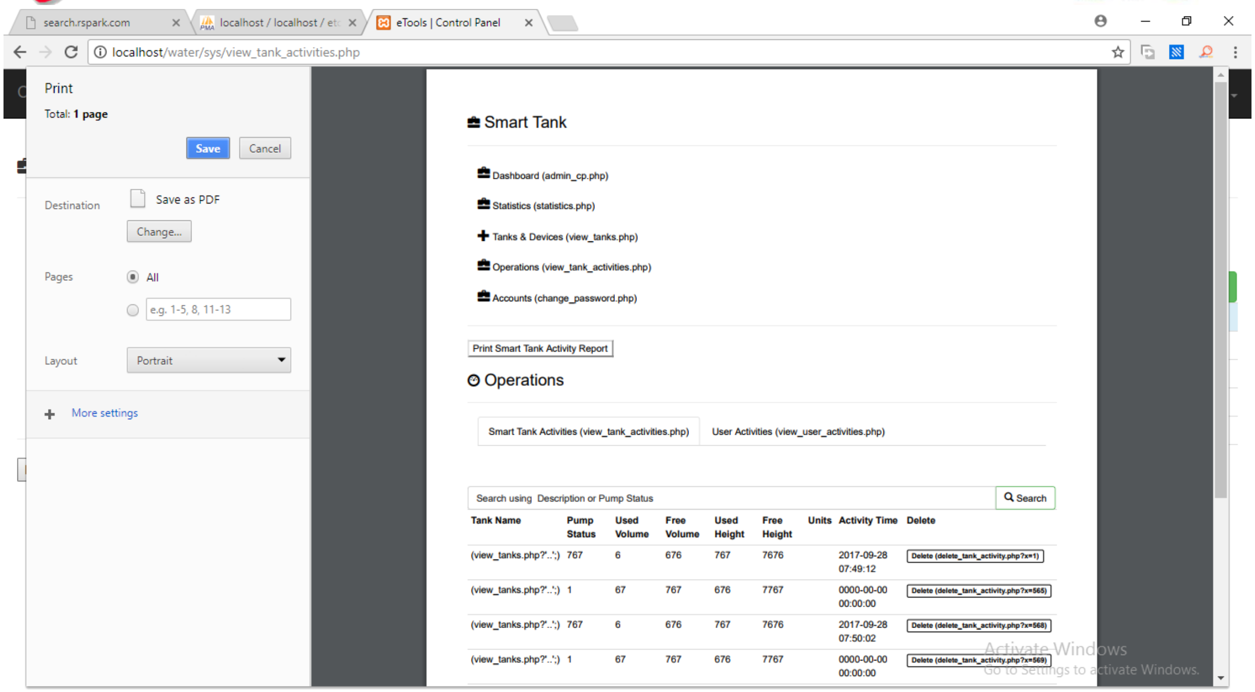


Figure 5.9 View and print reports

The image below shows the times the pumps were switched on. These graphs also help to trace other dependents such as fuel usage.

Figure 5.10 Graphical representation of the system on and off times

The image below shows the events taking place in the system over a period of time i.e. the logged in users, times the pump was running and the times users logged out.

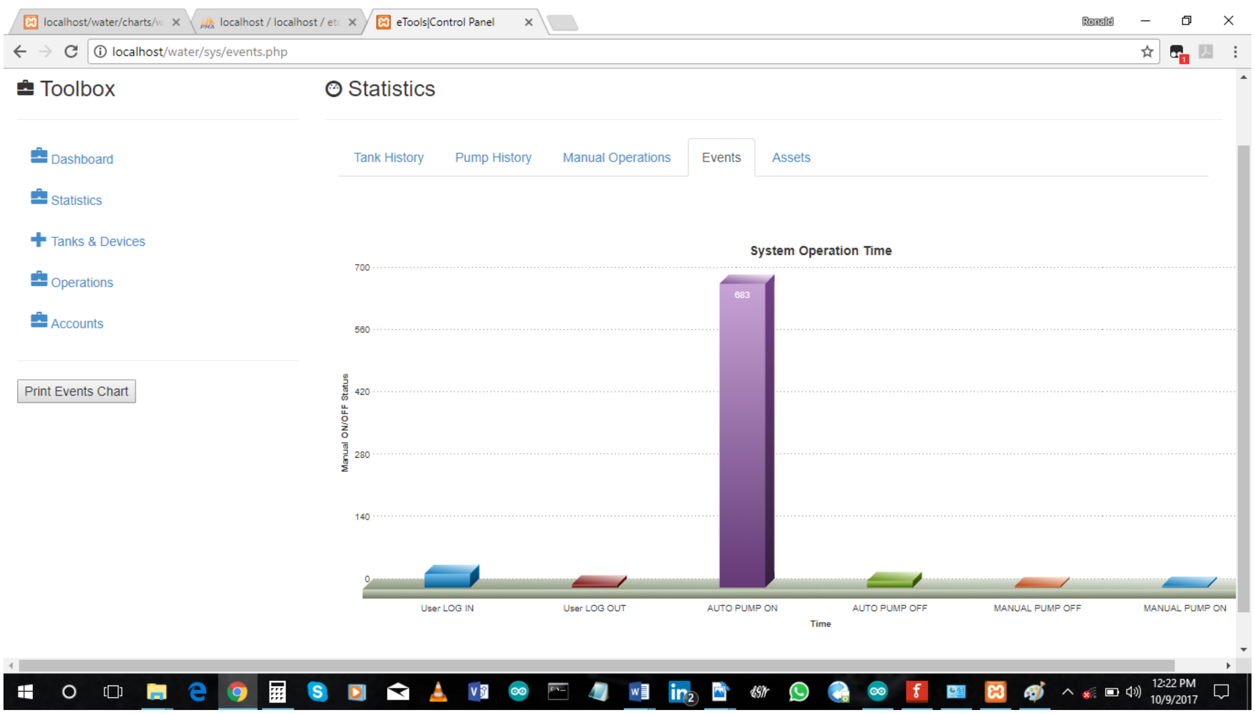


Figure 5.11 Bar graph showing system events

Objective 6

To develop a system which can be operated by different users of various shifts through user accounts for accountability.

System solution

The image below shows the users who logged in, duration taken in the system and the time they then logged out.

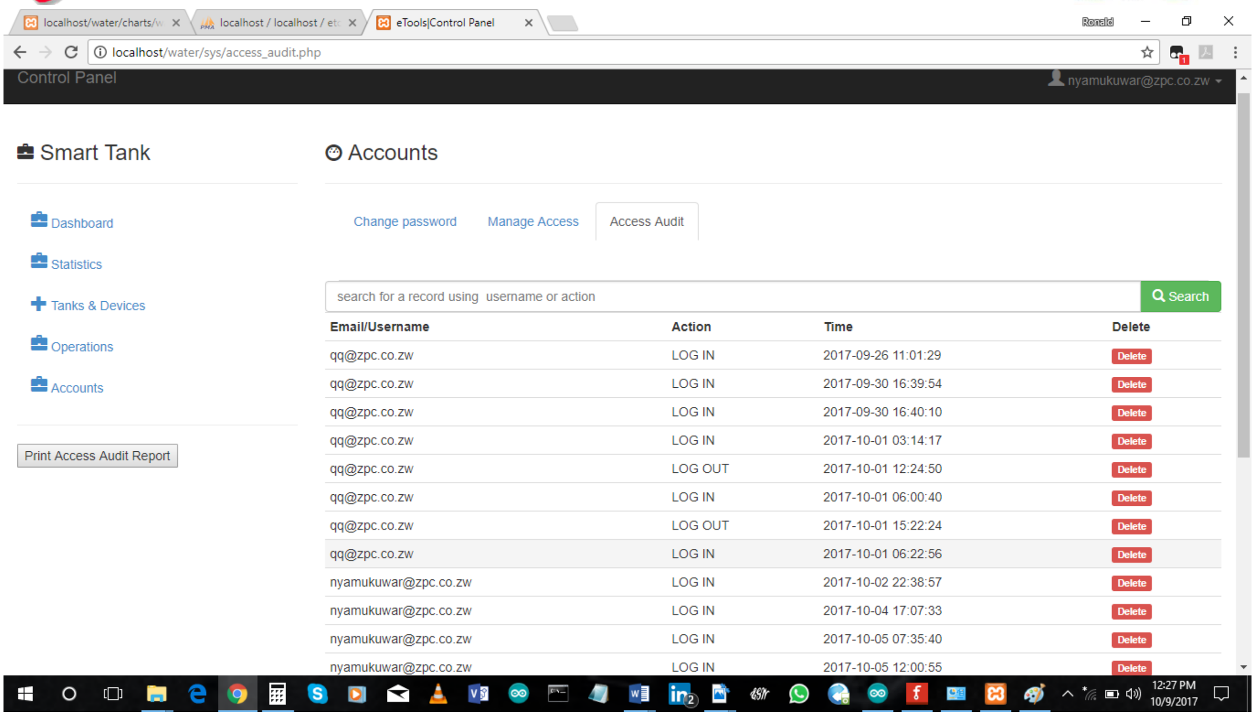


Figure 5.12 Log sheet

Objective 7

To develop a system which allows ZPC IT to manage the forepersons with access to the system as per instruction from the section head of operations.

System solution

Below is an image showing users who have requested a user account from the system however these accounts become active upon activation by the system adminitrstaor.

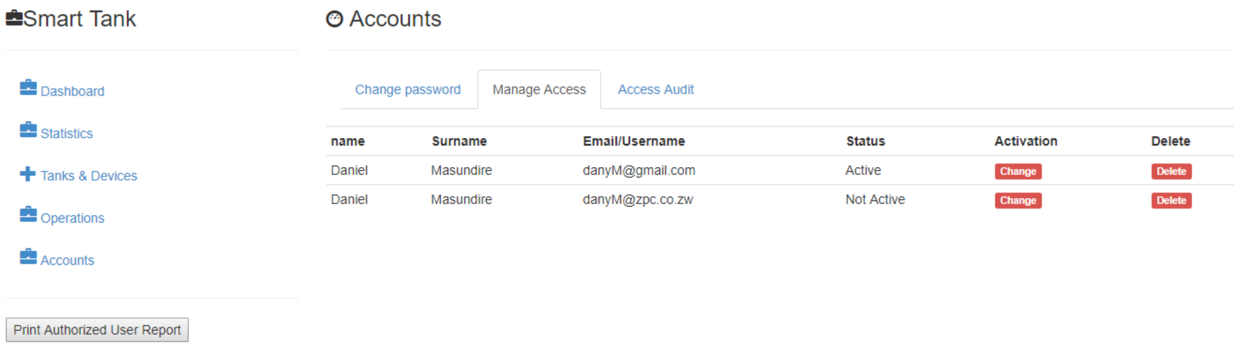


Figure 5.13 Managing User Access

5.3.7 Verification and validation

Verification and validation are methods of checking whether the system is being built in the right way (Cotterell, 2001). Verification checks for correctness in the way the system is being built and whether the developers are meeting the standards that must be met. Validation then confirms that we are building the right system according to the standards set and that the system development is strictly being guided by the systems objectives. At each test, the system is first verified and then validated.

5.4 Installation

This is the process of setting up this system for use by the employees, the system administrator adds the technicians and forepersons and to the systems and provides login credentials. The ultrasonic sensors are attached to the tanks and connected to the Arduino Uno and Ethernet shield. These will then connect to a webserver where readings are sent to and stored in a database. Employees will also be trained on how to operate the system which is also time for them to warmly embrace the technology hence when operations begin, there will be a smooth change over from the old system to the new one. Amid the various change over strategies that exist, there is need to look at the best strategy that exists and the one that is appropriated to Zimbabwe Power Company.

5.4.1 System change over

A system changeover is the phase when the company will need to change over from using the old system to using the new system (Stewart, 2009). Different companies apply different methods depending on the area of application in which the system will be used. Each change over strategy has its risks and benefits which need to be weighed before making the final decision. The intricacy of the system also affects the changeover strategy used and the time needed to effectively shift from old to new system. Below are the various strategies that can be used.

- Parallel change over
- Pilot change over
- Direct change over
- Phased change over

5.4.1.1 Direct changeover

This is when there is complete replacement of the old system with the new system resulting in the employees doing away with the old methods of doing things and shifting to new methods. ZPC would use this strategy if the new system has a direct impact on the electricity generation by increasing their daily capacity (Stewart, 2009). In such a situation it will be most appropriate to use this strategy as it will change their production capacity helping them to reach their daily target. ZPC may also use this strategy during their maintenance phase when the plant is down and there's no electricity generation being done.

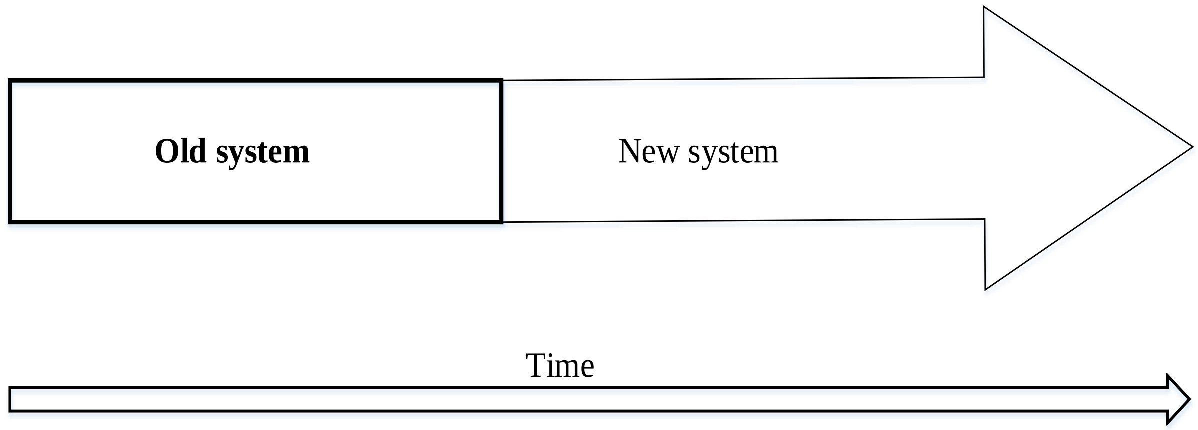


Figure 5.10 Direct changeover strategy

a) Advantages of the direct changeover strategy

- It is the fastest among other methods of implementing a new system.
- This changeover strategy is less costly to implement as compared to other methods.

b) Disadvantages of the direct change over strategy

- Employees will need to quickly learn the new system as it will be done away with immediately.
- There is need to ensure that the system is properly installed as it may be hard to revert back to the old ways of doing things.

5.4.1.2 Parallel changeover strategy

This strategy is used when there is need to run both old and new systems for a certain time period in an attempt to completely move away from the old system to fully implement the new one (Regatta, 2003). The motive behind is to closely monitor the new system while their records are slowly moved to the new one and performance is also being measured (Stewart, 2009). When the new system begins to show a sustainable amount of improvement then it may be safe to leave the old system. The diagram below illustrates the new parallel changeover strategy.

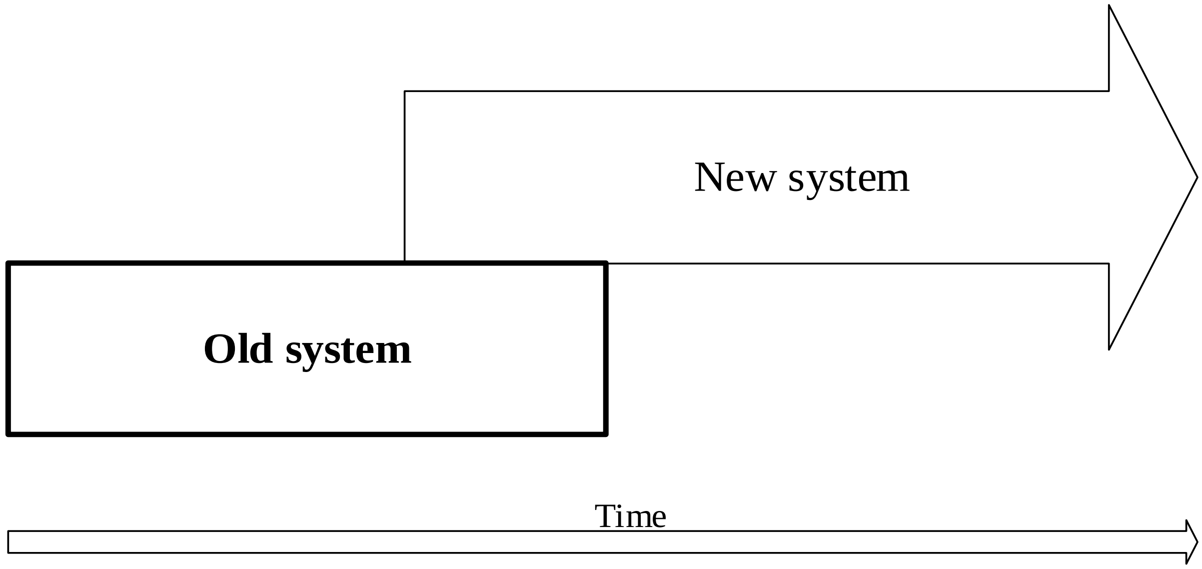


Figure 5.11 Parallel changeover strategy

a) Advantages of the parallel changeover strategy

- This method allows for both systems to be compared as they run parallel making any decision taken to be concrete and informed.
- It allows for a smooth transition from the old system to the as technicians and foreperson can transfer the data without losing any of it.
- There is enough time to check for bugs and errors which may only appear when the system, is being used by many employees continuously.

b) Disadvantages of the parallel changeover strategy

- The use of two systems may be high on costs which may turn out to unsustainable.
- Two separate systems will be used to stored data which will result in data being redundant.

5.4.1.3 Pilot changeover strategy

In this changeover strategy, prototypes are used to implement the new system until the whole system is implemented. The database will first be implemented followed by the module that uploads the water PH results (Stewart, 2009). When these two areas are seen to be functioning correctly then the sensors will be installed at the tanks at Dutchman's pool and lastly installed at the power station. When the technicians start uploading PH results to the system the shift forepersons will wait until the prototype is seen to be working before they can stop taking readings manually at each tank and start using the new system which automatically reads the water level. After one prototype is installed in one department, the next will be installed until the whole system is fully implemented by the organisation.

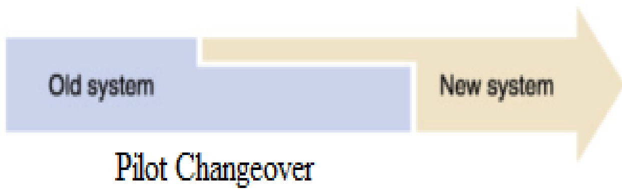


Figure 5.12 Pilot changeover strategy

a) Advantages of the Pilot changeover strategy

- This changeover strategy allows for step by step implementation of the new system making it easy to thoroughly see the effects of the changes hence becoming sure of the next move to take whether being backwards or forwards.
- This strategy allows ZPC to further decide whether they should continue implementing in prototypes or switch to direct changeover.
- The costs associated with this changeover strategy are manageable as prototypes are done on a small scale.
- If the system implementation in one area is successful, it becomes easier for other employees to embrace the new change and the already trained employees may assist in training others.

b) Disadvantages of the pilot change over strategy

- Although this strategy gives a thorough analysis and confirmation of the theoretical system, it is time consuming as each prototype requires time to fully analyse.
- If backups are not done and the pilot changeover is done, there may be loss of data and information.

5.4.1.4 Phased changeover strategy

This is a combination of the direct and pilot changeover strategies as it implements the system in phases. The old system will be gradually replaced until all the modules are implemented into the system (Stewart, 2009).

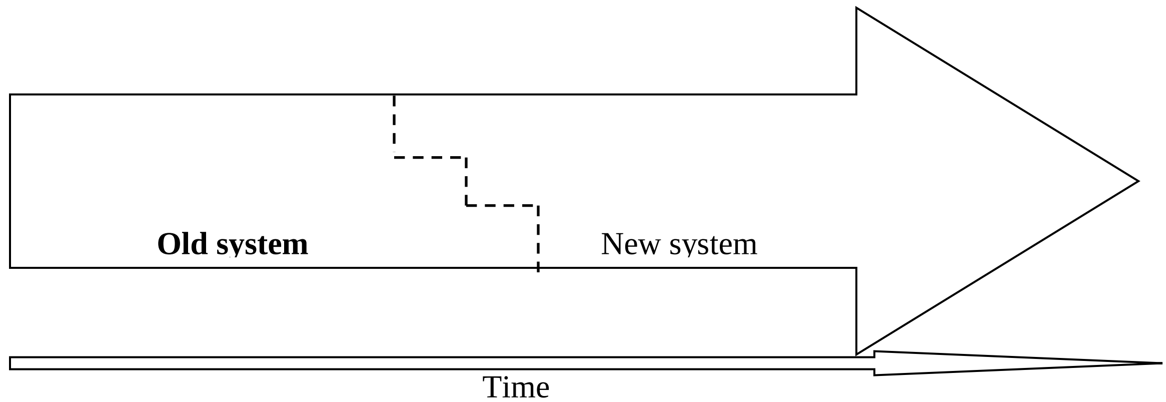


Figure 5.13 Phased changeover strategy

a) Advantages of the phased changeover strategy

- There is room for user training and support for each department as the system is installed module by module.
- The costs associated with this strategy are less than those of the parallel change over strategy.
- Installation of the system in subparts allows for full analysis of each module hence bugs and errors can easily be picked out.

b) Disadvantages of the phased changeover strategy

- It is more costly to implement as more effort and resources are needed to run two concurrent systems at each phase.
- More time is needed to implement the system as it is done in phases. This may mean over time allowances for technicians and forepersons which may not be in the best interest of the organisation.
- This strategy may not be effective at ZPC as the environment may not allow running of two systems at once.

Chosen method (parallel change over strategy)

ZPC will embrace the this strategy as it is most appropriate for the organisation. This will give the employees enough time to learn the new system whilst removing their work from the hard copy books and upload them onto the system.

5.5 Maintenance

This final stage of the system development life cycle allows for the system to be modified to best suit the employees as well as be repaired (Zuo, 2010). There are errors that may arise during the operation of the system that may need to be addressed, hardware failure may occur and the damaged components may need replacement. IT systems must constantly be upgraded so as to keep abreast with technological changes. Maintenance can be categorised as adaptive, corrective and perfective maintenance.

5.5.1 Adaptive maintenance

As the technological world changes every now and then, the proposed system must also be designed to accommodate the new changes that come every day. The system must have room for improvements to be done such that it is easy to upgrade to a new software and hardware (Thomas, 2012).

5.5.2 Corrective maintenance

This maintenance is done on the system after implementation has been done and users are already using the system. Not all errors are unravelled during the testing phase, some errors only come show as the user's daily use the system (Alain, 2008). The common bug that affects systems after implementation usually causes it to crush hence a system restore is the best solution as it reverts the system back to a point when it was fully functional.

5.5.3 Perfective maintenance

This is also known as preventive maintenance as adds value to the system after delivery to the end user. The main aim is to further better the already implemented system so as to improve the user experience. Errors are foreseen before they occur hence solutions to counter the problem are then formulated and applied beforehand. Below is a diagram explaining the system maintenance process.

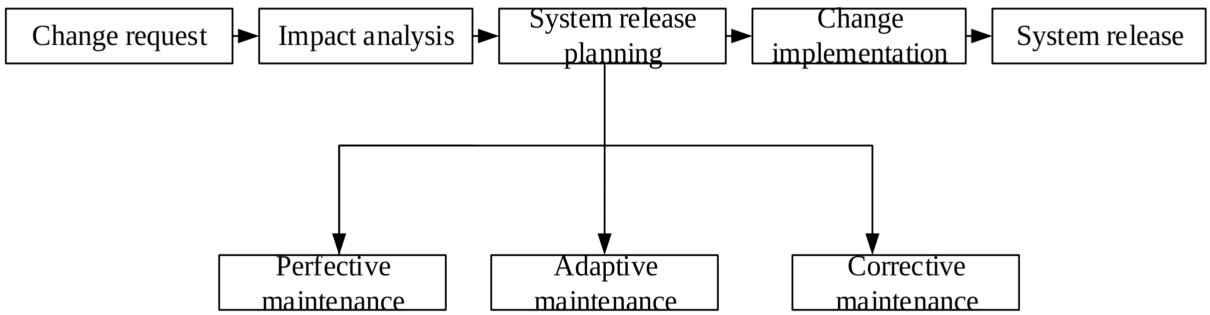


Figure 5.14 System maintenance process

5.6 Recommendations

After system testing and making sure that all objectives were met, there is room for further development and improvement of the system. Stated below are the recommendations that for further development of the system:

- The system must be able to automatically start or stop the system automatically as a security measure for the pumps safety. The pumps should always be inundated in water to avoid damage and costs.
- The system should be able to send real time notifications to mobile devices on the tank status and whenever there is a pump start or stop.
- The Arduino webserver must be accessible on both a wired and wireless network, currently the system is connected to the internet through an Ethernet cable which limits the accessibility of results.

5.7 Conclusion

After going through all the five stages of system development, the system was finally tested implemented and proven to be functional. A few changes and modifications had to be done to the system to suit the needs which were only unveiled on the ground. The employees slowly changeover from the old system into the new one hence data was backed up and stored for future reference. The testing process was made possible through code commenting which allowed even non-technical staff to make logic out of the code.

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APPENDIX A: User Manual

Introduction

The author designed the system to assist ZPC employees with their repetitive tasks that may not need professional qualifications to perform. The system allows shift forepersons to do other tasks while they monitor the water being filled in the tanks hence there is more productivity from all employees.

About the Micro-controller based water level sensing system

This application was developed using Arduino and PHP as the programming language and SQL server as the system database. The application is made up of the following modules:

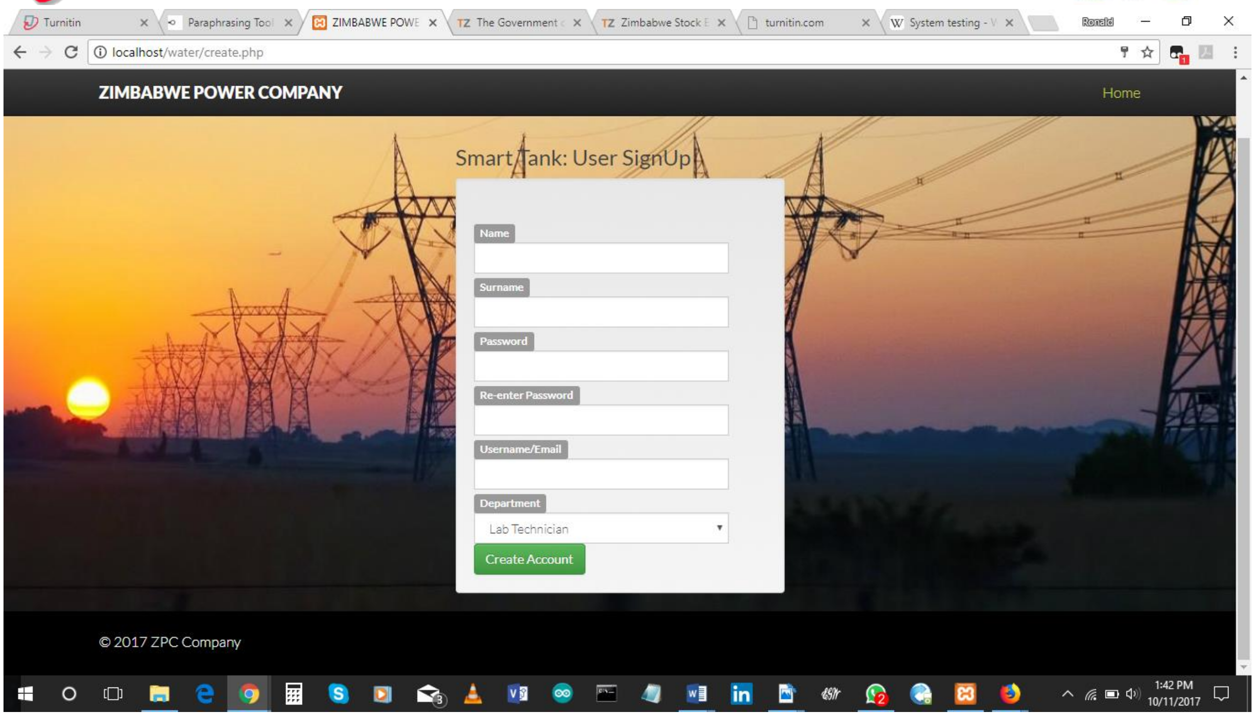
- Operations module
- Statistics module
- Tanks and devices module
- Accounts module

Getting started

Search for www.zpcwater.co.zw to access the portal from which one will be able to login

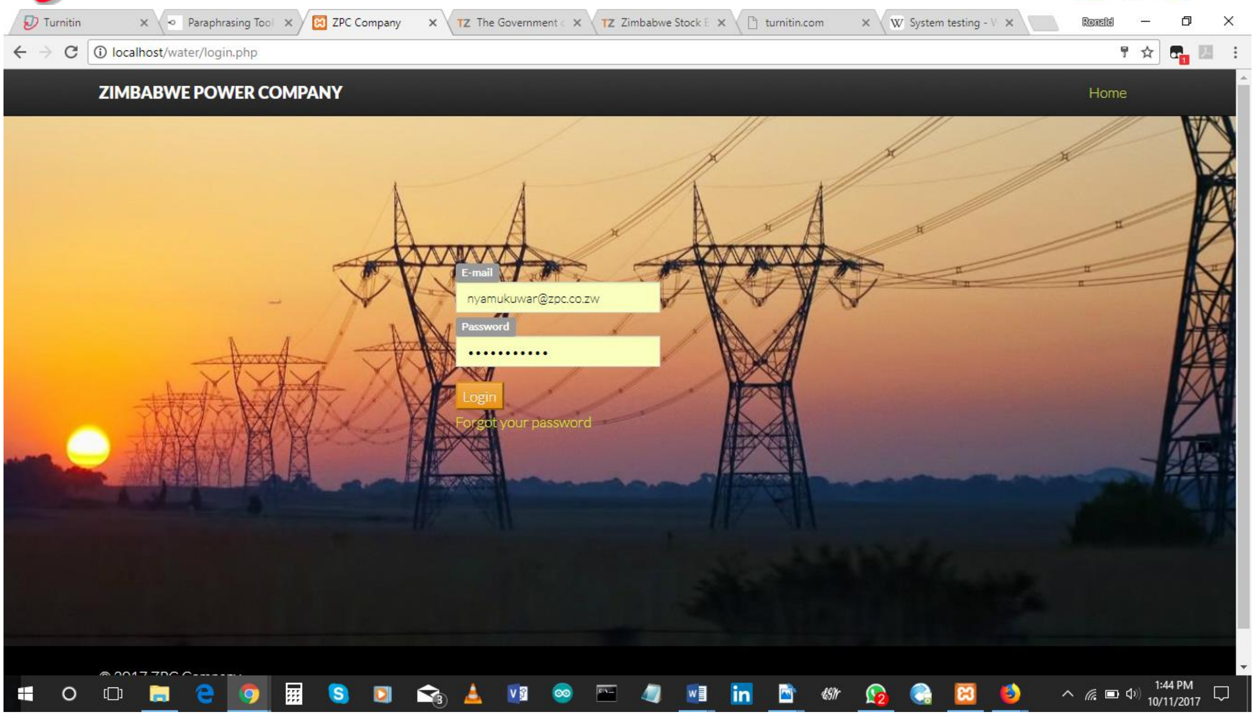
Registration form

Employees will be able to create a user account from the page below.



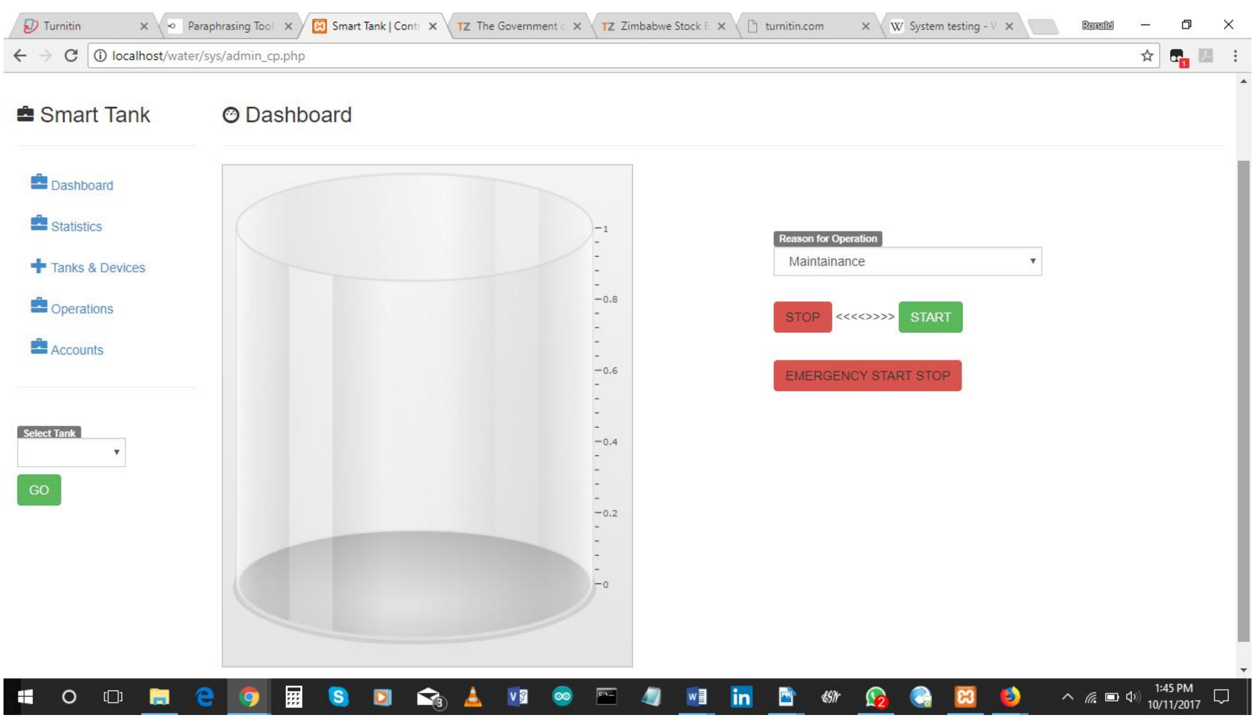
Login page

This is the doorway for the employees to access the system. Each user is allocated login credentials which they use to use the system. A correct username and password will only allow any user to view the system.



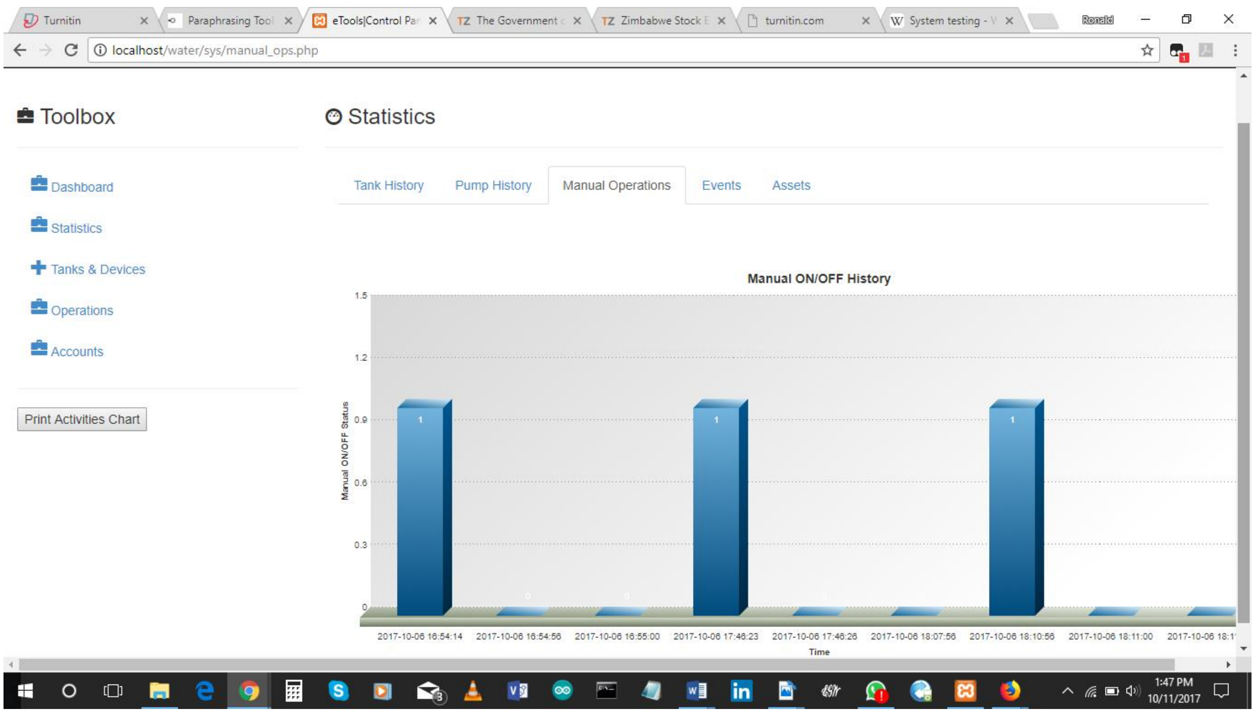
Main dashboard

After successful login, employees can now proceed to the main dashboard:

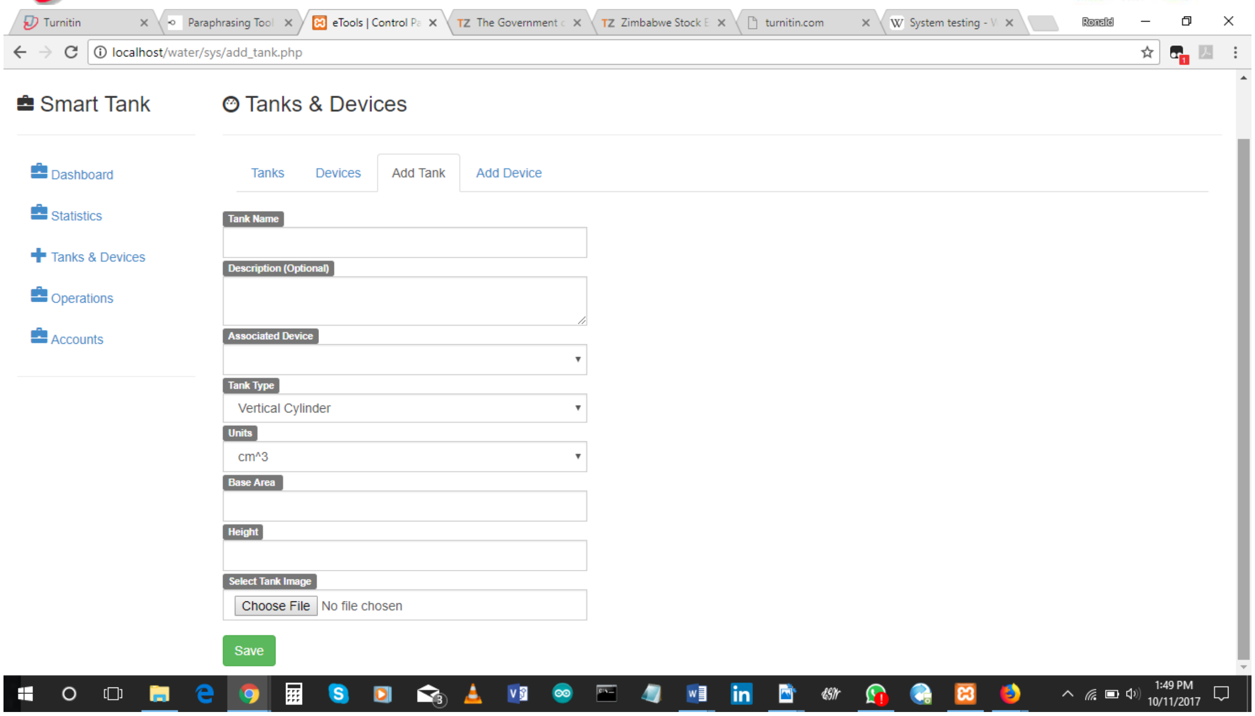


Navigation

Under each module on the left the user will be presented with information and requests pertaining to that area.



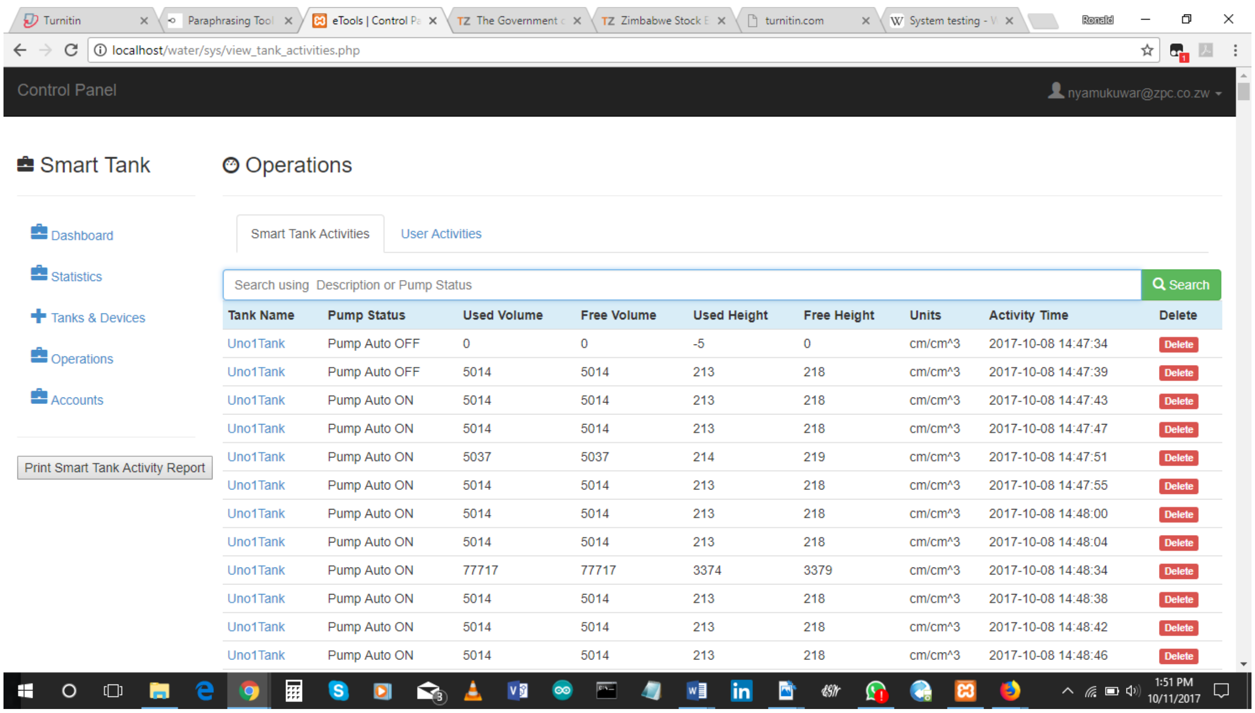
The employees will see the graphical representation of the system activities and daily data put into the system



If one clicks on the tanks and devices tab, the employee is able to add a new Arduino sensor and a tank. The description and details are then saved to the database.

Activities page

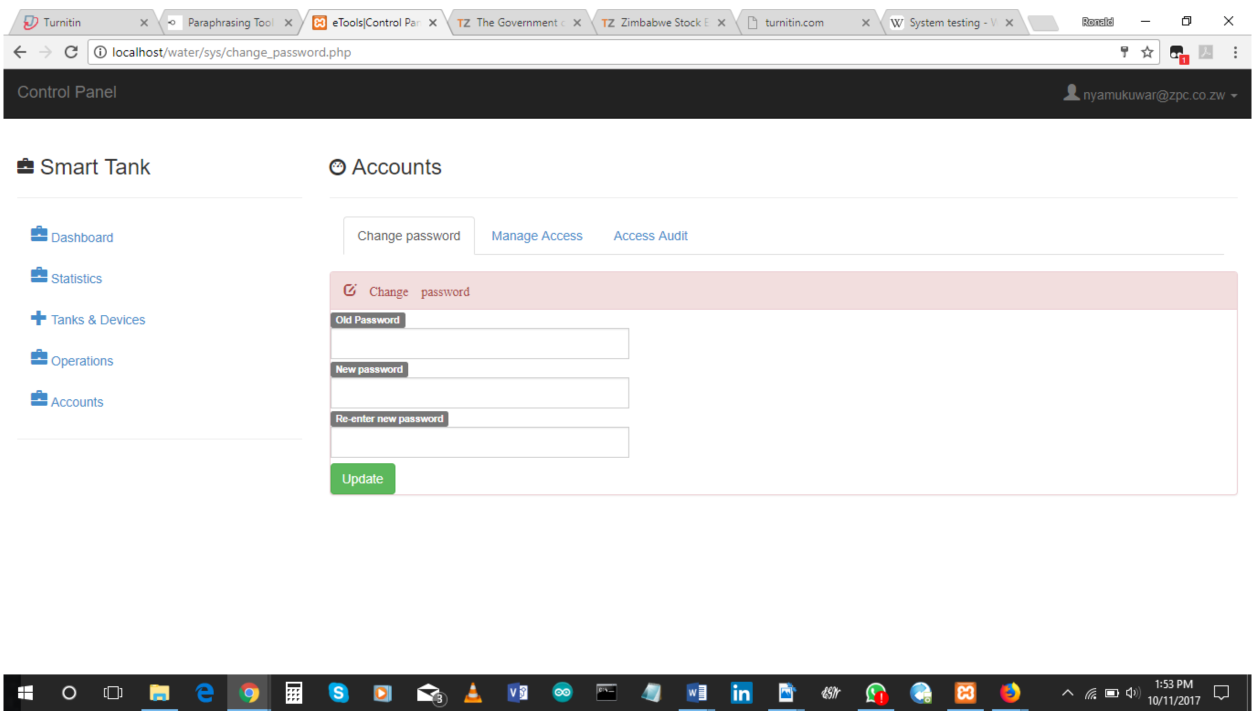
The section head of operations can see the activities happening in the system, users present during a certain shift and print shift related reports.



Tank Name	Pump Status	Used Volume	Free Volume	Used Height	Free Height	Units	Activity Time	Delete
Uno1Tank	Pump Auto OFF	0	0	-5	0	cm/cm^3	2017-10-08 14:47:34	Delete
Uno1Tank	Pump Auto OFF	5014	5014	213	218	cm/cm^3	2017-10-08 14:47:39	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:47:43	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:47:47	Delete
Uno1Tank	Pump Auto ON	5037	5037	214	219	cm/cm^3	2017-10-08 14:47:51	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:47:55	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:48:00	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:48:04	Delete
Uno1Tank	Pump Auto ON	77717	77717	3374	3379	cm/cm^3	2017-10-08 14:48:34	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:48:38	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:48:42	Delete
Uno1Tank	Pump Auto ON	5014	5014	213	218	cm/cm^3	2017-10-08 14:48:46	Delete

Accounts administration

The system administrator can manage access to the portal, activate user accounts and provide reports on the number of users the current system holds.



APPENDIX B: Interview Checklist

Interview Questions

Shift foreperson section

1. What kind of data do you need to record every day?

2. Please describe the process of recording data from the point of switching on pumps until the tanks are full.

Laboratory technician section

1. Do you enjoy working with the current manual system and if so what are the strengths?

2. Are there any challenges with the current system you are using? If so please note them down

3. Do you agree with the concept of automating the recording process such that readings are done and updated by the system?

4. Given that a new system is to be implemented to help execute the repetitive tasks like recording water level readings, what functions would expect the system to have without fail?

APPENDIX C: Questionnaires

Dear Participant

I am Ronald Nyamukuwa and I am a student at Midlands State University. My final project entails developing a Micro-controller based water level sensing system. The system will assist you with your daily water reading activities hence you will be able to achieve more tasks each day.

I am inviting you to participate in this research study by completing the attached surveys. The following questionnaire will require approximately two days completing. In order to ensure that all information will remain confidential, please do not include your name. If you choose to participate in this project, please answer all questions as honestly as possible and return the completed questionnaires promptly. Participation is strictly voluntary.

Thank you for taking the time to assist me with my educational endeavors.

Yours Sincerely

Ronald Nyamukuwa

+263771643354

NB: TICK ON THE PROVIDED TICK BOX

Checklist Section A: Managers

1. How do you rate the current system?

Excellent ☐ Good ☐ Fair ☐ Poor ☐

2. Given the choice to migrate from the current system to the new system, would you choose to migrate?

Yes ☐ No ☐

If No, what may be the reason______________________________________

____

3. Do you often experience very busy days and huge workloads during your operations?

Very often ☐ Sometimes ☐ All the time ☐

4. Have some of employees complained about the current system?

Yes ☐ No ☐

If YES, what were the complaints?

5. What problems are you facing with the current system?

____

____

Section B: Operators

1. Are you satisfied with the current system that you have been using all along?

Yes ☐ No ☐

If YES, give the reason

____

____

2. How do you rate the current system?

Excellent ☐ Good ☐ Fair ☐ Poor ☐

3. Are you pleased with the processing speed of the current system?

Yes ☐ No ☐

If No what are the suggestions? ____

APPENDIX D: Snippet of code

```
#include <SPI.h>

#include <Ethernet.h>

// Enter a MAC address and IP address for your controller below.

// The IP address will be dependent on your local network.

// gateway and subnet are optional:

byte mac[] = {  0x00, 0xAA, 0xBB, 0xCC, 0xDE, 0x02};

IPAddress ip(169, 254, 232, 177);

IPAddress myDns(169, 254, 232, 115);

IPAddress gateway(169, 254, 232, 115);

IPAddress subnet(255, 255, 0, 0);

// telnet defaults to port 23

EthernetServer server(80);

boolean gotAMessage = false; // whether or not you got a message from the client yet

void setup() {

  // Open serial communications and wait for port to open:

  Serial.begin(9600);

  // this check is only needed on the Leonardo:

  while (!Serial) { ; // wait for serial port to connect. Needed for native USB port only}

  // start the Ethernet connection:

  Serial.println("Trying to get an IP address using DHCP");

  if (Ethernet.begin(mac) == 0) {

    Serial.println("Failed to configure Ethernet using DHCP");
```

```
    // initialize the Ethernet device not using DHCP:
    Ethernet.begin(mac, ip, myDns, gateway, subnet);}
  // print your local IP address:
  Serial.print("My IP address: ");
  ip = Ethernet.localIP();
  for (byte thisByte = 0; thisByte < 4; thisByte++) {
    // print the value of each byte of the IP address:
    Serial.print(ip[thisByte], DEC);
    Serial.print(".");}
  Serial.println();
  // start listening for clients
  server.begin();}
void loop() {
  // wait for a new client:
  EthernetClient client = server.available();
  // when the client sends the first byte, say hello:
  if (client) {
    if (!gotAMessage) {
      Serial.println("We have a new client");
      client.println("Hello, client!");
      gotAMessage = true;}
    // read the bytes incoming from the client:
    char thisChar = client.read();
```

```
// echo the bytes back to the client:

server.write(thisChar);

// echo the bytes to the server as well:

Serial.print(thisChar);

Ethernet.maintain(); }}
```

```
// Import Libraries

#include <SPI.h>

#include <Ethernet.h>

// Define Pins

//#define PIN_ETH_SPI 10

#define echopin 9

#define trigpin 8

#define blueled 7

#define redled 6

#define pump 5

//Web Server Setup

byte mac[]  = {0x00, 0xAA, 0xBB, 0xCC, 0xDE, 0x02};   //physical mac address

IPAddress ip(192,168,1,118); // Set the static IP address to use if the DHCP fails to assign

IPAddress myDns(192,168,1,1);

IPAddress gateway(192,168,1,1);

IPAddress subnet(255,255,255, 0);

IPAddress server(192,168,1,100);  // numeric IP for cloud server
```

```
EthernetClient client; // Initialize the Ethernet client library @ Port 80

//Define Variables

int tankheight = 100;

unsigned long lastConnectionTime = 0;    // last connection time'

const unsigned long postingInterval = 10L * 1000L; // delay between updates, in
milliseconds:the "L" is needed to use long type numbers

long duration,Free_Distance,Status_Level;

char Device_Name[] = "Uno1"; // Change device name to match database

char manustart = "ON";

void setup()

{//pinMode(PIN_ETH_SPI, OUTPUT);     // set pin 10  as an output pin to control ethernet chip

pinMode (echopin, INPUT );       // set pin 9  as an input pin to recieve ultrasoud echo

pinMode (trigpin, OUTPUT);       // set pin 8  as an output pin to trigger an ultrasound echo

pinMode (blueled, OUTPUT);       // set pin 7 as an output pin to control blue led

pinMode (redled,OUTPUT);         // set pin 6  as an output pin to control red led

pinMode (pump, OUTPUT);          // set pin 5 as an output pin to control pump relay

//digitalWrite(PIN_ETH_SPI, HIGH);  // deselect Ethernet chip on SPI bus

Serial.begin (115200);

while (!Serial) {; // wait for serial port to connect. Needed for native USB port only}

   // start the Ethernet connection:

  if (Ethernet.begin(mac) == 0) {

    Serial.println("Failed to configure Ethernet using DHCP");

    // initialize the Ethernet device not using DHCP:
```

```
   Ethernet.begin(mac, ip, myDns, gateway, subnet);}

  // give the Ethernet shield a second to initialize:

  delay(1000);

  Serial.println("connecting...");

  // if you get a connection, report back via serial:

  if (client.connect(server, 80)) {

    Serial.println("connected");

    } else { // if you didn't get a connection to the server:

    Serial.println("connection failed");

    setup();}}

void loop (){{if (client.connect(server, 80)) {

  client.print("GET /water/charts/arduino_data.php?value1=100&value2=0&value3=Uno1"); //
This

 client.println(" HTTP/1.1"); // Part of the GET request

 client.println("Host: 192.168.1.100"); // IMPORTANT: IP address of your cloude server here

 client.println("Connection: close"); // Part of the GET request telling the server that we are over
transmitting the message

 client.println(); // Empty line

 client.println(); // Empty line

 client.stop();    // Closing connection to server

 Serial.println("done");}

  else { Serial.println("--> connection failed\n");    // If Arduino can't connect to the server web
page)
```

```
setup(); //restart connection}

  //  time to recieve the data and store. If u use a short delay server might not capture data.

 delay(10000);}}
```

```
// Import Libraries

#include <SPI.h>

#include <Ethernet.h>

// Define Pins

#define echopin 9

#define trigpin 8

#define blueled 7

#define redled 6

#define pump 5

//Web Server Setup

byte mac[]  = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED };   //physical mac address

IPAddress ip(192,168,1,118); // Set the static IP address to use if the DHCP fails to assign

IPAddress server(192,168,1,100);  // numeric IP for cloud server

EthernetClient client; // Initialize the Ethernet client library @ Port 80

//Define Variables

int tankheight = 100;

unsigned long lastConnectionTime = 0;    // last connection time'

const unsigned long postingInterval = 10L * 1000L; // delay between updates, in
milliseconds:the "L" is needed to use long type numbers
```

```
long duration,Free_Distance,Status_Level;

char Device_Name[] = "Uno1"; // Change device name to match database

char manustart = "ON";

void setup()

{//pinMode(PIN_ETH_SPI, OUTPUT);     // set pin 10  as an output pin to control ethernet chip

pinMode (echopin, INPUT );        // set pin 9  as an input pin to recieve ultrasoud echo

pinMode (trigpin, OUTPUT);        // set pin 8  as an output pin to trigger an ultrasound echo

pinMode (blueled, OUTPUT);        // set pin 7 as an output pin to control blue led

pinMode (redled,OUTPUT);          // set pin 6  as an output pin to control red led

pinMode (pump, OUTPUT);           // set pin 5 as an output pin to control pump relay

//digitalWrite(PIN_ETH_SPI, HIGH);  // deselect Ethernet chip on SPI bus

Serial.begin (115200);

 while (!Serial) {

    ; // wait for serial port to connect. Needed for native USB port only }

    // start the Ethernet connection:

  if (Ethernet.begin(mac) == 0) {

    Serial.println("Failed to configure Ethernet using DHCP");

    // initialize the Ethernet device not using DHCP:

    Ethernet.begin(mac, ip);}

  // give the Ethernet shield a second to initialize:

  delay(1000);

  Serial.println("connecting...");
```

```
  // if you get a connection, report back via serial:
  if (client.connect(server, 80)) {
    Serial.println("connected");
      // print the Ethernet board/shield's IP address:
  Serial.print("My IP address: ");
  Serial.println(Ethernet.localIP());
    // Make a HTTP request:
  } else { // if you didn't get a connection to the server:
    Serial.println("connection failed");
    digitalWrite (pump,LOW);
    digitalWrite (redled,HIGH);
    digitalWrite (blueled,LOW);
    setup(); }}
void loop (){  {
if (client.available())
{ // if there's incoming data from the net connection.
    char c = client.read();
    Serial.write(c);
    manustart = c;}
 while (!manustart == "ON") {
 Serial.println("Waiting for User to activate Pump");  // Waith Till Pump is activated to ON
possition}
digitalWrite (trigpin,LOW);
```

```
delayMicroseconds(2);

digitalWrite (trigpin,HIGH);

delayMicroseconds(10);

duration = pulseIn (echopin,HIGH);

Free_Distance = duration/58.2;

Free_Distance = Free_Distance;

delay (100);

Serial.println(Free_Distance);

Serial.println(Status_Level);

Serial.println(Device_Name);

httpRequest();


if (millis() - lastConnectionTime > postingInterval)

{  httpRequest();}}

if (Free_Distance >= tankheight - 5)

{digitalWrite (pump,HIGH);

digitalWrite (redled,LOW);

digitalWrite (blueled,HIGH);

Status_Level = 1;

Serial.println("Pump is now ON, Filling Tank");

delay(100);}

else if (Free_Distance <=10)

{Status_Level = 0;
```

```
digitalWrite (pump,LOW);
digitalWrite (redled,HIGH);
digitalWrite (blueled,LOW);
Serial.println("Pump is now OFF, Tank is Full Now");
delay(100);}
delay(1000);}
 void httpRequest(){ // this method makes a HTTP connection to the server:
 client.stop(); // close any connection before send a new request.
  if (client.connect(server, 80)) {
  client.print("GET /water/charts/arduino_data.php?"); // This
  client.print("value1=");
  client.print(Free_Distance); //  making a GET request with live data from the sensor
  client.print("&value2=");
  client.print(Status_Level); //  making a GET request with live pump status
  client.print("&value3=");
  client.print(Device_Name); //  making a GET request with device Name
  client.print(" ");
  client.println(" HTTP/1.1"); // Part of the GET request
  client.println("Host: 192.168.1.100"); // IMPORTANT: IP address of your cloude server here
  Serial.println("done");
  client.println("Connection: close"); // Part of the GET request telling the server that we are
over transmitting the message
  client.println(); // Empty line
```

```
   client.println(); // Empty line
   client.stop();    // Closing connection to server
   lastConnectionTime = millis();  }
  else {Serial.println("--> connection failed\n");    // If Arduino can't connect to the server web page)
   digitalWrite (pump,LOW);
   digitalWrite (redled,HIGH);
   digitalWrite (blueled,LOW);
   setup(); //restart connection}
  //  time to recieve the data and store. If u use a short delay server might not capture data.
  delay(2000); }
```