DESIGN AND COSTING OF DRAINAGE NETWORK FOR UNILORIN LAKE RESORT

(Approved Final Year Project Proposal)

By

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1. INTRODUCTION

Drainage is defined as the natural or artificial removal of surface and subsurface water from an area. Drainage network is the pathway in which storm water or runoff follows a flow path before getting to a receiving water body. Storm water drainage system is design to collect and convey runoff generated within a catchment area during and after rainfall event for safe discharge into a receiving watercourse. The magnitude of peak flows that have to be accommodated depends on the intensity of rainfall, topography and soil type and land use of the catchment. The collection and proper disposal of storm water and surface runoff is essential for any environment as it stabilizes the state of wellbeing of occupants in that vicinity reduces soil erosion for extensive agricultural productivity and therefore enhance quality of life.

In storm water management, the three primary drainage tasks are urban, highway and land. Urban storm drainage deals with the collection of excess water from the streets in cities. In developed communities, the water collection and conveyance can be done through inlets to buried conduits called sewers or pipes with their appurtenances. In most communities in Nigeria however, the collection of runoff is often carried out using open concrete channels that carry the excess water to an outfall where it can be discharged safely. Some of these points of discharge are dams, streams, lake, reservoirs and rivers.

Storm water collection systems are designed to provide adequate surface drainage. Traffic safety is intimately related to surface drainage. Rapid removal of storm water from the pavement minimizes the conditions which can result in the hazards of hydroplaning which is the separation of vehicle tire from the roadway surface due to film of water on the roadway surface. Hence it can be said that flows in urban drainage channels are usually open channel flows with free water surface. However, sewer pipes, culverts and similar conduits under high flow conditions could become surcharged and pressurized conduit flows do occur. The flow is always unsteady i.e. changing with time. Nevertheless, in situations for rainstorm runoff for sanitary sewers, change of flow with time is slow enough that the flow can be regarded as approximately steady

There are two basic types of drainage systems: (1) Surface (2) Subsurface. Surface drainage system is that which may be left open or partially covered with concrete slabs, and are used to convey runoff resulting from precipitation. This form of drainage system poses a lot of health risks if not properly managed. There are four basic types of open surface drainage channels namely rectangular, parabolic, and trapezoidal and triangular**.** Subsurface drainage System is the form of drainage system found in most developed countries in which the runoff is collected by underground pipes to the discharge points. Sub-surface drainage is usually designed to have sufficient capacity so that they do not run full when conveying the computed runoff. The stimulating force establishing flow in both surface and sub-surface drainage systems is mainly the gravitational force component acting parallel with the bed slope, but net pressure forces and inertia forces may also be present. Flow in channels may be unsteady resulting from changes in inflow such as floods.

A complete storm drainage system design includes consideration of both the major and minor drainage system. The minor system sometimes referred to as the "Convenience'' consists of the components that have been historically considered as part of the "Storm drainage system". These components includes curbs, gutters, ditches, inlets, access holes, pipes and other conduits, open channels, pump detention basins, water quality control facilities. The minor system is normally designed to carry runoff from 10- year frequency storm events. The major system provides overland relief for storm water flows exceeding the capacity of the minor system. This usually occurs during more infrequent storm events, such as the 25-, 50-, and 100 year storm. The major system is composed of pathways that are provided knowingly or unknowingly for the runoff to natural or manmade receiving channels such as streams, creeks, rivers, and lake. The major system normally uses a 100 year event as the check storm.

One of the major problems associated with new urban development is the increased volumes and rates of storm water runoff generated within previously natural watersheds. Runoff volume is increased when natural previous land surfaces are covered by such impervious structures as buildings, roadways, and parking lots and when natural depressions are removed, which serve as storage areas for surface runoff in their natural state. The rate of runoff including peak flow rates is significantly increased when structural drainage systems such as storm sewers and ditches which greatly reduced the time of concentration of runoff are constructed (Martin et al, 1997). Open channels can create a safety hazard therefore relevant stringent measures (devices and signals) should be installed to protect people and animals from accidents such as falling or drowning. The safety of the general public shall thus be an important consideration in the selection of cross-sectional geometry of artificial drainage channels. This study is aimed to design and cost the drainage network for University of Ilorin lake resort.

2. PROBLEM STATEMENT

It has been identified that areas in the University where structures have not been erected have good natural drainage and the rate of runoff and infiltration appear sufficient. However in specific areas for example the lake resort, rainfall runoff is a challenge and always pronounced during intense rainfall event and due to high water table in the area.

Due to this, stagnated water are been scattered in the area with attendant inconveniences to people and vehicles.

3. AIM AND OBJECTIVES

This study aims at providing design and cost estimation of drainage network for Unilorin lake resort development. The specific objectives are:

1. To carry out elevation profile of the drainage using total station and Google earth.
2. To carry out hydraulic and structural analysis of the drainage network.
3. To design a suitable runoff drainage system.
4. Determination of the cost implication of the drainage network.
5. Develop flood/erosion management strategies for the catchment.

4. SCOPE AND LIMITATION

The project shall be limited to carrying out hydraulic and structural analysis and design of drainage network for lake resort. The study which is limited to the landscape of the Lake resort in University of Ilorin will also include flood management strategies.

5. DESCRIPTION OF STUDY AREA

University of Ilorin was established in 1975 and physical development activities commenced on the main campus in 1979. It is located some 10km north-east of the Ilorin township which is the capital of Kwara state. Ilorin lies between latitude 8^o and 10^o of the equator and longitude $2^o24'$ and $6^o15'$ east of the prime meridian in the north central part of Nigeria. University of Ilorin main campus presently has 15 faculties namely: Agriculture, Arts, Basic Medical Sciences, Business and Social Sciences, Communication and Information Sciences, Clinical Sciences, Education, Engineering and Technology, Environmental Sciences, Law, Life Sciences, Pharmacy and Pharmaceutical Science, Physical Sciences, Veterinary Medicine. Each of the faculties has departments for different programmes. There are also the postgraduate school, Bank buildings, Staff quarters, Works department, Canteens, Health Centre.

The University of Ilorin lake resort is situated in University of Ilorin campus. There are different buildings in the environs of the lake resort. These are Centre for International Education, Centre for Ilorin Studies, Unilorin Documentation and Archives centre while Unilorin Entrepreneural Centre and University Researchers lodge are in progress. From the entrance of the main gate of the campus the lake resort is sited at the right side immediately before approaching the bridge.

6. LITERATURE REVIEW

Urbanization along with its impermeable structures is the major causes of flooding in urban areas. Urban storm water influences the service life of urban infrastructures. The rainfall intensity and characteristics of catchment area are the major factors for designing urban storm water drainage facilities. Drainage channel should be economical to construct and maintain. Open channel should be reasonably safe for vehicles traversing that routes, pleasing in appearance, convey collected water without adverse effects to adjacent

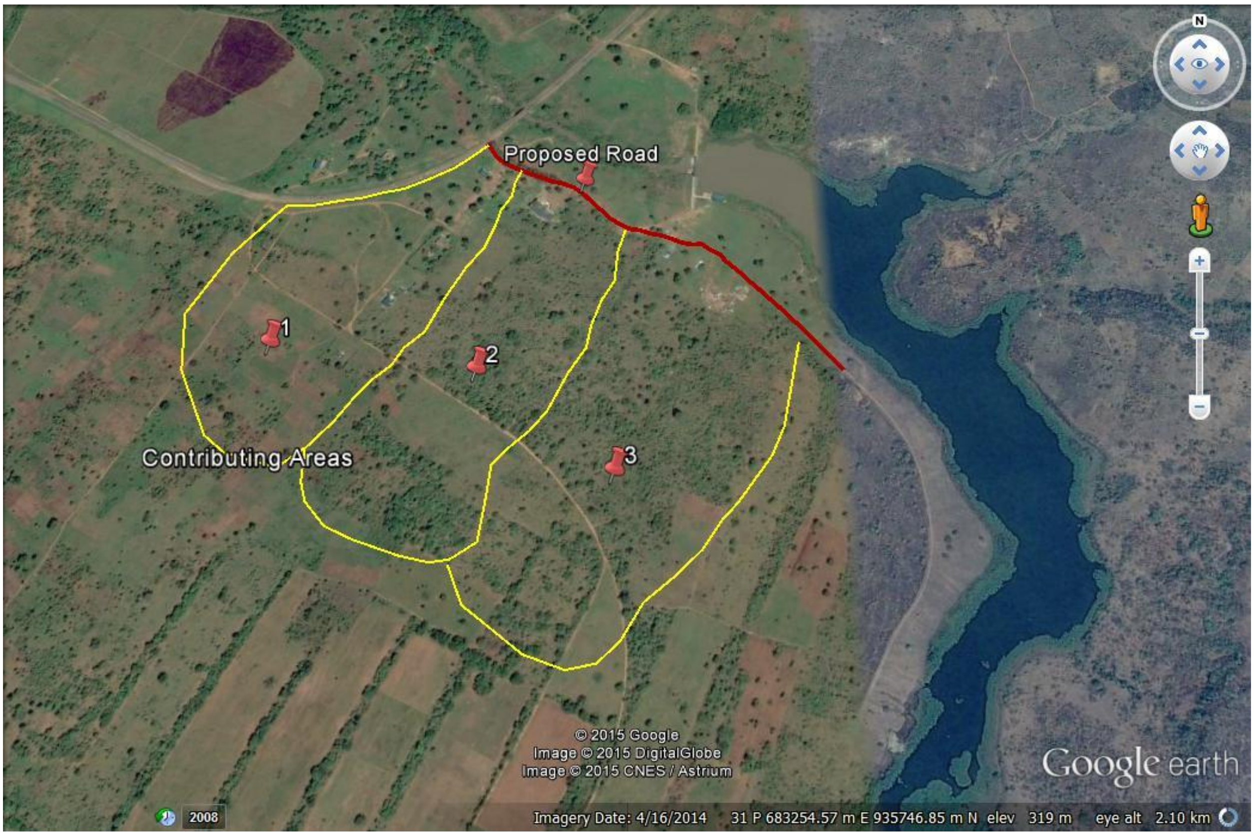

Fig 1. Satellite imagery of study area

properties and minimize environmental impacts. Different studies have been done on urban drainage systems.

Dagnachew (2011) carried out a research on road and urban stormwater drainage network integration in Addis Ketema subcity, Addis Ababa to identify sites most prone to flooding problems, to assess the existing condition of road and urban stormwater drainage infrastructure in road projects provision and to examine the impact of urban stormwater integration on road performance and related environmental issues. Exploratory and descriptive methods were used to investigate the existing condition and coverage and level of integration between road and urban storm water drainage infrastructures respectively. Data collection was done using both primary and secondary sources and was analyzed and presented using Microsoft excel, AutoCAD and ArcGIS. The findings of the study includes inadequate storm water drainage lines followed by blockage of drains by solid waste were the major causes of erosion in the areas. Flood prone areas were identified and management strategies were initiated to mitigate it.

Ganiyu (2012) carried out reinforced concrete drainage design for Olu Daramola road in University of Ilorin, Kwara state. Rectangular and trapezoidal channels were designed. Trapezoidal channel was recommended being economical and having the least wetted perimeter with the best hydraulic section for easy discharge. Rational method was used for the computation of the surface runoff resulting from the watershed while manning's equation was adopted for getting the dimensions of the drain and visual urban software adopted for optimum dimension of the drain. The rainfall intensity of the area was 98.46mm/hr and the maximum discharge is 6.39m^3/s. The largest dimension of the rectangular channel was 1.74m X 0.87m depth while trapezoidal channel was 2.15m X 1.07m X 0.82m. Bill of Engineering Measurement and Evaluation (BEME) were prepared to ascertain the cost implication. Adeyemi (2005) also provided a design of drainage network for Salaudeen Abdul Baki area of Fate road in Ilorin. Rational and manning equation were adopted in Microsoft excel package to compute the channel peak discharge and dimension respectively. The structural detailing of the channel was carried out based on limit state design. The total channel length was 4.2km and the rectangular channel dimensions are 750mm depth by 1060mm width and 300mm depth by 430mm width for trapezoidal channel.

Nasiru (2009) conducted a study on the engineering design of drainage network for Rahamaniyah Oil and Gas tank farm at Apapa, Lagos. The design was based on American petroleum Institute (API) standards to direct oily water to the separator pit in the gas tank farm. Reconnaissance and route surveys were used to obtain the relevant data used to plot the layout, cross sectional profile to determine the change in the elevation of the surface of the ground. Rainfall intensity duration value proposed by Salami and Sule (2009) was adopted. Surfer 8 and AutoCAD 2007 were used to plot the contour and profile generation and visual basic for the determination of the depth and width of the channel. The maximum peak flow of the area was determined using rational formula and the channel sizes were obtained with manning's equation. From the study the peak discharge was 4.13m^3/s. The dimension of the rectangular channel is 1.19m X 0.71m depth. Mohammed (2005) carried out a study on the engineering design of drainage network for Kulende housing estate phase III Ilorin. He adopted two alternative conduit drainage systems. The peak discharge was based on rational method and the hydraulic design of the channel estimated with manning's equation. The peak discharge obtained is 2.48m^3/s. The dimensions of the trapezoidal channel are channel depth 0.89m, bed width 0.73m while that of rectangular channel were obtained as depth 0.84m and bottom width of 1.2m.

7. METHODOLOGY

The methodology involves field and desk works. The field work involves carrying out a preliminary survey to have the first hand information about the site condition and determine possible drainage routes and Total station equipment will be used to determine the slope and contour lines profile of the area. The desk study includes hydrological and hydraulic analysis to determine the design volume and drainage sizes and structural design.

7.1 Reconnaissance Survey

Reconnaissance survey is done to familiarize with the area of work and identify the scope, topology, topography including an insight that guide into proper planning. Total station and remote sensing techniques will be employed to capture topographical information of the area.

7.2 Field work

Field work is carried out to check the runoff situation in the area and identification of topographic features and existing natural drainage patterns.

7.3 Methodological Tools

I. Google Earth

Google Earth is a virtual globe, map and geographical program. It maps the earth by the superimposition of images obtained from Satellite Imagery, Aerial Photography and Geographic Information System (GIS) 3D globe. Google earth displays satellite images of varying resolution of the earth's surface, allowing users to see things like cities and houses looking perpendicularly down or at an oblique angle. The degree resolution available is based somewhat on the points of interest but most land (except for some Islands) is covered in at least 15 meters of resolution. For other parts of the surface of the earth, 3D images of terrain and buildings are available. Google earth uses Digital Elevation Model (DEM) data collected by NASA's Shuttle Radar Topography Mission (SRTM). This tool will be used to capture satellite imageries of the study area.

II. Total Station

Total station is the use of electronic survey equipment to carry out horizontal and vertical measurements in reference to a grid system. Total station is the combination of Electronic Distance Measuring instrument (EDM) and electronic theodolite. It is also integrated with microprocessor, electronic data collector and storage system. The instrument can be used to measure horizontal and vertical angles as well as sloping distance of object to the instrument. Microprocessor unit processes the data collected to compute:

1. Average of multiple angles measured
2. Average of multiple distance measured
3. Horizontal distance
4. Distance between any two points
5. Elevation of objects and
6. All the three coordinates of the observed points.

iii. AutoCAD CIVIL 3D

AutoCAD civil 3D offers a better way of designing, analyzing and documenting civil engineering projects. It helps in delivering high quality transportation, land development and environmental engineering projects faster. The software purpose built tools support building information modeling (BIM) processes and help reduce the time it takes to design, analyze and implement changes. AutoCAD civil 3D will be used to design the drainage network by inputting the hydrological parameters.

7.2 Desk Study

7.2.1 Hydrological Analysis

Precipitation in form of rainfall if not intercepted by vegetation or artificial surfaces such as roofs or pavements, falls on the earth and either evaporates, infiltrates or stay in depression storage. When the losses are accounted for, some proportion flows over the surface to the nearest stream channel. When the rain is particularly intense or prolonged, the surplus runoff becomes too large and thus results in flood.
A direct relationship exists between runoff and rainfall depth. There are several methods of estimating local inflow otherwise referred to as runoff. Each of these methods of estimation necessarily neglects some factors and makes simplifying assumptions regarding the influence of others. The following method is used in runoff estimation.

I. Rational Method

The Rational method is the most widely used for storm water drainage design for its simplicity. The idea behind the rational formula is that for a spatially and temporally uniform rainfall intensity which continues indefinitely, the runoff at the outlet of the catchment will increase until the time of concentration when the whole catchment is contributing flows to the outlet.

The peak runoff is given by the following expression;

$\boldsymbol{Q_p = 0.278\ CiA}$ ....Equation 1

Where
$Q_p =$ Peak runoff in m³/s
C = runoff coefficient (dimensionless)
i = rainfall intensity in mm/hr
A = catchment area in Km²

For a catchment consisting of m sub-catchments of areas A_j (Km²) each with different runoff coefficients C_j, the peak runoff at the drainage outlet is given thus:

$\boldsymbol{Q_p = 0.278 i \sum_{j=1}^{m} C_j\, A_j}$...Equation 2

The basic assumptions used in the application of the rational formula are as follows;

1. The return period of the peak discharge is the same as that of the rainfall intensity.
2. The rainfall is uniform in space over the watershed under consideration.

3. The storm duration associated with the peak discharge is equal to the time of concentration for the drainage area the time for the most hydraulically –distant point to contribute to the peak outflow at the point under consideration.
4. The runoff coefficient R is not influenced by the return period.
5. The runoff coefficient R is independent of the storm duration for a given watershed and reflects any changes in infiltration rates, soil types and antecedent moisture conditions.

Although the basic principles of the rational method are applicable to large drainage areas in which reported practice generally limits it use to urban areas of up to 12km². For areas larger than this, storage and subsurface drainage flows result in an attenuation of the runoff hydrograph so that rates of flow tend to be overestimated by the rational formula method unless these are taken into account.

II. Soil Conservation Method (SCM)

SCS Curve method was developed by U.S Soil Conservation Service for uniform rainfall using assumptions of triangular hydrograph. The volume and the peak of the runoff can be estimated for 24-hour design storm. This method requires the determination of the runoff curve number, CN for the drainage basin, which is the function of the soil and surface characteristics and land use. The SCS method uses a dimensionless unit hydrograph and drainage inputs to determine flow volumes and peak discharge.
SCS runoff equation is given below;

$$\mathbf{T_P = \frac{D}{2} + T_L = \frac{D}{2} + 0.6T_C} \text{ .... Equation 3}$$

Where
T_P = time to peak
D = duration of excess rainfall
T_L = time of lag
T_C = time of concentration
The peak runoff rate derived from the triangular hydrograph is

$$\boldsymbol{q = 0.0021QA\left(\frac{1}{T_p}\right)} \text{ ....Equation 4}$$

Where
q = runoff rate (m³/s)
Q = runoff volume in millimeter depth
A = Catchment area (Square metres)
T_P= time of peak (hour)

III. Modified Rational Method

Modified rational method is an extension of the rational method for rainfalls lasting longer than the time of concentration. This method was developed so that the concepts of the rational method could be used to develop hydrographs for storage design rather than just flood peak discharges for storm drainage design. The modified rational method can be used for the preliminary design of detention storage for watersheds of up to 81000m^2 to 121500m^2.

IV. Flood Frequency Analysis Method

This method of run off estimation depends upon the existence of a number of years of record from the basin under study. These records then constitute a statistical array that defines the probable frequency of recurrence of floods of given magnitudes. Extrapolation of the frequency curve enables the hydrologist to predict flood peaks for a range of return periods.

7.2.2 Runoff Coefficients

The coefficient of runoff C refers to the propensity of precipitation to contribute to the peak runoff rate. The coefficient represents the runoff-rainfall ratio and includes many factors such as type of cover, soil types, infiltration, evaporation, evapo-transpiration, and any antecedent moisture condition. The rational method assumes that the storm duration is at least as long as the time of concentration, which is the time for the most hydraulically distant point to contribute to the flow rate at the point under consideration.

7.2.3 Time of Concentration

The time of concentration at any point in a hydraulic design is the time required for run-off from the most remote portion of the drainage area to reach that point. The most remote portion provides the longest time of concentration but is not necessarily the most distant point in the drainage area. The basic assumption of the Rational Method is that all portions are contributing run-off. The time of concentration (t_c) is calculated in order to estimate the intensity of the design storm.

Time of concentration is estimated with equation 5

$$\boldsymbol{t = 0.0078 \frac{L^{0.77}}{S^{0.5}}} \quad \text{....................Equation 5}$$

Where:

t = time of concentration in minutes

L = Length of watershed area in metres

S = Slope of watershed area in metres per metre

A minimum time of concentration of twenty minutes is recommended for design except for inlets where a minimum time of five minutes should be used.

7.3 Hydraulic Analysis

7.3.1 Open Channel Flow

The flow in an open channel is a uniform flow. The energy equation between two points A and B is given by (Linsley, et al. 1992);

$$\boldsymbol{z_A + y_A + \frac{V_A^2}{2g} = Z_B + y_B + \frac{V_B^2}{2g} + h_L} \text{..Equation 6}$$

Where $z =$ Elevation of the channel bottom above an arbitrary bottom

$y =$ Depth of flow

$V =$ Average velocity

$h_L =$ Head loss between two point A and B

Where each term in the equation is in Nm/N (newton-metres per newton)

In uniform flow, the flow cross section remains constant in size and shape from one section to another. Hence, in uniform flow, $y_A = y_B$, $V_A = V_B$, and the channel bed, water surface, and energy line are parallel to one another. Thus, in uniform flow, the slopes of the channel bed, the water surface and the energy line are identical. The depth at which uniform flow will occur is called the Normal depth, determined with Manning equation for discharge (Linsley, et al. 1992):

$$\boldsymbol{Q = \frac{1}{n} A R^{\frac{2}{3}} S^{\frac{1}{2}}} \text{...Equation 7}$$

Where $Q =$ Discharge in m^3/s

n $=$ Roughness coefficient

$A =$ Cross sectional area in m^2

$R =$ Hydraulic radius

$S =$ Energy gradient

7.3.2 Hydraulic Efficiency of Channels

From Equation 7, it can be said that with uniform flow and fixed values of A, S and n, the rate of flow will be maximum when the hydraulic radius R is maximum. The cross section having the highest efficiency (maximum R for a given A) is the half circle. For a trapezoidal channel the maximum efficiency $R = y/2$. The best trapezoidal section has the shape of a half hexagon, while the best rectangular section is one with depth equal to one-half width (Linsley, et al. 1992).

7.4 Hydraulic Design of a Channel

7.4.1 Drainage sizing

The following steps would be adopted in determining the required dimension of the drainage.

(a) Labeling of selected channel routes
(b) Measurement of each channel length and slope calculation.
(c) Computation of the time of concentration of the channel
(d) Selection of suitable return period (10years) and determination of the rainfall intensity.
(e) Calculation of direct discharge in the channel using rational formula.

(f) Computation of the peak flow of the channel.
(g) Calculation of the channel depth of flow and dimension (using manning's equation).

7.4.2 Structural design and detailing

The drainage wall will be considered as earth retaining structure with the following steps adopted.

(a) Computation of horizontal force on the channel wall.
(b) Computation of design moment for the channel.
(c) Determination of required steel reinforcement using the limit state design method.
(d) Detailing of the channel reinforcement.

7.5 Cost Estimate

Cost estimate will be carried out to ascertain the material and labour costs for the execution of the construction work. This will be done using Bill of Engineering Measurement and Evaluation (BEME). Unit rate of materials will be derived either from direct market survey or from Physical Planning Unit (PPU), University of Ilorin.

8. PROJECT TIME FRAME

The estimated duration of this project is 32 weeks, 16 weeks in the Harmattan semester and 16 weeks in the Rain semester. In any project work to be carried out, there is necessity of project scheduling and estimation to be able to monitor the project progress to know if a task is behind schedule or not. Work Breakdown Structure is used in this study. Table 2 shows the WBS:

9. EXPECTED RESULT

At the end of this study, the rate of runoff leading to the design of the actual drainage dimensions that will accommodate the capacity of the runoff should be confidently determined and the cost implication for the drainage network determined.

10. PROJECT DELIVERABLES

On completion of the project, the following will be submitted as project deliverables to the project supervisor/department for the purpose of documentation.

1. Final year project proposal
2. Extended abstract
3. Printed project document
4. Soft copy of project

11. PROJECT COST

The amount of money to be spent on the study is estimated at ₦36,500 (Thirty six thousand and Five Hundred Naira) and the breakdown is shown in Table 1.

Table 1: Project Cost Details

S/No.	Item Description	Cost (₦)
1	Printing of Literature materials	5,500.00
2	Internet facility	6,000.00
3	Data Acquisition	15,000.00
4	Project Documentation	6,000.00
5	Contingencies	4,000.00
	Total	**36,500.00**

Table 2: Project Work Breakdown Structure

Activity Code	Activity Description	Resources	Duration(Weeks)
HS	**Harmattan Semester**		**16 weeks**
HS 1	**Project Initiation**		**2 weeks**
HS 1.0	Project Topics	DO	1 Day
HS 1.1	Discussion of Project Topic with Supervisor	OB	1 Day
HS 1.2	Discussion of project Scope of work with supervisor	OB, DO	4 Days
HS 1.3	Identification of specific project needs	OB	5 Days
HS 2	**Project Planning**		**14 weeks**
HS 2.0	Identifying and studying existing literature	OB	6 weeks
HS 2.1	Develop Project proposal (Draft)	OB	4 weeks
HS 2.2	Reconnaissance survey	OB, DO	2 weeks
HS 2.3	Carrying out Topographical surveys and Data Collection in the case study area	OB	2 weeks
HS 2.4	Review second draft of proposal with supervisor	OB, DO	2 weeks
HS 2.5	Issue final version of project proposal	OB	3 Days
RS	**Rain Semester**		**16 weeks**
RS 1	**Project Execution**		**14 weeks**
RS 1.0	Field work	OB	2 weeks
RS 1.1	Further detailed literature review	OB	3 weeks
RS 1.2	Hydrologic analysis and Hydraulic design	OB	4 weeks
RS 1.3	Cost estimate of the drainage network	OB	3 weeks
RS 1.4	Interpretation of Result	OB	1 week
RS 1.5	Review of results with Supervisor	OB	1 week
RS 2	**Project Close- out**		**2 weeks**
RS 2.0	Review final Draft of Report with Supervisor	OB, DO	1 week
RS 2.1	Print and Document Final Report	OB	5 Days
RS 2.2	Issue final Project Report	OB	1 Day

OB = Obot. B. S
DO = Dr. OG. Okeola

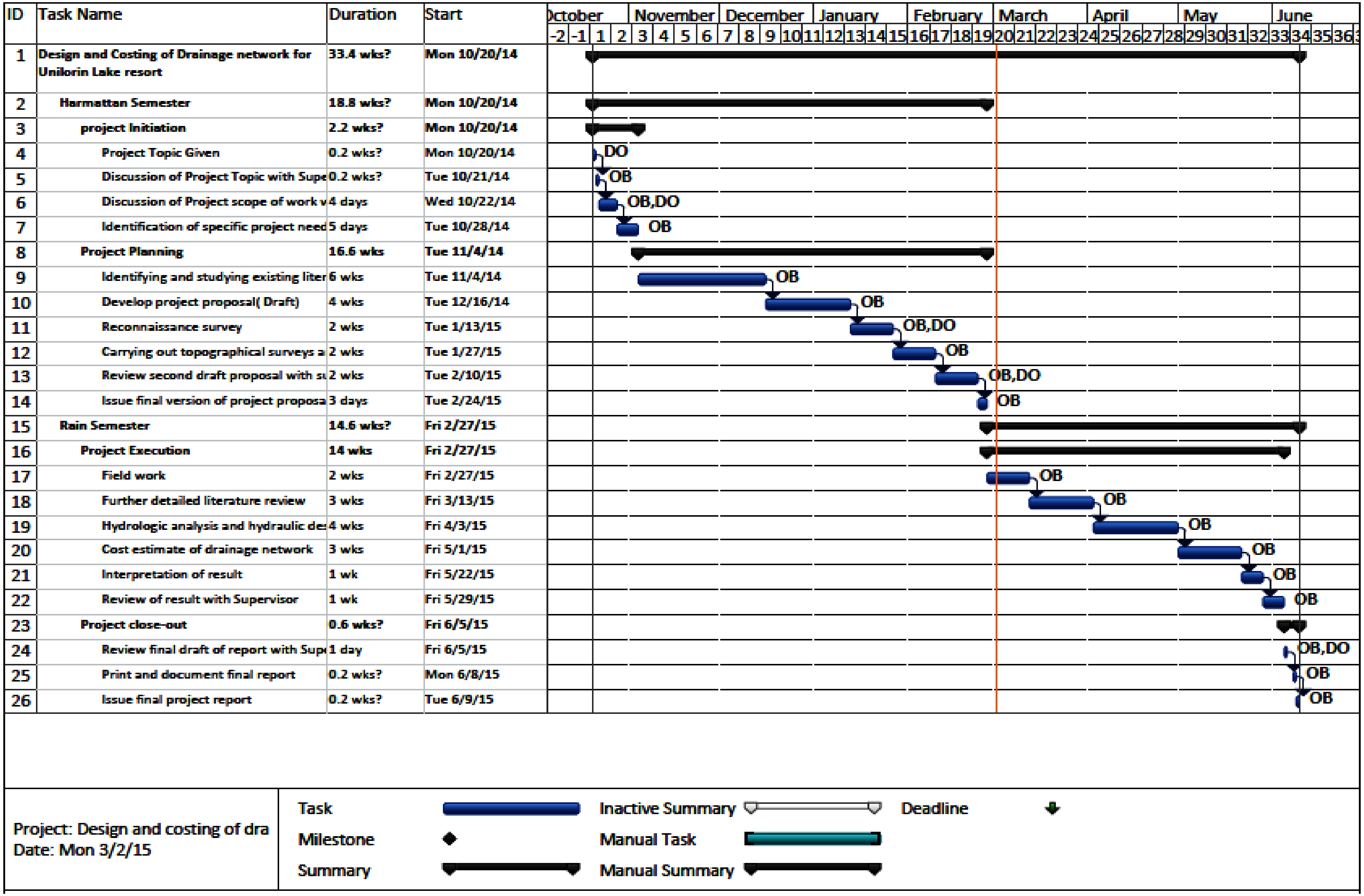

Figure 1: Gantt Chart of Project Work Breakdown Structure

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