NEEDS AND CHALLENGES IN STORMWATER DRAINAGE IN GHANA

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ABSTRACT:
The need for sustainable development in Ghana's infrastructure calls for review, from time to time, of the urban stormwater drainage philosophies and practices in Ghana. This is necessary if we are to keep pace with present global trends in that field of engineering practice. The purpose of this paper is, therefore, to present the state-of-the- art in urban stormwater drainage in Ghana and its shortcomings. An account of the needs and challenges in the current practices of stormwater drainage in the country will be presented after which the necessary recommendations will be given.

Keywords: Stormwater drainage, needs, challenges, design practices, Ghana

1. INTRODUCTION

Engineering is about innovative development, development that is sustainable and satisfies environmental, economic and social criteria (Bruce, 1992). Since urban stormwater drainage is one of the most important urban infrastructure in Ghana, it is necessary that, from time to time, the development of this infrastructure is analysed and reviewed to find out whether it meets current global developmental criteria and strategies.

In all the urban centres in Ghana, provision of the relevant infrastructure facilities has woefully lagged behind the rapid rate of housing development; unfortunately because of the low priority given stormwater drainage has become one of the most serious problems facing these urban centres today. In the midst therefore of the sprawling urban settlements exist a fragile environment characterized by erosion, flooding, silting of drains and their attendant pollution and health hazard problems.

The purpose of this paper is, therefore, to discuss the needs and challenge in the current practices of storm drainage in Ghana. Effective sanitation of any kind in Ghana requires sustainable stormwater drainage. Pit latrines, septic tanks and sewers can transmit diseases when flooded, as their contents mix with runoff an overflow into streets and homes of the urban settlement. In recognition of these and other problems, the discussion will be carried out in the light of current philosophies of sustainability in urban drainage. The paper is presented in two parts. The first part – Current Design Practices in Ghana – gives a summary of the design approach and principles in urban stormwater design in Ghana. The objectives of the design are given, followed by the hydrological and hydraulic principles commonly used in urban stormwater drainage design. The discussion ends with a short comment on the weaknesses of the current approach in the light of sustainability. The second part presents the needs and challenges of stormwater drainage in Ghana with reference to present global trends of what effective and sustainable urban stormwater drainage should be. It is hoped that engineers and planners involved in urban planning, development and management will be challenged to effect appropriate improvements by including current stormwater management objectives in their schemes.

2. CURRENT DESIGN PRACTICES IN GHANA

Effective and sustainable stormwater drainage should achieve the following objectives: hygiene, flood protection and pollution control. Analysis of the existing drainage systems the country reveals that, whereas attempts are being made to achieve the two objectives of good hygiene (collecting and transporting of water in channels), and flood protection, measures to control the pollution of the receiving waters are not addressed in the designs. This has resulted in the complete "death" of rivers and streams in the major urban settlements in Ghana.

The separate system of wastewater collection is practiced, and the procedure follows the flowchart in figure 1. Open channels are predominantly used for the collection and transport of the urban stormwater; covering of the channels or the use of buried pipes is applicable to the Central Business District (CBD's) and some selected areas (as recommended by the client).

Pumping of stormwater is not encouraged, and existing ground gradients (with slight alternations where possible) are followed as much as possible. Stormwater is finally discharged at logical points into receiving waters without any treatment. To determine the appropriate drain size, the engineer needs to estimate the design runoff and the velocity of flow; and, using this information estimates the size of the drain. The design stormwater is most commonly calculated using the Rational Formula. This is suitable for catchments up to 5km^2. The synthetic unit hydrograph methods are also used by some consultants. A design return period is chosen following a consideration of the location, cost and safety implication, and this return period is used for estimating the mean rainfall intensity of the area which will be used as input into the rainfall – runoff model.

Once the amount of stormwater and sullage flowing from the catchment area has been estimated, the capacities of the different drainage channels are determined to enable the designer to choose the best option. The Mannings'

formula is commonly used for sizing the drains. Although this formula is commonly used for steady state and uniform flow conditions it provides a reasonable estimate for calculating the stromwater velocities in the drains. The final flow velocities (the design flow velocities) are usually kept within recommended standard limits.

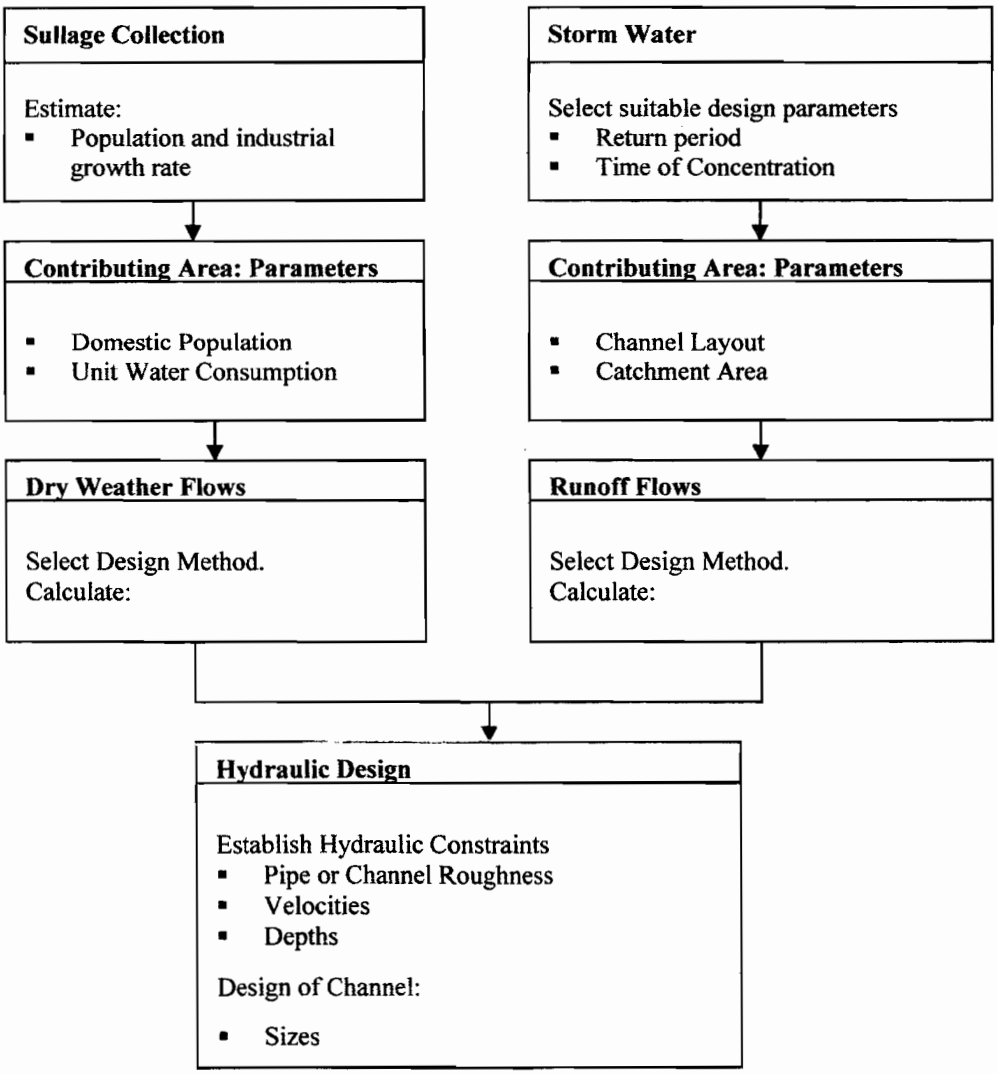
The state-of-the art in urban stromwater drainage as summarized above has many obvious weakness which call for research and improvement. These weaknesses include: abuse of the channels where the channels are open; flooding of flat areas through which the drains pass; silting of channels in flat areas; high maintenance costs; and disregard of measures to mitigate the pollution of receiving waters.

3. NEEDS AND CHALLENGES OF STORM WATER DRAINAGE IN GHANA

A lot of publicity has been given at both international and national workshops/symposia/conferences on the looming threat on the world's water resources. Emphasis has been given at such meetings on the need to embark on sustainable water use and wastewater collection, especially in the urban areas. Of particular importance to Ghana is the challenge taken up by the United Nations (UN) in the International Drinking Water Supply and Sanitation Decade (1981-1990), then by Safe Water 2000 and Health for All 2000, and now the idea to develop a Long Term Vision for Water, Life and Environment in the 21st Century or in short, the World Water Vision. In their concluding remarks Gijzen and Galvis (2002), the following observations and recommendations were made which should inspire every country to identify the needs and challenges in the water-related infrastructures: "The coming water crises as identified in the Vision Document has developed since we have burdened our water resources with bad institutions, bad governance, poor incentive schemes, and bad allocation of resources.

The crisis is caused by managing the water so badly that both people and the environment suffer, but it is not too late to act. Continuing the business as usual scenario is no option, as this will widen and deepen the crisis in the short term. The Vision Document, presented and discussed during the Second World Water Forum held in March 2000 in the Hague, the Netherlands, suggests to launch a movement to move from Vision to Action by

Figure 1. Flow Chart Showing Steps for the State-of-the-Art of Urban Drainage System



making water everybody's business".

On the local front, a private newspaper, in a GNA Feature (Azumah, 2003) gives a vivid description of the conditions of Ghana's rivers under the heading "Let's Sit Up: Our Rivers are Dying". The writer goes on to quote Alhaji Mustapha Ali Idris, Minister of Works and Housing as saying. "The celebration of this year as freshwater year is to provide Ghanaians and the world at large with the opportunity to raise awareness, promote good practices, motivate people and mobilize resources in a sustainable way".

3.1 Needs

It is generally accepted that after sewage management, stormwater is the second major urban flow of concern to the municipal engineer. Safe and efficient drainage of stormwater is particularly important to maintain public health, safety, and to protect the receiving water environment. The following needs have therefore been identified as requiring urgent attention in Ghana.

(i) Master Drainage Plans

Logically, the sewage and stormwater drainage master plans assemble all actions to be taken in an urban area under the existing and future conditions. They must define the technical requirements and layout of the systems considering the existing or proposed regulations and all institutional aspects. Unfortunately, all the urban settlements have developed without any master drainage plans. Attempts to provide such plans in Ghana started in Accra in the 1960's and recently revisited in Accra, Takoradi and Kumasi in the 1990's. The studies carried out by Watertech Consulting Engineers for Kumasi (WATERTECH, 1991) and, SNC Lavalin International Inc. in association with Twum Boafo and Partners for Accra and Sekondi-Takoradi (SNC Lavlin and Twum Boafo, 1996) can truly be described as drainage improvement studies for the existing stormwater drains. Given the rapid rate at which the regional capitals, districts capitals and commercial towns in Ghana are developing, it is very necessary that drainage master plans are prepared so that the effect of poor drainage being experienced in Accra, Kumasi, etc, can be avoided in these urban centers.

The following captions may guide the development of a Master Drainage Plan and the preparation of a study report.

- Purpose and Background of Study: Need, legal background, regulatory background (health, flooding and pollution control criteria), possible updates and regulations, institutional background.
- Identification of Drainage Related Problems: Description of drainage area (topographic and soil conditions, existing drainage facilities, landuse), extent of study area, assessment of existing conditions, planning horizon, forecast of future development (population, landuse, industrialization), expected drainage problems for the planning horizon and, intermediate development stages.
- Definition of Study Objectives: Human needs, health requirements, environmental concerns, socio-economic aspects, natural constraints, policy constraints, financial constraints, the list of attainable objectives, priorities of objectives, scope of work.
- Data for Planning: Programme for collection of field data, preliminary basic system layout, design periods for conduits and individual structures, dry weather flow quantity and quality, stormwater or combined sewage quality, infiltration inflow and unit cost.
- Methods for Planning Design: Choice of analysis procedures, procedures to be used, check for local applicability, possible comparison with field data for existing conditions, availability of input data.
- Identification and Investigation of Drainage Data: Performance of existing systems, optimization of existing facilities, non-structural measures (landuse policies, zoning, prohibition of flood plain occupancy, maintenance of streets (solid waster disposal), minimal structural alternative, open channels, surface ponding), structurally intensive alternatives (infiltration ponds, diversion structures, surface and subsurface detention facilities, pumping stations, channels), operational measures (maintenance, flow control), performance of alternatives, implementation and operational costs, screening for alternatives yielding an optimum solution with respect to technical feasibility, environmental impact, political acceptance, costs and financial reality, selection of the final drainage scheme.
- Impact of Future Drainage System: Proof that objectives are met, environmental impact, acceptance by public, control and operational requirements of the selected scheme, check of proprietary rights, other constraints and, overall financing.
- Final Design of Individual Structures: Local availability of construction materials, availability of skilled labour, layout of design of all components, specifications, for future operation and maintenance.
- Implementation: Stages of implementations, time frame, financing of the individual stages, indications that objectives are met at the individual stages of implementations, interim benefits for the urban population and schedules and requirements for planning updates.

Naturally, not all of the subjects listed apply to every study. On the other hand, special problems encountered may require some additional considerations not listed. It is important that maps and construction drawings are prepared and incorporated in the report. Major calculations must be attached as appendices. Besides the Detailed Report with all technical and financial aspects, Executive Summaries should be prepared for politicians

and the information of the public. Preparation and training for control, operation, and maintenance of the planned system are vital for the success of the overall effort.

(ii) Collection, Analysis and Use of Urban Stormwater Data

Rising project complexity, increasing potentials for investments, continually changing design standards, more extensive land-use planning and more stringent environmental requirements, etc, are all resulting in an ever-increasing need for more field data. Many government organizations are essentially on their own doing their own thing in the acquisition of local urban stormwater data. Documentation of methodology for acquiring and analyzing urban stormwater data is scattered throughout the literature in the government organizations and consultant's reports. Guidelines for developing a complete "Urban Stormwater Data Collection Package" are not presently available. It is recommended that urgent action be taken to effect the collection, analysis, and use of Urban Stormwater Data in Ghana.

Given the level of the state-of- the art of urban stormwater drainage practices in Ghana, the following areas of research needs are recommended for immediate action.

- Review of the present intensity-duration-frequency relationship developed by the Ghana Meteorological Service in 1975 (J.B. Dankwah, 1975). More stations and data from 1976 to date are to be included;
- Development of alternatives to intensity-duration-frequency relationships;
- Review and improve the existing hydrometeological data collection network, including urban stream/ river flow monitoring/water quality monitoring;
- An improved data collection programme, including education for those who will be doing the collection;
- Since rainfall is the most important input to the rainfall-runoff models, more research is recommended on the temporal and spatial rainfall distribution and their statistical properties;
- Development of an urban stormwater database;
- International co-operation and technology transfer;
- More information on sediment/pollutant relationships – especially organics and metals;
- Transferability of information to ungauged/ unsampled catchments;
- Impact of urban stormwater on receiving waters.

3.2 Effective Maintenance Strategies

It is common knowledge that in developing countries, such as Ghana, cleaning and maintenance of stormwater drains is performed when problems arise, for example, when flooding is caused by blocked drains and culverts. There is usually no scheme for preventive maintenance nor for regular inspection of the drainage system. When funds are made available, the emphasis is on construction of new drains rather than on maintenance operations. The management of urban stormwater projects is not complete without an efficient maintenance unit. It is therefore recommended that an appropriate Urban Drainage Monitoring and Maintenance Unit be included in any Municipal Engineering Operations Maintenance Department.

3.3 Integrated Urban Flood Management

Flooding has become an annual occurrence in many urban settlements in Ghana. The current solutions generally involve the construction of hydraulic structures to improve conveyance. Experiences from urban settlements in the developed countries do reveal that the inclusion of non-engineering and source control measures are very effective in flood mitigation. They are very important components of an Integrated Urban Flood Management. These measures include such activities as: good land-use planning which identifies and plans flood prone area for development, public education, flood warning, institutional and legal measures, insurance schemes, etc. Source control measures include all activities which are designed to reduce flood peaks, that is infiltration, upstream impoundments, diversion etc.

It is recommended that appropriate research needs are identified for these non-engineering and source control measures, especially with relevance to their suitability to the various urban settlements.

3.4 Public Awareness Education

Lack of knowledge of the consequences of dumping both solid and liquid wastes in drains and natural water courses, and the building of houses in flood-prone areas in our urban settlements are issues which have to be tackled seriously. This will require the inclusion of pollution control lessons in the primary and secondary school curricula throughout the country. Education of the general public on pollution and abuse of drains will have to be organized by the various Metropolitan and District Assemblies for the various urban centres. On the issue of development within the flood prone areas, a more rational criteria – based on hydrological studies – should replace the current rule of thumb used by urban physical planners in mapping out flood prone and green belt areas. Relevant hydrological studies should be included in the syllabuses for planners at the tertiary institutions.

4. CHALLENGES

Business as usual scenarios in urban drainage started giving way to more suitable methods in the developed countries since the 1980's. This was not without a lot of political courage and financial commitment. For example, the UK had to yield to the stringent pollution regulations set by the European Union when she joined the it. Huge investment in coastal wastewater disposal schemes

was carried out in response. For example, in the south-west of England, the "clean sweep" programme was developed to improve the sea water quality at eighty – one beaches and surroundings. This was based on thirty-two engineering schemes valued at £900 million (Brokenshire, 1995).

If Ghana is to attain the middle-income status in 2025, there must necessarily be changes in the design concepts of our infrastructure to merit that status. The current philosophy of seeing stormwater drainage as the removal of water from surfaces especially roads, housing estates, commercial centres, as quickly as possible and disposing of it via drainage channels to the nearest water course has to change. Environmental and social issues have to be factored into the new concepts. The challenges are surely enormous! These include the following:

4.1 The Rapidly Growing Urban Population

Despite the government's efforts to check the rural-urban drift, the urban population has grown from 30% to 45% of the total population of Ghana between the last two national censuses. This phenomenon has the tendency to force the urban poor to settle and develop their dwelling places in flood-prone areas. The abuse of drains also increases.

4.2 Inadequate Drainage System in the Urban Areas

It has already been stated that the development of houses precede the provision of drainage infrastructure in most urban areas in Ghana. Rapid urbanization will further increase the lag between the housing development and the provision of the infrastructure. Another related problem is the fact even where drainage channels exist that the some of the urban houses are not connected to the existing drainage network. This is evident in Accra and Kumasi where attempts have been made to provide some basic network in some parts of the cities.

4.3 Lack of Funding

Providing an efficient stormwater drainage system to Ghana's urban settlements occupied by people with limited financial resources is an enormous challenge. This challenge has to be taken up by the government. The greatest need can be found in the peri-urban areas and slums. These are rarely given services prior to their establishment and subsequent provision places severe financial strain on already over-stretched government resources.

4.4 Political Will

The past years have experienced instances where compromised decisions have been taken for political expedi ency, but to the detriment of environment sanity. The flouting of approved land-use regulation such as building or settling in flood-prone areas are common news items in the print and electronic media. The government that is determined to bring sanity to the urban areas in Ghana will need enormous political courage.

4.5 Bringing to "life" the Urban "dead" Rivers

Rivers such as the Odaw River in Accra, the Suben in Kumasi are at present environmentally dead water-courses. These have to be cleaned up if they are to be restored to fresh water rivers. Sources of pollution along all such rivers have to be identified, monitored on continuous basis, and effluents discharged into them treated to accepted standards. This will call for a lot of resources ; both human and financial.

5. CONCLUSION

Sustainable development is the new philosophy, and this has been on the world agenda since the 1987 World Commission on the Environment. So, while a prime purpose of drainage is still to protect people and property from stormwater, attention is now being paid not only to the surface being drained but also to the impact of the drained flow on the receiving water environment. Attempts have therefore been made in this study to analyse the existing conditions in Ghana and followed with the important needs and challenges in stormwater drainage which have to be addressed if the nation has to fit into the new trend of global development in stormwater drainage. It is therefore recommended that policies and research activities be formulated and implemented by appropriate government and professional institutions in the country so as to provide data and revised design standards needed to up-date the present scenario in stormwater drainage design in Ghana.

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