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**WATER RESOURCES ENGINEERING**

**INTRODUCTION**

The study and use of equipment, facilities, and strategies used to govern and conserve water resources are known as water resources engineering. Water resources refer to the amount, quality, and fluctuation of groundwater and surface waters. Water resource engineers may plan, design, procure, build, manage, and run facilities to meet the frequently conflicting requirements of residential consumers, industry, agriculture, and navigation by understanding the natural dynamics of the hydrological cycle. Engineers are also in charge of ensuring that water is returned to the natural surroundings sustainably. Water resource engineers counsel on ecological sustainability through saving water, constructing dams, and transporting water to consumers in a larger sense. Their planning ensures that water is managed holistically and integrated, balancing the needs of nature and those of people.

**Future Career Potential of Water Resources Engineers**

Water resource engineers with more experience can work as consultants or advance to senior positions in water firms, legislative bodies, and other organizations. Whereas the engineering features of significant water facilities investments may garner the most attention, they must be supported by well-thought-out and expressed long-term plans and strategies that can withstand public scrutiny and dispute.

**Water Interaction and Balance**

Humans, animals, vegetation, and fauna cannot survive on the planet without water. Water consumption is growing each day, and the only reliable source of high-quality water is precipitation, which is relatively steady. The primary requirement is freshwater conservation, which necessitates significant research efforts in this area. The development, planning, and implementation of designs to maximize the use of the water to avoid harm from too much water are all required to manage or control water resources.

Water resources management is a specialized field. Water supply and use for municipal, manufacturing, and agricultural purposes, water quality in streams erosion and sedimentation, preservation of ecosystems, recreation, transportation, hydroelectric power production, rainwater drainage, and flood disaster mitigation are covered by engineering. People, natural wealth, and built infrastructure all play a role in water resources engineering. Water resources engineers develop and execute resource management plans and plan, develop, create, and manage structures and facilities to satisfy society's water-related demands.

**Water Resources Engineering in the Future**

Water is significantly more critical to modern civilization than previous civilizations. Today's hygiene requirements necessitate far more water than they did a century ago. The growing population needs more agricultural land, which must be obtained by surface drainage or irrigation. More focus on stormwater, water supply, and sewage is required as urban populations grow. Water is being used more and more in industrial systems and in electricity production as technology advances.

Engineers working in water resources in the future will be heavily involved with new technologies and concepts. In all sectors of water usage, wastewater reclamation, weather manipulation, land management to increase water output, and innovative water-saving measures are growing interest and research. A growing global population is altering ecological patterns in several ways, and water management must include an assessment of strategies to reduce unfavorable effects.

**The Hydrological Cycle**



This cycle is a natural mechanism that transports water from reservoirs and seas towards the atmosphere, into the land surface, and finally to the dams and oceans. Water takes on the forms of a liquid, a solid, and a gas at various points of the transportation cycle. Water, liquid in dams and seas, evaporates and transforms into a gaseous state to produce clouds; the water eventually precipitates in liquid from rain and solid snow and hail. Most of this precipitation makes its way to the streams via runoff, a surface, and sub-surface flow. The dynamic characteristics of water are involved in this water flow process in a hydrologic cycle. The figure below shows the hydrological cycle;

**Global Availability of Water**

The hydrological cycle produces a set amount of water every period on average; human actions cannot considerably modify this total quantity. 97% of the world's water is ocean water, while only 3% is freshwater. Eighty-seven percent of freshwater is inaccessible, whereas only 13 percent is (0.4 percent of total) is accessible. Human garbage is dumped in waterways at a rate of 2 million tonnes every day.

**Hydraulic Infrastructure, Social and Economic Aspects**

Resource insecurity is rooted in temporal and geographical variability, exacerbated by uncertainty and climate change, leading to vulnerabilities and a negative influence on economic growth. The issue is to build an environment that encourages investment in water infrastructure to prevent floods, provide water storage capacity for flow management, and make water available for productive use to offset the US climate's temporal and geographical unpredictability.

If there is infinite cash, there is no need for much ability to construct a structure for a particular purpose. The engineer's specific talent is evident in developing projects that achieve their original goal at a cost that is proportional to the benefits. Most projects need an economic study to decide which of numerous options the best is. Engineers working on future projects are unsure if the forces used to build structures may be surpassed. To reduce the likelihood of failure, which might increase the project's cost, generous safety factors are utilized.

**Water supply sources**

Groundwater and Surface water are the two primary sources of water. Geography, human activities, and climate all impact their quantity and quality. In most cases, groundwater may be utilized with minimal or no treatment. Surface water frequently needs significant treatment, significantly if it is contaminated;

**Surface Water**

Because of the significant withdrawal rates that rivers and lakes can generally tolerate, they are significant sources of water supply. Pollution of any form can enter surface waterways. Municipal and industrial wastewater wastes, runoff from agricultural and urban regions, and soil erosion in river catchments contribute to contamination.

**Surface Water Storage**

During low flows, a water system, farming, or hydroelectric power plant that draws water straight from a river may be unable to meet the needs of its customers. During high flow seasons, extra water can be stored in a storage or preservation reservoir for use during droughts. Floodwater storage may prevent flood impacts below the reservoir and store water for later use. However, the main challenge facing storage reservoirs is sedimentation, and this can be prevented by;

* Designing a portion of the dam capacity for sediment storage.
* Choosing a point on the river where the sediment flow is low for the reservoir.
* Utilizing soil conservation methods in the drainage basins such as contour plowing and terracing.
* Providing ways of discharge of sediments, for instance, sluice gates.

**Measurement Streamflow**

Measurement of streamflow is critical for water resource evaluation and hydrologic balance research. The velocity area technique and dilution gauging are the two main types of streamflow measurement;

**The velocity area technique**

The velocity area technique involves

* measuring or estimating the average velocity (V) of flow through a river cross-section and measuring the cross-sectional area,
* computing the discharge as q = V A, or
* Utilizing the equation of continuity.

The size of a cross-section can be determined relatively quickly, but measuring velocity is more complicated. A gauging site is chosen to measure the velocity, and the water level heights are physically or via an autographic liquid level recorder monitored. The discharge is connected to the measuring heights (also called stage). A current meter floats, and other devices can determine velocity.

**Dilution Gauging Method**

A tracer solution is introduced into the channel, and the fluid is sampled at one point downstream when the turbulence has uniformly mixed the tracer. The concentration difference between the injected solution and the sampling station is used to calculate discharge. A chemical tracer, a fluorescent tracer (dye), or a radioactive tracer are all required for this procedure. The tracer should be thoroughly mixed in the stream water, and authorization to inject tracer entering rivers is required for environmental reasons.

**Ground Water**

This refers to water seeped down through the soil pores from the ground surface. It is extensively spread beneath the ground and, unlike other earth resources, is a resource that can be regenerated. Because groundwater is unseen, it is difficult to investigate and harness. Although groundwater is less vulnerable to contamination than surface water, rehabilitation is complex and time-consuming once polluted. The filtering function of soil particles removes the most harmful organisms and many unwanted chemicals.

Groundwater reservoirs are soil and rock formations that have been saturated with water. Water-bearing formations come in various shapes and sizes; an aquifer is a water-bearing geological structure capable of transferring water through the pores at a pace suitable for good extraction. Aquiclude is a geological feature capable of absorbing water and not transporting large volumes of it. An aquifuge is a geological structure that lacks linked pores and cannot absorb or transport water. An aquitard is a geological structure with a somewhat impermeable character that transports water at a slower rate than an aquifer (inadequate for pumping from wells). The diagram below shows the occurrence of groundwater;



**INTEGRATED WATER RESOURCES MANAGEMENT (IWRM)**

IWRM refers to a method for coordinating the growth and water management, land, and associated resources to optimize the resulting economic and social benefit equitably without jeopardizing the long-term viability of critical ecosystems.

Water resource thinking in the future must be done from water resource sustainability. Water resources sustainability refers to the capacity to utilize water insufficient quality and amount from the community to the worldwide scale to address the requirements of and people ecosystems for the coming generations to sustain life and protect people from the harm incurred by natural or human catastrophes that affect sustaining life.

**Factors Affecting Water Resources Sustainability**

* **Urbanization;**Urbanization causes declining water quality due to washing accumulated contaminants from impervious surfaces into local rivers.
* **Floods and Droughts.**
* **Climate Change.**

The old system's failure necessitated the adoption of Integrated Water Resource Management. The old system of water management had the following characteristics;

* It was primarily sectoral management techniques, in which each sector was controlled independently.
* The top-down approach was commonly used.
* Supply management dominated the water resource industry.
* Gender disparity- water governance was dominated by males.

In Integrated Water Resources management, different water uses are interdependent, are considered together, and the management involves a systematic process.

**Reasons Why Integrated Water Resources Management is needed**

* Population expansion, economic activity, and rising competition for water among consumers strain water supplies.
* Water withdrawals have grown at a rate greater than twice as fast as the population increase.
* Concerns about climate unpredictability and change necessitate better water resource management to cope with more severe floods and droughts.

**Principles of Integrated Water Resources Management**

 These principles were arrived at in a conference on water and environment in Dublin in January 1992;

* Freshwater is a limited and sensitive resource necessary for life, development, and environmental sustainability.
* Water management and development should be done in a specific manner, with users, planners, and makers of policies involved at all levels.
* Water development should be done in a participatory manner, with users, planners, and policymakers involved at all levels. Water provision, management, and conservation are all dominated by women.
* Water has a monetary worth in all of its competing applications, and it should be treated as such.

**Implementing Integrated Water Resources Management**

It is done using the following tools;

**(a) Enabling Environment;**Policies to establish goals for water consumption, protection, and conservation should be established by policies, a legislative framework to change water policies into law, and finances to allot financial resources to fulfill the water demand.

**(b) Institutional Framework;**Organizational framework for managing water resources and enhancing institutional capacity (human resources).

(c)  **Management Instruments;**Assessment of Water Resourcesto resolve disagreements and ensure equitable distribution of water benefits, management, and exchange of information to share knowledge for improved water management.

**Barriers that Hinder Implementation of** **Integrated Water Resources Management**

* Lack of awareness - The most significant barrier to change is a lack of knowledge among all water users.
* Lack of political commitment - Another significant impediment is a lack of political own will challenge established interests. The interests that win out are not always the most important ones.
* Inadequate financial and human resources - Inadequate resources prevent integrated water resource management from being included in planning and development.

**Water Management Legal and Organizational Framework**

The legislative and administrative framework for water management in the United States is evaluated in this section. The scope of federal water resource jurisdiction; the development of fragmented national regulations; the administration of freshwater resource legislation; central authority over natural water resources; underground water laws; regulatory hurdles to water governance; federal involvement in the management of water resources; and a strategic plan to address significant risks to water resources are among the topics covered.

**Aspects of Engineering and Planning With IWRM**

Planning is described as the systematic examination of a project from its inception through the appraisal of options to the ultimate choice on the course of action. The examination of options using engineering economic concepts is part of planning. Planning and management efforts for water resources have the goal of determining:

* How to manage and use finite renewable resources.
* Managing finite renewable resources in an environment with increasing demands and uncertain supplies.

**The Need for Management and Planning**

* The severity of droughts, floods, and excessive pollution's negative implications.
* River training and floodplain reclamation for industrial and urban development have harmed aquatic and riparian systems.
* Deeper rivers are required for port development; limiting the river for transport will raise the flood level.
* Due to low water quality, sediment has accumulated in the reservoir.

The interplay of three interconnected subsystems is required for water resource planning and management:

1. Physical, chemical, and biological processes occur in the natural river subsystem.

2. Socioeconomic subsystem: Human activities include utilizing natural river systems.

3. National governance subsystem: Governance, legislation, and regulation, which governs decision-making, planning, and management.

**Watershed Management/Planning**

Watershed planning refers to directing and coordinating land and various resource usage on a watershed to provide the desired goods and services while minimizing negative impacts on soil and water resources. Watershed planning allows for diversity between localities, promotes accountability and efficiency in management, and allows for the coordination of different sectors in a watershed.

**The procedure of Implementing and Evaluating a New Project in a Watershed**

* **Site selection;**choosing two or more watersheds for experimentation.
* **Calibration;**establishing relationships between watersheds based on their outputs.
* **Watershed treatments;**all watersheds except the control watershed are put under various treatments.
* **Measurement of results;**measuring the parameters again on the treated and control watersheds and making a comparison of the results.
* **Evaluation of results;**doing a regression analysis on both the post-treatment and calibrated data and plotting them together for comparison to establish the effects of treatments.

**Pitfalls in Project Management/Planning**

* **The preliminary report's** implementation is based on short-cuts and approximations, which should not be the case.
* **Agency standards;**a number of the standards are not appropriate due to changing technology.
* **Early construction;**if construction is done before the required time, it may lead to waste.
* **Use of market prices;**these prices are not a satisfactory method for calculating benefits.

**Conjugative Utilization of Groundwater and Surface Water**

* The low flows during the dry season can be boosted by groundwater.
* Excess runoff can be utilized for groundwater recharge.
* Waterlogging and Irrigation; wells can be dug to prevent waterlogging and raised to be used again in Irrigation.

**FLOODS**

Caused by melting snow, high amounts of rainfall, melting snow combined with heavy rain, tsunamis, and obstructing glaciers. Rainfall factors such as duration, intensity, moving storm, and storm distribution affect the flow of floods. Also, catchment characteristics such as area, shape, and slope of the catchment also influence flood flow.

**Mitigation Methods of Flood Damage**

* Reducing the peak flow by the use of reservoirs.
* Confining the flow within channels, for instance, by using closed conduits and levees.
* Reducing river peak elevations by increasing river velocities through channel improvements.
* Reducing the runoff of floods by land conservation and management.
* Managing floods in the plains.'

**CONCLUSION**

In summary, water resource engineering is essential because water is an essential commodity necessary to support life. Water resource engineers organize, design, procure, build, manage, and run facilities to meet human and industrial water requirements. Therefore, the water resource engineering field has excellent future potential globally. The water circulates in nature through the hydrological cycle. Water sources are divided into surface and groundwater sources. The old system of managing water resources had many drawbacks, which led to the adoption of Integrated Water Resources Management (IWRM), whose principles were formulated in Dublin in January 1992. IWRM is implemented using IWRM tools. Sometimes, excess surface runoff may be out of control leading to floods which have to be controlled to flood their damaging effects.

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