HYDROLOGY

QUALITY THROUGH INNOVATION AND DESIGN

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Energy, Water, Environment.
Global Sustainable Solutions.

03 Hydrology

The term Hydrology, is the scientific discipline concerned with the waters of the Earth including their occurrence, distribution, and circulation via the hydrologic cycle. Hydrology has as its primary objective the study of the interrelationship between water and its environment. Hydrology Science is also fundamental for application in Flash Flood Early Warning Systems (EWS).

As hydrology is mainly concerned with water close to the land surface, it focuses on those components of the hydrologic cycle that occur there, that is: precipitation, runoff, river discharge and the related water level and water velocity in the rivers, as well as the evapotranspiration, and groundwater.

The measurement of all these hydrological parameters is the primary objective of the ENEA Grupo HydroMET System. The different parameters are measured using specific sensors for determining the precipitation, runoff, river discharge, water level, water velocity, water currents, etc. all of them connected to our METEODATA/HYDRODATA -2000/3000 Remote low power Data Acquisition and Transmission Unit. Data transmission can be carried out via GPRS/3G cellular network, by Point-to-Point / Point-to-Multipoint Radio-Link or via Satellite, as well as mixing these communication ways.

Due to the very low power consumption of ENEA Grupo®'s solutions, our automatic hydrological stations can be installed at remote unattended sites, operated by its internal battery pack and charger, all under a compact mount in a weatherproof enclosure box, plus an external solar panel of reduced dimensions.

River discharge & level in Real-Time – HydroMET System

River discharge at any given point is the volume of water flowing through a river channel and is normally measured in cubic meters per second.

ENEA Grupo® offers specific solutions for the continuous measurement of the river discharge (water flow) and level, with data transmission in real-time.

Water level sensors of different technologies such as: Non-contact RADAR, Ultrasonic, Hydrostatic, Bubbler-in, etc. can be connected to our HYDRODATA data logger for continuous measurement of river level, storing all the level data in its internal memory.

HYDRODATA unit also allows the connection of RADAR Doppler water surface velocity meters, storing velocity data in its internal memory. In base of the averaged data of water level and surface velocity in programmable periods of time, it is possible to calculate the flow rate of the river in real-time by an equation adjusted for any specific moistened cross-sectional area of the river.

How the RADAR Doppler Velocity System Works

The flow velocity is measured using the Doppler effect. A radar signal with a frequency of 24 GHz is transmitted towards the water surface. The signal is partially reflected with a frequency change due to Doppler effect when water is moving. A spectral analysis is performed on the reflected signal and the water's surface velocity "Vs" is calculated. The radar signal has to be transmitted at an angle to the water surface. This angle is internally measured to automatically correct the calculated velocity.

How the river discharge is calculated

A commonly applied methodology for measuring, and estimating, the discharge of a river is based on a simplified form of the continuity equation. The equation implies that for any incompressible fluid, such as liquid water, the discharge (Q) is equal to the product of the stream's cross-sectional area (S) and its mean velocity (Vm).

So, the discharge "Q" is determined by the continuity equation:

Q = Vm • S

The moistened cross-sectional area "S" as a function of the water level (S=f(l)), is determined by the crosssectional profile at the measuring point.

The RADAR system does not measure the mean velocity "Vm" but the surface velocity "Vs", that is, the mean velocity is calculated with the conversion factor "k" , as:

Vm = Vs • "k"

So according to the continuity equation: **River Discharge: Q = Vs • "k" • S**

The k-factor can either be determined by a reference measurement, for instance by means of one Acoustic Doppler Current Profiler (ADCP) or by specific modelling. The surface level, the k-factor and the cross-sectional area are stored on the HYDRODATA unit, enabling it to calculate and output the discharge directly from the measured surface velocity of water and its level in real-time.

River Discharge in connection with Early Flood Alert Systems

It is important to mention that the river discharge measurement in real-time is a fundamental input for ENEA Grupo® Rain Alert System and Early Warning System (EWS), in combination with the implementation of a suitable rainfall network which must be installed upstream in the drainage basin.

This allows knowing in advance the corresponding rainfall intensity and duration to determine the volume of total rainfall in the basin during a certain period of time when the objective is to establish flood risk warning conditions to alert the population.

However, the prediction of the level of the river, not only depends on the intensity and amount of rainfall, but there are many other factors to be taken into account to adjust a predictive model for flood risk. Evapotranspiration and storage factors are well known, but also other factors affecting a river's discharge are indicated below:

• Rock and soil type (permeable or not rock and soils)

• Land use (urban or rural areas, vegetation cover, deforestation, ground saturation and surface run-off)

• Rainfall (type and intensity or accumulated)

• Relief (Steep slopes mean that rainwater is likely to run straight over the surface before it can infiltrate.

• Weather and Climate conditions (hot dry weather, evaporation, frozen ground)

Measurement of River discharge by means of Acoustic Doppler Current Profilers (ADCPs)

In recent years, advances in technology have allowed to make discharge measurements by use of an Acoustic Doppler Current Profiler (ADCP). An ADCP uses the principles of the Doppler Effect to measure the velocity of water in the whole cross-sectional area, but this procedure for measuring flow of a river is performed at a given moment, and consequently this is a single measurement, which does not allow obtaining continuous and real-time river discharge data.

In this method, the whole stream cross-section of the river is measured by means of a bottom tracking acoustic procedure and divided into numerous vertical subsections. In each subsection, its area "s" is pre-defined and its associated mean velocity calculated. The discharge in each subsection is computed by multiplying the subsection area by the measured individual velocities. The total discharge is then computed by integrating the discharge of all subsections of the whole cross-section of the river.

To make a discharge measurement, the ADCP is mounted onto a boat or into a small watercraft with its acoustic beams directed into the water from the water surface. The ADCP is then guided across the surface of the river to obtain measurements of velocity and depth across the channel.

The river-bottom tracking capability of the ADCP acoustic beams or a Global Positioning System (GPS) is used to track the progress of the ADCP across the channel and provide channel-width measurements. Using the depth and width measurements for calculating the area and the velocity measurements, the discharge is computed by the ADCP using also the equation $Q = V \times S$, similar to the conventional current-meter method.

Horizontal water velocity profilers (H-ADCPs)

The ADCP is also available in a horizontal version (H-ADCP) and in this case can be connected to our HYDRODATA data logger for real time measurements and data transmission.

The compact H-ADCP is a two-beam, horizontally oriented ADCP designed to obtain high accuracy velocity data at ranges up to 300 meters, utilizing 1 to 128 cells of data. Connected to our HYDRODATA Logger/Transmitter it allows to obtain unmatched data quality, even in low velocities and complex flows, where a single cell cannot provide enough information.

In connection to our HYDRODATA unit, our solution is ideally suited for use in rivers, streams, estuaries, open channels, sea ports and harbours for real-time measurements with data transmission via GPRS/3G, Radio Link, INMARSAT Satellite or connected to an existing fiber optic line available in the port..