



A STUDY ON THE SIGNIFICANCE OF HYDROLOGY AND ITS APPLICATIONS

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Abstract

Water resources cannot be managed, unless we know where they are, in what quantity and quality, and how variable they are likely to be in the foreseeable future. Data from hydrological networks are used by public and private sectors for a variety of different applications. This paper discusses the value proposition behind the collection, analysis and use of hydrological data in support of these applications. The need for hydrological data and the requirements for the data are outlined, and information is provided on topics such as status of networks and data access and sharing. This paper outlines elements of the contribution by the World Meteorological Organization (WMO) to hydrological data collection and covers aspects related to quality management in the collection of hydrological data, especially regarding stream flow gauging, network design and capacity building for services delivery. It should be noted that the applications which make use of hydrological data may also be significantly impacted by climate change.

Keywords: Ground water, geo-electrical, Vertical Electrical Soundings



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INTRODUCTION

One of the essential elements of life on this planet is freshwater. Sustainable development therefore demands sustainable management of the world's limited freshwater resources. The Integrated Water Resources Management (IWRM) approach is a more holistic approach to water management aimed at the efficient, equitable and sustainable development and management of the world's limited water resources and for coping with conflicting demands. In implementing IWRM, water resources management institutions and professionals deal with a highly variable environment, in terms of, inter alia, weather, climate, land use and natural vegetation. They must be aware of and manage the response of a particular water regime to climatic and human interventions on hydrological regimes and water courses, including land-use changes, changes in water-use patterns, as well as the construction and management of dams and embankments, and changes in the freshwater–ocean interfaces, amongst others. Water managers have developed a range of standard methods to assess and manage water-related risks. Functioning water observation networks, producing fit-for-purpose data and information, and sharing of the data and information with all stakeholders

are therefore essential for informed decision-making for water management and minimizing uncertainties (WMO 2009).

However, water resources cannot be properly managed unless we know where they are, in what quantity and quality, and how variable they are likely to be in the foreseeable future. Data from hydrological networks are used by public and private sectors for a variety of applications, including, inter alia, planning, designing, operating and maintaining multipurpose water management systems; the preparation and distribution of flood forecasts and warnings aimed at protecting lives and property; the design of spillways, highways, bridges and culverts; flood plain mapping; determining and monitoring environmental or ecological flows; managing water rights and trans boundary water issues; education and research; protecting water quality and regulating pollutant discharges (USGS 2006).

The data quality required for a specific purpose will depend to a significant degree on the requirements of the above application areas and it needs to be recognized that not all data is fit-for purpose in all application areas. For example, where there is a safety of life issue, greater confidence is required in the quality and accuracy of the data.

The resistivity of the aquifer between 30 m to 140 m showed the increasing value, which indicated the existence of fresh groundwater. The groundwater after 140 m to 200 m possesses marginally good quality having larger TDS values than the upper zone. Surface geophysical methods can be used to assess soil and rock properties and for the non-destructive testing of man-made structures. They are also frequently used for archaeological investigations. Geophysical methods can be used for Geotechnical forensics in which the cause of a structural failure is investigated.

To improve the precision of the gate openings, the original position controllers were overridden by software. The main idea behind this decision was to tune the controllers as much as possible and to incorporate practical knowledge in the control law. The servos were operated at constant speeds and the controllers were forced to follow the following simple orders: open gate, off, close gate.

Using these orders, it was possible to implement the following simple position control algorithm: This algorithm should be executed repeatedly at fast rate in order to obtain good results; in this case the repetitions were performed every 0.1 s. The objective of the algorithm is to move a gate until reaching an acceptable positioning error. Then, it switches the servomotor off. The reason to stop a gate before reaching a set point, is that the inertial forces make a gate to move farther than the switch off point. Thus, it is necessary to make approximately equal to the inertial effect in order to get a gate position close to a set point.

RESEARCH METHODOLOGY

Storage yield

Although there are no formal guidelines for the minimum period of record, reasonable stability with respect to yield analyses is generally reached with a record length of 10 to 20 times the critical period. Where little variability in stream flow occurs and where the need is mainly for seasonal storage (less than one year), a minimum record period of 10 to 20 years may be acceptable. However, in semi-arid to arid areas, over-year storage is generally required as critical periods of 5 to 10 years and longer is common.

A record length of 50 to 100 years should preferably be used in such cases. Even where reasonably long stream flow records exist, worse floods and worse droughts than those historically observed are bound to occur in future. It is also virtually certain that the exact configuration of a stream flow sequence, as recorded in the past, will never be exactly repeated in future. However, it is evident that the longer the period of record on which the inflow sequence is based, the more reliable the estimation of the yield is likely to be.

Design rainfalls

Sevruk and Geiger (2011) argue that for extreme precipitation frequency analysis a 25-year period of record may be sufficient in humid regions such as the northern Russian Federation, but even a 50-year period is not adequate in other regions where a distinct periodic fluctuation of precipitation exists. According to these authors, a record of 40 to 50 years is, in general, satisfactory for extreme precipitation frequency analysis.

Benefit–cost ratios

There have been many studies in the past that have shown the high benefit–cost ratios associated with the use of hydrological data and this paper will not go further into that topic. Suffice to say that the value of hydrological time series records increases over time. For example, stream gauges with a long period of record are particularly valuable as they form a baseline for information about future changes. It is also important that, in the future, both the number of users and the ways in which the data are being used will increase, and the information's value will increase accordingly.

INSTRUMENTATION TECHNIQUES

Measures like soil and water conservation (especially bunds), drainage line treatments such as check dams, tree planting may aim to reduce the runoff and increase percolation. A watershed may be as small as a flower bud or a parking lot or as large as hundreds of thousands of square kilometers as exemplified by the Mississippi River basin. Watershed models are fundamental to water resources assessment, development and management. They

are, for example, used to analyze the quantity and quality of stream flow, reservoir system operations, groundwater development and protection, surface water and groundwater conjunctive use management, water distribution systems, water use, and a range of water resources management activities. There were also attempts to quantify other abstractions, such as interception, depression storage, and detention storage.

With the start of a new millennium, human race has to face environmental challenges greater in magnitude than ever before because the scale of the problem is shifting from local to regional and to global ones. Indeed, the footprint of human activity continues to expand to the point that it is exerting a major effect on nearly all of the Earth's systems.

Global environmental problems such as global climate change, threat of biological and chemical warfare and terrorism and unsustainable development in many parts of the world have become the significant issues for the future of the planet and of mankind. During the past decades, more and more of the complex environmental challenges have been addressed by using a watershed approach.

According to the U.S. Environmental Protection Agency (EPA), environmental management using a watershed approach constitutes "a coordinating framework for environmental management that focuses public and private sector efforts to address the highest priority problems within the hydrologically defined geographic areas". The highly complex nature of human and natural systems, the ability to understand them and project future conditions using the watershed approach have increasingly taken a geographic dimension.

Geographic Information Systems (GIS) technology has played critical roles in all aspects of watershed management from assessing watershed conditions through modeling impacts of human activities on water quality and to visualizing the impacts of alternative management scenarios. The field and science of GIS have been transformed over the last two decades. Increasingly, researchers, resource planners and policy makers have realized the power of GIS and its unique ability to enhance watershed management.

DATA ANALYSIS

Reliable hydrological data and information are key inputs to the sound and wise management of water resources. Particularly under the changing paradigm of Integrated Water Resources Management, where decisions are increasingly being made through a consensual approach including relevant stakeholders, it is imperative that reliable data and information be accessible in a timely manner to facilitate informed decision making. The value of such data and information increases when they are provided through organization(s) that value and adhere to quality management principles.

Decisions in various sectors of the economy are becoming increasingly dependent on hydrological information. Depending on a particular country's circumstances it is possible that various agencies may be involved in hydrological data collection within a basin. Lack of standard procedures of obtaining measurements, storage of data, data manipulations, and protocols for data and metadata exchange, as well as acceptable analytical methodologies for transferring data into information, may often result in the generation of conflicting information, data and products being made available among various sectors, administrative regions, and diverse users. Such a situation can lead to disagreements, generate reluctance to cooperate and can undermine the importance and credibility of the work of the NHS. In transboundary basins, the equation evolves into another level of complexity requiring assurance and compatibility of the quality of data and products.

Given the uncertainties associated with hydrological processes and the impossibility to eliminate them in the data and information production, it is useful to make the clients aware of these uncertainties. Further, research on the Global Water Cycle and impacts of increasing climate variability and potential climate change on the availability of water resources requires the sharing and use of data from many countries. It is important that in such analyses the data be compatible, comparable and of known assured quality.

Although the costs of implementing and utilizing standard procedures are commonly perceived to be high, the cost of having no standards may well be higher. A Service may discover that observations it had made over several years were in error because of an unrecognized fault in an instrument, or that a flow record required complete reprocessing because a weir was incorrectly rated. Fixing such problems will invariably force the Service to incur more direct costs than it would have done had standard procedures been implemented and utilized. No less important, however, are the potential indirect costs of being perceived by the user community as a Service that does not always provide reliable data or services.

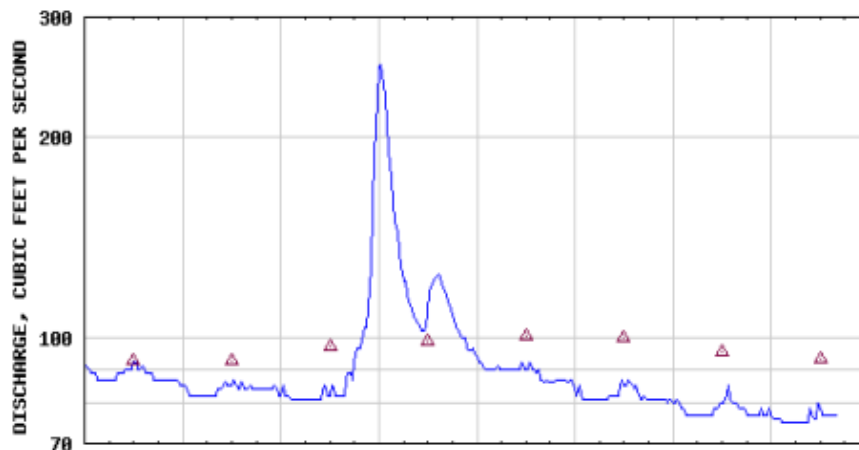
A core aspect of quality management is the delivery of products and services that are as close as possible to the users' requirements (specifications). This necessarily involves a continuous search for non-conformance in product and service specification, and the tracking of sources of such non-conformance. It implies considerable control of operational processes at all supervisory levels to ensure that instruments are regularly and properly calibrated and maintained, that field procedures are carefully selected and followed, that data are properly recorded and quality assured, and that improved methods of reporting data and information are evaluated and utilized.

RESULTS

Gates convey a flow rate supplied from distant reservoirs. Thus, it is highly possible that a level controller, especially during operational transitions, computes a required gate discharge that is impossible to attain at that moment, but that the controller assumes accomplishable leading to the windup in the result of the integration. Both problems have been studied by the control community and can be solved by modifying the original algorithm with suitable solutions. One solution that can solve both problems, consist in gradually modifying the integral value in order to equal the controller output with the saturated actuator value or the manually driven action.

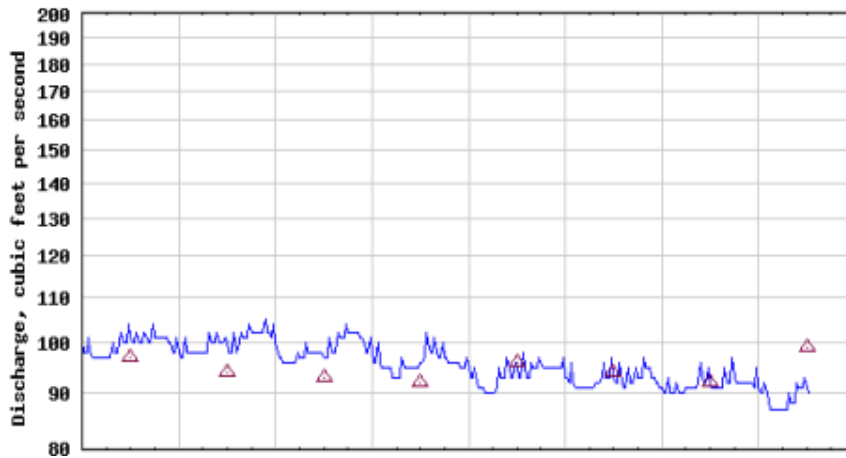
Particularly, these tuning rules have been developed for pools represented by the Integrator Delay (ID) model .It has been also stated that the resonant modes limit the achievable performance of PI controllers.

As a consequence, the magnitude (R_p) and location (τ_r) of these modes are also needed to tune these controllers properly. There is also one alternative to overcome this restriction: to use a PI controller in series with a low pass filter . This type of scheme can diminish the controller sensibility to resonance, centering the controller attention on the long-term response.



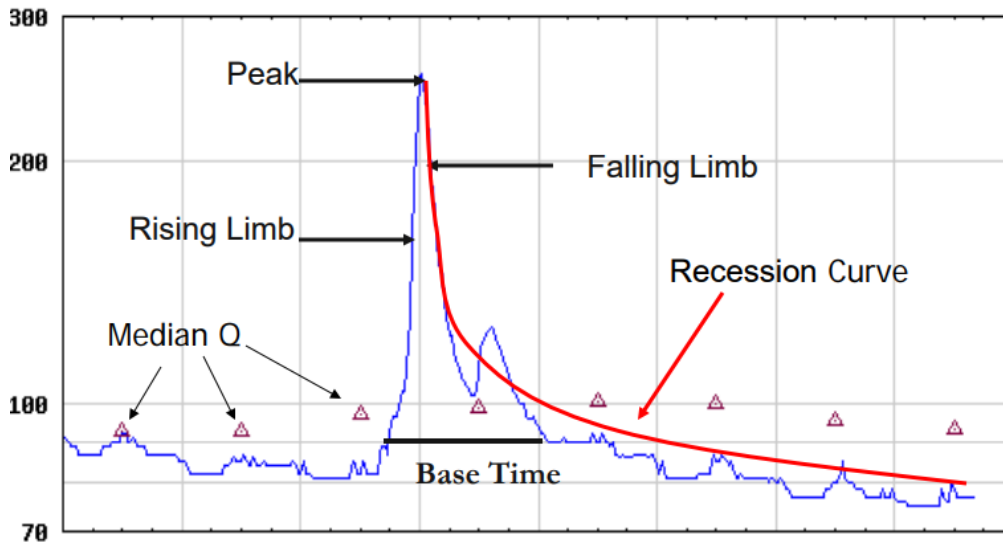
Any type of low pass filter can do the job. For instance, in Schuurmans it was proposed the use of the following first order discrete-time filter where T is the control period and T_f is the filter time constant. Decoupling and feed forward Decoupling and feed forward loops can also been added to any of the previously designed control schemes. In general, decoupling loops try to diminish the interrelationship among coupled variables in a MIMO system. Feed forward loops give an important feature to any control system: to take into account measurable disturbances in the control solution. These issues have been already addressed in Schuurmans for this type of irrigation canal control solutions. A typical control scheme with

decoupling and feed forward enhancements is depicted in figure . The decoupling goal, in this case, is to reduce the effect that a gate discharge can produce over an upstream water level, i.e. to reduce the disturbing effects of control actions .



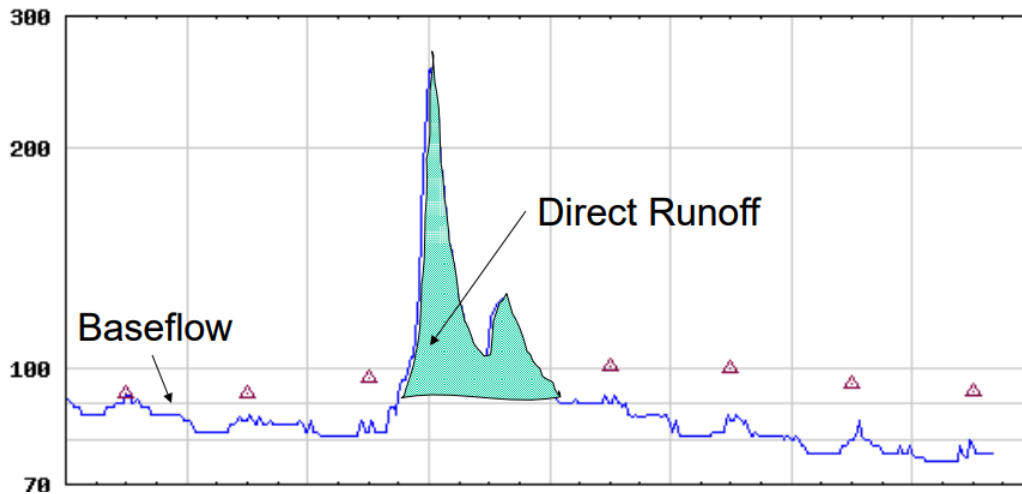
The inclusion of a decoupling element is very important in this type of PI control strategy; the use of the SISO design rules presented before are strongly based on the loop independence assumption. On the other hand, it is always helpful to feed a control scheme with the most available information. If there are reliable measurements of the off take discharges, the feed forward loops can only benefit the control performance, specially when the results are not as good as required. This type of strategies are implemented in a very simple way in Schuurmans.

With respect to the Canal PAC-UPC, the first two pools can be directly modeled using the ID model. However, the last pool is somewhat different; the final weir eliminates the pure integrator from the process as demonstrated. As a consequence, the tuning rules presented in table cannot be applied to this particular pool. The PI controller of this pool is alternatively tuned using a standard closed loop tuning rule such as the one proposed . This tuning rule is based on the Ultimate Cycle Analysis, a procedure that determines the stability limit of a controlled system by inducing a sustained output oscillation. Once this limit is known, the tuning is performed so as to ensure a stable response.



The A-H tuning formulas are presented. There are two parameters that have to be determined: the ultimate gain (k_u), which is the minimum controller gain that causes the system to continuously cycle and the ultimate period of oscillation (T_u). In summary, it is necessary to estimate the ID model parameters of Pool 1 and Pool 2 and the ultimate cycle parameters of Pool 3 in order to calculate the parameters of the PI controllers. These parameters have been calculated from the Canal PAC-UPC identified ARX model. Hence, they are based on a system approximation around an operation point.

For Pool 3, the Ultimate Cycle Analysis was performed using a computer simulation of model to avoid oscillations in the real canal. These values were substituted in the PI tuning formulas and several sets of parameters were obtained. These formulas were developed in a continuous time framework so, in order to recover this performance using a sampled PI control, it is necessary to choose an appropriate control time T . For systems with delays, this value should be around 0.5 or 0.33 times the delay. When the resulting operation rate is not tolerated by the actuator, it is better to consider this sampling constraint in the controller design. MIMO based analysis It is worth to remark that the controller tunings were performed assuming simplified models in a SISO framework.



A whole linear control scheme acting over an also linear MIMO process can be well analyzed inspecting the singular values of the system or using any Nyquist-like multivariable techniques. For instance, the characteristic locus of a MIMO process plots of the eigenvalues of a system gives the chance to apply the Generalized Nyquist theorem in order to test the stability of a final control design and to formulate some conclusions about the performance of a multivariable feedback system. This point can be exemplified by testing one of the suggested tunings. For example, the characteristic locus of the Canal PAC-UPC model controlled by the Litrico PI controller set is shown in figure. The first aspect that should be noted is that this control scheme is absolutely unstable. Controlled irrigation canal systems are unstable when their characteristic locus encircles the point $(-1,0)$, according to the Generalized Nyquist theorem. This behavior was somewhat expected. The authors themselves have remarked in Litrico and Fromion 2006 that, when there is a strong influence of resonant modes, they should be filtered in order to use their tuning recommendations. As a result, this tuning is going to be only implemented with appropriate filters from here on Litrico PIF.

CONCLUSION

For simplicity reasons, the same filters designed for Schuurmans PIF are going to be used. Some performance conclusions can also be obtained from figure. If the characteristic locus penetrates the 3 dB m-circle, then at least one principal gain of the closed loop system will exhibit a resonance peak greater. This is usually not advisable because, in a system like this, measurement noise can easily destabilize the controlled system. In this case, each control scheme was analyzed and it was found that neither of them fulfil this requirement. Hence, the PI and PIF control schemes were retuned so as to remain outside the 3 dB m-circle. Later on in this chapter, all the set of PI tunings obtained in this section are going to be tested in

identical situations in order to attain some performance results. In the next section, Predictive Control is briefly presented as a tool for designing decentralized controllers for canal pools. Conceptual basis Predictive control methods aim to obtain a control action that can fulfil at best, certain time performance criterions in the near future. In general lines, a process model is used to predict what is going to happen if a certain control action is taken and the result is evaluated in a near future time period called "prediction horizon".

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