ABSTARCT

The mounting pressure on available water supplies is resulting in a need to increase the productivity of water for irrigation. With increasing demands for water for domestic use, industry and the environment, supplies of water for irrigation can be expected to fall, hence the need for "more from less" in irrigated agriculture.

This study addresses the issue of water conservation and increased water use efficiency through measures of canal control and operation. In the design of new irrigation schemes the selection of the appropriate method of canal design and control for a given operating environment is a fundamental decision to be taken at the planning stage.

Many efforts have been conducted for improving the operation and management of open channel networks. Implementing simulation models and software is an effective step in achieving better operation of control structures in open channel networks. The purpose of this study was to develop a tool and procedures for assisting designers and open channel network managers in development of design procedure for canal system and in operating flow control structures, with the objectives of conservation of water, human and capital resources.

In this study the SIC software (a mathematical model) is employed to simulate the hydraulic behaviour of the main irrigation canal in Upper Atbara Project, under steady and unsteady flow conditions. In particular, the model is used to simulate the canal actual hydraulic and operational conditions, to test design modifications (hydraulics structures, new calibration, etc.), and to test new management rules aimed at achieving water savings. (SHARK) hydraulic model is also employed to investigate and test the most suitable methods for sediment control including sluiced settling basin, and mechanical excavation and design the relevant option.

The main purposes of application of these models are: (1) to provide a research tool to gain in-depth knowledge of the hydraulic behaviour of the main canal and distributaries, within an irrigation system; (2) to identify, through the model, appropriate operational practices at regulating structures with a view to improving the present canal operations; (3) to evaluate the influence of possible modifications to some design parameters with a view to improve and maintaining the capacity of canal to satisfy the discharge and water targets; (4) To develop operating scenarios as an intervention for solutions of operating problems of night operation, canal automation (using SCADA) and sediment control (sluiced settling basin).

The study of hydraulic behaviour of the main canal under steady state conditions revealed that: no capacity problem is expected, changes in actual roughness after the construction cannot endanger the canal if the design assumptions are respected, and scenarios of 90% and 70% night storage indicate that a buffer volume of 1.8 Mm^3 at the end of the Main canal, corresponding to 1m increase of the canal embankment of the Main canal when night storage is adopted.

The hydraulic behaviour of operation of the main canal under unsteady state indicates that: the acceptable envelope of velocity is bounded by the range of 0.62 to 0.9 m/sec, and it is advised to run the canal with inflow of 55 to 150 m^3/sec. It is observed the perturbation amplitude decreases with distance.

Simulation of operation of the system at emergency situations (the sudden closure of an off take) shows that the volume of water lost via the spill is function of the operator’s reaction time and the travel time for the moving water; thus, it is advised to erect an automatic operation (SCADA) of the Main Canal.

A procedure is presented and applied to aid the selection, design and economically evaluating desilting basin structures to reduce sedimentation in the main irrigation canal and to replace the costly mechanical excavation currently in use.

It is hoped that the developed guidelines, and procedures will prove useful for designers of new or rehabilitated schemes, and for scheme managers. For designers the Guidelines provide a comprehensive guide to the canal control methods currently in use together with guidance on measures to ensure optimum operability of the irrigation network.

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GENERAL LIST OF ABBREVIATIONS

A

AOSM	Adjustable Orifice Semi-Module
APM	Adjustable Proportional Module
ATV	Auto Tuning Variation

B

BCM	Billion Cubic Metres = 1 km^3
BDL	Bed Level
BDW	Bed Width
BKL	Bank Level
BKW	Bank Width

C

CDS	Cross Drainage Structure
CH	Chainge
CI	Cropping Intensity
CLIMWAT	FAO computer program for climatic data
CP	Cropping pattern
CRE	Cross Regulator
CROPWAT	FAO computer program for water requirements
CWR	Crop water requirements

D

D/S	downstream
DCUA	Dams Complex of Upper Atbara
DIU	Dams Implementation Unit
DORC	Design of Regime Canal
DOSSBAS	Design of Sluiced Settling Basin
DP	Drop
DWLC	Downstream Water Level Control

E

E	Overall irrigation efficiency
Ea	Field application efficiency
Eb	Field canal efficiency
Ec	Conveyance efficiency
Ed	Distribution efficiency

el.	elevation
FAO	Food and Agriculture Organisation of the United Nations
FBD	Freeboard
FOP	Field Outlet Pipe
FS	Feasibility Study
FSL	Full Supply Level

G

GIS	Geographic Information System
GL	Ground Level
GoS	Government of Sudan
GPS	Global Positioning System
GRS	Gezira Research Station

H

ha	hectare
HR	Head Regulator
HRS	Hydraulic Research Station

I

IRR	Internal Rate of Return

K

k_c	Crop coefficient
kg	kilogramme
km	kilometre

M

m	metre
m a.s.l.	metres above sea level (in Alexandria)
MC	Main Canal
MIMO	Means Multiple Input, Multiple Output
MIP	Merowe Irrigation Project
MISO	Means Multiple Input, Single Output
mm	millimetre
Mm^3	million cubic metres
MOI	Ministry of Irrigation
MUSD	Million United State Dollar

N

NPV	Net Present Value

O

O&M	Operation and Maintenance
OUTS	Outside Slope

P

PD	Proposed Depth
PID	Proportional-Integral-Derivative
PS	Pumping Station

S

SCADA	Supervisory Control and Data Acquisition
SDG	Sudanese Pound
SISO	Single Input, Single Output
SRTM	Shuttle Radar Topographic Mapping
SS	Side Slope
SWOT	Strength, Weakness, Opportunity, Threat

T

t	tonne
TD	Trial Depth
ToR	Terms of Reference

U

u/s	upstream
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNSO	United Nations Sahel Organisation
USBR	United States Bureau of Reclamation
UWLC	Upstream Water Level Control

W

WL	Water Level
WUA	Water User Association
WUC	Water User Cooperative
WUF	Water User Federation
WUG	Water User Group
WUO	Water User Organisation