TABLE OF CONTENTS

Page

1 INTRODUCTION 1-1

1.1 MOTIVATION FOR THE STUDY 1-1

1.2 MOTIVATION FOR THE DEVELOPMENT OF A REAL TIME HYDRAULIC MODEL 1-4

1.3 OBJECTIVES OF THE STUDY 1-5

1.4 TECHNOLOGICAL DEVELOPMENTS 1-6

1.5 BACKGROUND TO THE RESEARCH 1-7

1.6 LAYOUT OF THE REPORT 1-8

2 BASIC CONCEPTS OF THE DECISION SUPPORT SYSTEM 2-1

2.1 REAL TIME HYDRAULIC MODELLING 2-4

2.2 DETERMINATION OF THE RELEASE SCHEDULE 2-7

2.3 SUMMARY 2-9

3 GRAPHICAL USER INTERFACE 3-1

3.1 DESCRIPTION OF THE FILE STRUCTURE 3-2

3.1.1 The ISIS Data File (*.DAT) 3-2

3.1.2 The Remote Data File (*.RTM) 3-3

3.1.3 The Policy Files (*.POL) 3-3

3.1.4 The result files (*.ZZS, *.ZZN, *.ZZL, *.ZZR, *ZZD) 3-3

3.1.5 Calibration File (*.CAL). 3-4

3.1.6 The log file (*.LOG) 3-4

3.2 THE PROCESSES OF THE DECISION SUPPORT SYSTEM 3-4

3.2.1 Real Time Simulation 3-6

3.2.2 Forecast simulations 3-7

3.3 SCREENSHOTS OF THE GRAPHICAL USER INTERFACE 3-8

3.3.1 The real time simulation 3-12

3.3.2 The forecast simulation 3-16

3.3.3 The Utilities 3-17

3.4 SUMMARY 3-19

4 HYDRAULIC MODELLING DEVELOPMENTS 4-1

4.1 THE REAL TIME UNIT 4-1

4.1.1 The Flow-Time Real Time Control (QTBREAL) 4-2

4.1.2 The Flow-Stage Real Time Control (QHREAL) 4-2

4.1.3 Potential Future Developments to the Real Time Control 4-5

4.2 ADAPTIVE TIMESTEPPING 4-6

4.3 SUMMARY 4-7

5 THE REAL TIME TELEMETRY NETWORK 5-1

5.1 SUMMARY 5-6

6 THE HYDRAULIC MODEL 6-1

6.1 PREPARATION OF THE HYDRAULIC MODEL 6-1

6.1.1 Cross sectional data 6-1

6.1.2 Channel roughness 6-2

6.1.3 Real Time Units 6-2

6.1.4 Summary of the physical nature of the Orange River downstream of Vanderkloof Dam 6-3

6.1.5 Abstractions from the river 6-7

6.1.6 River Losses 6-7

6.1.7 Calibration of the model 6-8

6.2 SUMMARY 6-15

7 ASSESSMENT OF THE DECISION SUPPORT TOOL 7-1

7.1 THE EFFECT OF THE REAL TIME MODEL ON THE FORECAST SIMULATIONS 7-1

7.2 ESTIMATE OF SAVINGS IN WATER DUE TO THE DECISION SUPPORT TOOL 7-3

7.3 SUMMARY 7-4

8 CONCLUSIONS AND RECOMMENDATIONS 8-1

9 REFERENCES 9-1

A THEORETICAL BACKGROUND A-1

A.1 REYNOLDS TRANSPORT THEOREM A-1

A.2 THE ST VENANT EQUATIONS A-4

A.3 SUMMARY A-9

B HYDRAULIC MODELS B-1

B.1 LUMPED FLOW ROUTING B-1

B.1.1 Level Pool Routing B-1

B.1.2 The Muskingum Method B-2

B.1.3 The linear reservoir model B-2

B.2 DISTRIBUTED FLOW ROUTING B-4

B.2.1 The kinematic wave model B-6

B.2.2 The Diffusion Wave model B-7

B.2.3 The dynamic flow model B-7

B.3 SELECTION OF A MODEL FOR THE ORANGE RIVER B-7

B.3.1 Lumped Flow Routing Models B-8

B.3.2 Kinematic Wave Model B-9

B.4 SUMMARY B-11

C SOLUTION OF THE ST VENANT'S EQUATIONS C-1

C.1 FINITE DIFFERENCE SCHEMES C-1

C.1.1 Solution of finite difference schemes C-2

C.1.2 The Explicit Scheme C-3

C.1.3 The implicit scheme C-4

C.2 SOLVING THE ST VENANT EQUATIONS C-6

C.2.1 Boundary Conditions C-9

C.2.2 Initial Conditions C-10

C.2.3 The Newton-Raphson Method as a solution to the St Venant's equations C-11

C.3 SUMMARY C-16