NATIONAL WEATHER SERVICE
OFFICE of HYDROLOGIC DEVELOPMENT

TEST PLAN

National Weather Service River Forecast System (NWSRFS) Reservoir Tools Enhancements

Version 4.4

Revision History

Date	Version	Description	Author
05/09/2007	4.1	Initial Draft	D. Sharp (RTi)
06/20/2007	4.2	Final Version for OHD review	D. Sharp (RTi)
08/28/2007	4.2.1	Changes to 4.2 to reflect knowledge gained during final development, turn-on, and testing; incorporate J. Gofus (OHD) and K. Hsu (OHD) comments	D. Sharp (RTi)
09/07/2007	4.3	Incorporate additional OHD comments	D. Sharp (RTi) J. Gofus (OHD) K. Hsu (OHD)
09/18/2007	4.4	Incorporate documentation for additional Node testing outside of MaxStage suggested by K. Hsu	D. Sharp (RTi)

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1. Introduction

The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service (NWS) has a need to enhance the Joint Reservoir Regulation Operation (RES-J) and LOOKUP3 operation to improve stream-flow regulation accounting within the River Forecast Centers (RFCs). RFCs utilize the hydrologic model software package developed by the Office of Hydrologic Development (OHD) known as the NWS River Forecast System (NWSRFS). The software contains the RES-J and LOOKUP3 operations and handles a variety of scenarios encountered in daily forecasting operations. However, operational use and testing of the current version of RES-J and LOOKUP3 operations, in relation to stream-flow regulation accounting within the Missouri Basin River Forecast Center (MBRFC) area of responsibility, has revealed the need for several enhancements. The completion of this work, and the delivery of these enhancements, is necessary for the MBRFC to move forward with the larger project of implementing Advanced Hydrologic Prediction Service (AHPS) in the South Platte River basin. This new capability will enable the MBRFC to characterize regulation and more accurately prepare long-range probabilistic forecasts of streamflow.

The following two enhancements were identified for inclusion in this task:

1. Multi-valued Time Series Lookup Operation – The existing LOOKUP3 Operation linearly interpolates for a dependent result given two independent arguments and a family of curves relating the two independent arguments to the dependent argument. This method utilizes a 3-variable relationship between upstream flow (Q1), downstream elevation (E2) or flow (Q2) and elevation from the upstream location (E1): E1 = f (Q1, E2). Only single valued time series are allowed. Soil moisture zone contents and runoff time series can be useful in making operational decisions related to streamflow regulation. For example, soil moisture and runoff can be considered when estimating diversions that are occurring for agriculture. The Sacramento model includes two multi-value time series containing zone contents and runoff components. The values from these time series may be plotted using PLOT-TS (e.g., to facilitate calibration); however, the time series cannot otherwise be accessed for manipulation by other NWSRFS operations. Enhancing the LOOKUP3 operation to have access to the multi-value time series will allow the information to be used in regulation modeling. Additionally, allowing a lookup based on the day of year will allow operating rules to be specified in lookup tables.
2. Integrate NWSRFS Rating Curves – The existing MAXSTAGE method in RES-J allows control of a reservoir release based on only on allowable stage at a downstream streamflow station control point. The MAXSTAGE method requires the user to input a rating curve for the downstream node. It is requested that rating curves defined in the system be accessible to this method in place of the rating curve defined in RES-J. Additionally, the rating curve will always be entered through the NODE Component corresponding to the downstream station. Adding the rating curve at nodes will allow the specific nodes to be used as a forecast point. An option will be allowed to enter a rating table at any nodes to overwrite the rating curve. The existing rating table in the MAXSTAGE Method will be retained only for backward compatibility. This enhancement will ensure the model always uses the most up-to-date rating curve data from NWSRFS database. The current MAXSTAGE method also requires that a stage value be specified, which limits application in cases where operations are based on discharge; consequently, the ability to specify a maximum discharge is needed.

1.1 Identification

Project Title: "Reservoir Tools Enhancement" (RTE)

Project-ID: SON 06-002

1.2 Document Overview

This Test Plan details the work to be accomplished during testing and the responsibilities of each participant. The testing requirements are provided in the requirements section of the CONOPS document. A companion document, the Test Procedures, will contain the specifics of how to execute the tests described in this document.

The audience is expected to be largely familiar with the RES-J/MAXSTAGE method and the LOOKUP3 operation, their overall functionality, and descriptive terms. As necessary, the audience is encouraged to reference existing NWSRFS and RES-J documentation for further background and certain details described in this plan.

2. Testing Approach

RTi will test the RTE modifications to verify that the updates satisfy the requirements submitted in the CONOPS document (i.e., certification tests).

For the certification tests, RTi will construct test cases and package them for MBRFC and OHD to execute and approve. RTi will furnish the data needed and will help MBRFC and OHD set up the environments to be able to successfully run the tests. Because the numbered tests are created to satisfy the CONOPS requirements, each test must be passed and reported as passed for successful completion of HOSIP stage 4.

The testing will be performed on an OB8.1 system, and it is assumed that the project is targeted for OB8.1 systems. However, there is no known reason why the RTE binaries should not work on an OB7.2 system as available at the MBRFC.

3. Certification of Requirements from CONOPS

The enhancements will be tested by following the Requirements Table from Appendix B of the Gate 3 CONOPS document. Only requirements 1.0, 2.0 and 4.0 include qualification by testing.

4. Testing Methodology

4.1 Deliverables

The following tables specify the deliverables. See the RTE Test Procedures document for an explanation of the directory structure in which they will be delivered.

Source Code
ex53.f, prp53.f, pin53.f, puc53.f, Node_SetGet.cxx, Node_Constructors.cxx, Node_initialize.cxx, Node.h, MaxStage_construct.cxx, MaxStage_solveMethod.cxx, MaxStage_initialize.cxx, MaxStage_Constructors.cxx, MaxStage.h, chekmv.f, extrts.f, cvtidx.f intfgq.f, intfrc.f, fstgq.f

The source code will be useful to OHD, but not the MBRFC.

Runtime Environment	
Executables	**Libraries**
mcp3, opt3, fcinit, fcst, ifp_nwsrfs	libfcinit_pntb, libfcinit_puc, libfcst_ex, libfcinit_prp, libresj_toplolgy, libresj_system, libfcinit_util

The runtime executables will be provided primarily for the MBRFC. It is expected that OHD will use the provided source to build their own binaries.

Input Data Files	
Required For	**Files**
MCP3	Calibration decks
OPT3	Calibration deck
OFS (new test cases)	fcinit define segments, print, and punch input files; fcst execute input files, fs5files
OFS (regression, as part of the existing OFS test suite)	none

The Input Data Files will be used by both OHD and the MBRFC.

Expected Results (i.e. "archive") Files (generated prior to running tests)	
Required For	
MCP3	Std_out archives
OPT3	Std_out archives
OFS (new functionality)	Std_out archives
OFS (regression)	N/A (will use existing OFS tests)

The archive files will be used by both OHD and the MBRFC.

Actual Test Results Files (as a result of RTi release testing)	
Required For	
MCP3	Std_out
OPT3	Std_out
OFS (new functionality)	Std_out
OFS (regression)	N/A

The actual results generated by RTi will be useful to both OHD and the MBRFC and will be compared to the expected results to confirm software functionality – any differences will be explained.

4.2 Setup

The test suites can be executed from either a "test" location (i.e. with development software installed in an isolated location), or in a "production" location (i.e. installed in an operational location). Control of this capability is via a parameter to the test scripts within the delivered testing framework. See the RTE Test Procedures document for more details.

4.3 Test Matrix

The following matrix specifies the NWSRFS programs to be tested and the test suite to be used. In this context, a "test suite" is defined as the framework within which the program is tested. It includes all the scripts, expected and actual output files, and directories necessary to fully test the target software. More information on each test suite can be found in the appropriate Appendix (see table). Note that required input files and expected/baseline/benchmark output files are specified in the Test Procedures document.

Target to Test	**Test Suite Used**	**Brief Description of Test Suite**	**Appendix**
mcp3	test_calb (MCP3)	Test enhanced LOOKUP3 and RES-J/MAXSTAGE functionality within MCP3	A
opt3	test_calb (OPT3)	Test enhanced LOOKUP3 and RES-J/MAXSTAGE functionality within OPT3	B
fcinit	test_new_ofs (new functionality); ofs_regresstion_test (regression) (OFS)	Test enhanced LOOKUP3 and RES-J/MAXSTAGE functionality within OFS; OFS regression testing	C
fcst			
ifp_nwsrfs (IFP)	IFP_interactive (IFP)	Test enhanced LOOKUP3 and RES-J/MAXSTAGE functionality within IFP; IFP interactive regression testing	D

5. Roles & Responsibilities

Role/Name	Responsibility
RTi Principal in Charge, Jay Day	Monitor project delivery, and also provide insight on technical work.
RTi Program Manager, Saud Amer	Coordinate, monitor and report within the terms of the AHPS contract.
RTi Software Group Manager, Steve Malers	Provide support and consultation during all aspects of HOSIP Stage 4.
RTi Task Manager,	Coordinate the task's completion, including: implementation of software changes necessary to meet the

Software Development and QA/QC Engineer, Darrin Sharp	requirements (using the NWSRFS development environment); implementation and execution of tests in the OFS and MCP3 test frameworks; author HOSIP Stage 4 documents (Design, Test Plan and Results, and software documentation).
RTi Project Engineers and scientists: Mark Woodbury, James VanShaar Shaun Carney	Provide insight into the current NWSRFS software and proposed changes, help prepare, execute, and document OFS and MCP3 test cases, and participate in the HOSIP Gate 4 meeting, as needed.
RTi Administrative Support, Laura Baker	Help prepare documents and provide administrative support.
NWS OHD Project Area Lead, Joe Gofus	Provide general oversight of the project
NWS OHD Project Leader, Kuang Hsu	Review RTi deliverables and provide oversight of, and guidance to RTi
NWS OHD DSA, Gautam Sood, Hank Herr	System related software support
MBRFC, Tom Gurss	Review and test RTi deliverables and provide guidance to OHD and RTi
NWS OHD, Mike Smith	Provide scientific assistance and guidance on the SAC-SMA Model
HOSIP Admin, Christopher Holte	Review and QA HOSIP documents and facilitate the HOSIP process

APPENDICES

Appendix A: test_calb (MCP3) Test Suite

This test suite is used to test the RTE in the MCP3 calibration framework.

In the following matrices, each cell represents at least one test case. The result of the test case is either an OK or ERROR. Each test case will be given a unique name.

Standard output files from the tests will be compared to "archive" (i.e. known good) output in order to determine a test's passing/failing status.

A.1 LOOKUP3

Times Series Data Type vs. Multi-Value Data Type Validity Matrix

	Multi-Value Data Type				
Time Series Data Type	**None**	**UZTDEF, UZFWC, LZTDEF, LZFSC, LZFPC**	**TCHANINF, IMP-RO, DIR-RO, SUR-RO, INTERFLO, SUPBASE, PRIMBASE**	**Anything Else**	**CONOPS Req's Satisfied**
SMZC	OK[1]	OK	ERROR	ERROR	1.1,4.1,4.2*
ROCL	OK[1]	ERROR	OK	ERROR	
Any Other Valid Type[2]	OK	ERROR	ERROR	ERROR	

[1]Defaults to the first element (UZTDEF for SMZC; TCHANINF for ROCL), i.e. "1"

[2]Any single valued time series is used.

Argument I (X) vs. Argument II (Z) Validity Matrix

(see Reservoir Tools Enhancement Project Design Document, section 2.3.1)

	Argument II		
Argument I	**Multi-Value Data Type**	**Not Multi-Value Data Type**	**CONOPS Req's Satisfied**
Multi-Value Data Type	OK	OK	1.1
Not Multi-Value Data Type	OK	OK	

A.2 Node

Table or Rating Curve ID at Node Specification Validity Matrix

	Table	**No Table**	**CONOPS Req's Satisfied**
Rating Curve ID	Error[1]	OK	1.3,1.4
No Rating Curve ID	OK	OK[2]	

[1]Error #1 (see Reservoir Tools Enhancement Project Design Document, section 3.4). A rating table and a rating curve are specified at a single node.

[2]This node will be used only as a confluence point.

The above table assumes that the Node functionality is being tested concurrently with RES-J/MaxStage functionality (i.e. there is an associated RES-J/MaxStage operation active when the Node is being tested). In order to assure backwards compatability, a Rating Table and a Rating Curve ID will also be defined at a node when no RES-J/MaxStage operation is active – this will assure backward compatibility.

A.3 MaxStage

MAXSTAGE TABLE Specification Validity Matrix

	TABLE or Rating Curve ID Specified at Node		
TABLE Specified in MAXSTAGE	**YES**	**NO**	**CONOPS Req's Satisfied**
YES	Error[1]	OK[2]	1.5
NO	OK	Error[3]	

[1]Error #3 (see Reservoir Tools Enhancement Project Design Document, section 4.4). MAXSTAGE defines a rating table, and a rating table or curve ID are specified at the node (NODE_ID) as well.

[2]This option is retained only for backward compatibility

[3]Error #4 (see Reservoir Tools Enhancement Project Design Document, section 4.4).). Stage constraint used but no rating curve ID or table found at Node NODE_ID.

MAXIMUMDISCHARGE/MAXIMUMSTAGE (Specified for MAXSTAGE METHOD) Validity Matrix

	MAXIMUMDISCHARGE Specified		
MAXIMUMSTAGE Specified	**YES**	**NO**	**CONOPS Req's Satisfied**
YES	Error[1]	OK	1.6,4.2
NO	OK	Error[2]	

[1]Error #1 (see Reservoir Tools Enhancement Project Design Document, section 4.4)

[2]Error #2 (see Reservoir Tools Enhancement Project Design Document, section 4.4)

Appendix B: test_calb (OPT3) Test Suite

This suite tests a subset of the MCP3 tests (see Appendix A) to verify that new functionality has not corrupted the OPT3 program. The OPT3 Test Suite will test a subset of the MCP3 functionality using the automatic optimization program. The general MCP3 framework will be used, with additions for OPT3 testing in the input deck. Note that RES-J testing is not part of the OPT3 test suite, as RES-J is not supported in opt3.

Appendix C: OFS Test Suite

This test suite is used to test the RTE in the OFS framework, as well as to verify that existing tests continue to work (i.e. regression testing using the ofs_testit framework). The new functionality will be tested to ensure it operates properly within OFS. For regression testing, runs will be executed using both the enhanced binaries.

The following test scenarios potentially impacted by the RTE's:

Operation	**Program Tested**	**CONOPS Req's Satisfied**
Define a segment	fcinit	2.1*,2.2*
Forecast Run/Carryover	fcst	
Carryover Save Run	fcst	
Redefine a segment	fcinit	
Punch	fcinit	
Print	fcinit	
ESP Run	fcst, fcinit	

As with the calibration testing, in order to assure backwards compatability, a Rating Table and a Rating Curve ID will also be defined at a node when no RES-J/MaxStage operation is active – this will assure backward compatibility for those scenarios where a Rating Table or Rating Curve ID is defined at a Node, outside of a MaxStage operation.

Appendix D: IFP Interactive Test Suite

This suite tests the interactive capabilities of NWSRFS/IFP. The standard OHD/RFC interactive IFP test procedure will be used.

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Appendix E: Table of Acronyms

AHPS	Advanced Hydrologic Prediction Service
AWIPS	Advanced Weather Interactive Processing System
ESP	Ensemble Streamflow Prediction
FCEXEC	Forecast Execute
FCINIT	Forecast Component Initialization Program
FCST	Forecast Program
IFP	Interactive Forecast Program
MBRFC	Missouri Basin River Forecast Center
MCP3	Manual Calibration Program
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast System
OHD	Office of Hydrologic Development
OFS	Operational Forecast System
OPT3	Automated Optimization Program
RES-J	Joint Reservoir Regulation operation
RFCs	River Forecast Centers
RTE	Reservoir Tools Enhancement
RTi	Riverside Technology, inc.