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To: Bill Graham (IDWR)

From: Scott King

cc: Carter Borden

Date: January 17, 2005

Project: DHI Project Number: 4021.252
IDWR Contract Number: 00629

Subject: Report on the East Fork Salmon River MIKE Basin Model

Memorandum

This memorandum describes the initiative by the Idaho Department of Water Resources (IDWR) to develop a surface water budget model for the East Fork Salmon River Basin, Idaho. The purpose for developing the East Fork MIKE Basin Model (EFMBM) is to quantify and collectively represent significant sources and uses of streamflow throughout the East Fork Salmon River system upstream of its confluence with the Salmon River near Clayton, Idaho.

The model construction occurred from July to December 2004. During this period, IDWR and DHI, Inc. personnel developed the river network, compiled and populated the model with existing data, and identified data gaps. The result of this phase is a skeleton model with a defined network, data files ready for population with data, and customized supporting spreadsheet files for processing and loading data and aiding in the calibration of the model. A calibrated model is not possible at the conclusion of this phase due to insufficient stream and diversion flow data throughout the basin. Upon collection and incorporation of the stream and diversion flow data into the model, and subsequent model calibration, the model will be able to accurately evaluate diversion operations in the East Fork Salmon River Basin.

This memorandum provides an overview of the methods and data used in the construction of the model. Specifically, the memorandum includes:

- A brief description of the numerical model used for the demonstration
- Summaries of data and assumptions that went into the model setup
- Results from the modeling effort
- Data gaps to be filled

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As this report supplies a summary of the activities for the EFMBM, much of the background material for the modeling effort can be found in *Evaluation of Diversion Operation Plans to Meet Negotiated Flow Targets for Salmon and Steelhead in the Lemhi River Basin Using the MIKE Basin Model* (DHI 2003). For the Lemhi River, sufficient data was available to construct a calibrated surface water budget model. With sufficient data, the EFMBM may be expected to perform similar analyses in the East Fork Salmon River Basin.

The US Bureau of Reclamation (Reclamation) is acknowledged and appreciated for funding this project. Appreciation is also expressed for the assistance of several individuals, including Bill Graham, Sudhir Goyal, and Roxanne Brown from IDWR. In addition, Doug Baker, an East Fork Salmon River water user and long time resident, provided extremely valuable insight into the use and delivery of water within the East Fork Salmon River Basin.

Background

IDWR is charged managing the use of Idaho's waters, a task that requires addressing the needs and desires of diverse parties competing for the same limited resource. Increasingly, the needs of fish and wildlife must be balanced against the needs of irrigators and other water users. IDWR cooperates with federal agencies, such as Reclamation, to address limited systems and meet goals. For fish and wildlife needs, agencies are required to address flow, passage, and screening problems. One specific objective is to increase stream flow during critical migration and spawning periods. Other objectives include improving habitat and experimenting with innovative ways to increase tributary flows by, for example, establishing a water brokerage or acquiring land and water.

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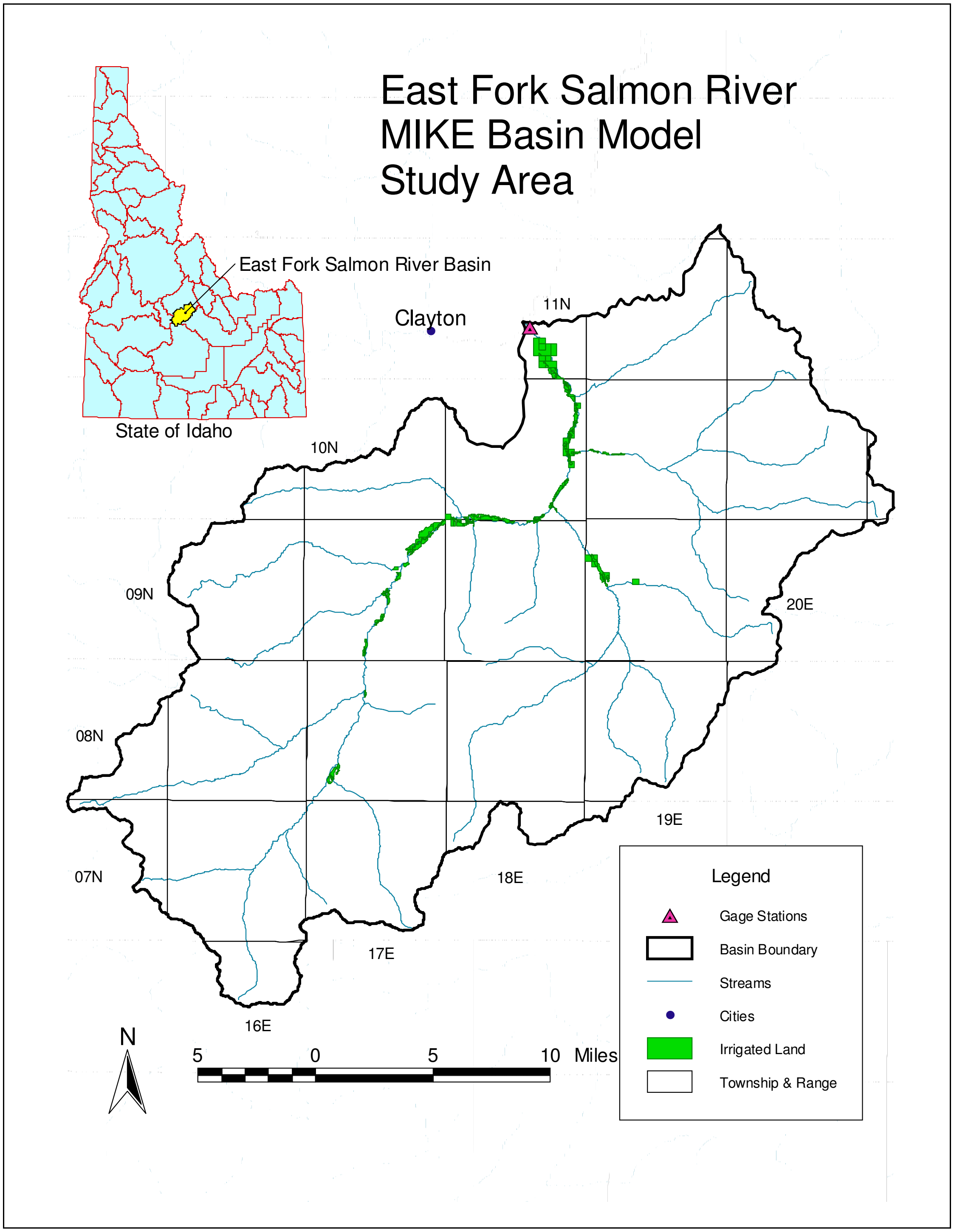

Figure 1. East Fork Salmon River Basin. The study reach includes the East Fork Salmon River upstream from its confluence with the Salmon River near Clayton, Idaho as well as Big Boulder, Big Lake, Herd, Little Boulder, Pine, Road, & West Pass Creeks.

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As one step towards managing the state's waters to balance the needs of multiple competing interests, IDWR is developing and using new technologies. They are employing GIS to assist with prioritizing watersheds. Towards understanding the water allocation and movement in basins, IDWR is using MIKE Basin, a surface water budget tool. IDWR may use MIKE Basin to:

- Evaluate watershed priorities
- Move forward with existing water transaction proposals
- Develop new water transactions with special focus on the East Fork Salmon River drainage
- Implement monitoring and evaluation processes
- Improve communication within the department and with the public regarding water movement and use within the East Fork Salmon River drainage
- Achieve more efficient delivery and regulation of water rights within the basin

Model Used: MIKE Basin

MIKE Basin is an integrated water resource management and planning computer model that integrates a Geographic Information System (GIS) with water resource modeling (DHI 2003). This gives managers and stakeholders a framework within which they can address multisectoral allocation and environmental issues in a river basin. In general terms, MIKE Basin is a mathematical representation of the river basin, including the configuration of the main rivers and their tributaries, the hydrology of the basin in space and time, and existing as well as potential major water use schemes and their various demands for water.

MIKE Basin is a network model in which the rivers and their main tributaries are represented by a network of branches and nodes. Branches represent individual stream sections while the nodes represent confluences, diversions, locations where certain water activities may occur (municipal, industrial, reservoir, and hydropower water uses), or important locations where model results are required. The river system is represented in the model by a digitized river network that can be generated directly on the computer screen in ArcView 3.x (a GIS software package). All information regarding the configuration of the flow simulation network, location of water users, reservoirs and intakes, and outlets of return flow are also defined by on-screen editing.

Basic model inputs are time series data for catchment run-off, diversion, and allocation of water for the off-river nodes. Catchment runoff can be specific runoff data or gage data. Diversion nodes require either a time series of water allocation to each branch or an equation partitioning flow to each branch based on incoming flows to the diversion node. Irrigation nodes require time series data for demand, fraction of the demand satisfied by ground water, fraction of the demand returning to the river branch, and lag time for the return fraction to re-enter the stream. Water demand can be specified directly from an input time series or indirectly from agricultural use information.

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Once the water usage has been defined, the model simulates the performance of the overall system by applying a water mass balance method at every node. The simulation takes into account the water allocation to multiple usages from individual extraction points throughout the system. Results from the model can be viewed as:

- A time series or monthly summary in graphic or tabular form.
- A map of visualized groups of results for the entire or any specified part of the model network in the ArcView Graphical User Interface (GUI). Map views can be stepped through time to generate animation files. The GUI can help create graduated color result presentations for many combinations of results. Several result groups can be animated simultaneously (e.g. flow in the mainstem of the stream and extractions by users). Animations can be saved as a Windows movie (*.avi file) and imported into PowerPoint presentations.
- Model results stored in a database that can be queried using Microsoft Access. The user can create programs in Microsoft Access to automatically generate reports to display results.

MIKE Basin has additional capabilities, including the ability to simulate municipal, industrial, reservoir, and hydropower water users; apply priorities to water distribution; simulate ground water use; and simulate transport and degradation of substances affecting water quality in rivers and reservoirs. Water quality constituents that MIKE Basin simulates include ammonia/ammonium, nitrate, oxygen, total phosphorus, and organic matter. Organic matter is represented in terms of biological oxygen demand and chemical oxygen demand. A more complete description of the capabilities and applications of MIKE Basin can be found at http://www.dhisoftware.com/mikebasin/.

East Fork Salmon River MIKE Basin Modeling

Developing the skeleton model of the EFMBM involved building the river network; compiling, formatting, and inputting the available data; and developing customized MS-Excel spreadsheets. The model network has the following criteria:

- EFMBM encompasses the East Fork Salmon River from just above its confluence with West Pass Creek to its confluence with the Salmon River near Clayton, Idaho as well as selected tributaries including Big Boulder, Big Lake, Herd, Little Boulder, Pine, Road, & West Pass Creeks.
- Model simulations are run on a daily time step from 39 offtake nodes along the East Fork Salmon River and its tributaries and 39 irrigation nodes (representing about 1780 acres of irrigated area associated with the offtake nodes).
- Generally, one diversion node is connected to one irrigation node, and the irrigation node represents an irrigation scheme, which is at times a group of fields irrigated from the same diversion. However, some diversion nodes have connected to them multiple irrigation nodes (e.g. EF-11, EF-12, & BBC-2) where water is applied to more than one distinct location and where return flows are expected to enter at significantly different locations.

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- Return locations for each irrigation node represent the downstream location where the majority of the return fraction is expected to have returned to the East Fork Salmon River and its tributaries.
- Catchment nodes at upstream network boundaries of the East Fork Salmon River and selected tributaries represent direct flow input into the model.
- A catchment node at the East Fork Salmon River stream gage near its confluence with the Salmon River at Clayton, Idaho represent a point where reach gains/losses can be incorporated. Installation of additional gaging stations along the river would offer more opportunities to incorporate reach gains and/or losses.
- A MS-Excel spreadsheet calculator is used to determine the return fraction parameter for an irrigation node. In addition, this spreadsheet allows for simple upload of time series records, such as gage readings, into the model.

The following section describes the construction methods, data availability, and assumptions for the EFMBM.

Network Setup

Information contained in the river network was compiled from GIS coverages, aerial photographs (primarily from two sources including 2003 SPOT satellite imagery and 1992 DOQQs), IDWR GIS shapefile for point of diversion (POD) and place of use (POU) locations, and USGS gaging station locations. The planar course of the East Fork Salmon River and selected tributaries is based on 1:24,000 scale NED GIS shapefile provided by IDWR, with minor modifications to better represent actual conditions. Selected tributaries in the EFMBM include Big Boulder, Big Lake, Herd, Little Boulder, Pine, Road, & West Pass Creeks.

The locations of the 39 offtake nodes were determined primarily by a combination of GPS point locations, IDWR's POD GIS shapefile, image interpretation, and Doug Baker's knowledge (Baker, 2004). The 39 irrigation nodes, representing the irrigated area associated with offtake nodes, were determined by linking the water right identification number in both IDWR's POD and POU GIS shapefiles, along with input from Doug Baker and image interpretation. Mr. Baker was instrumental in establishing the model network and verifying that this information represented actual field conditions.

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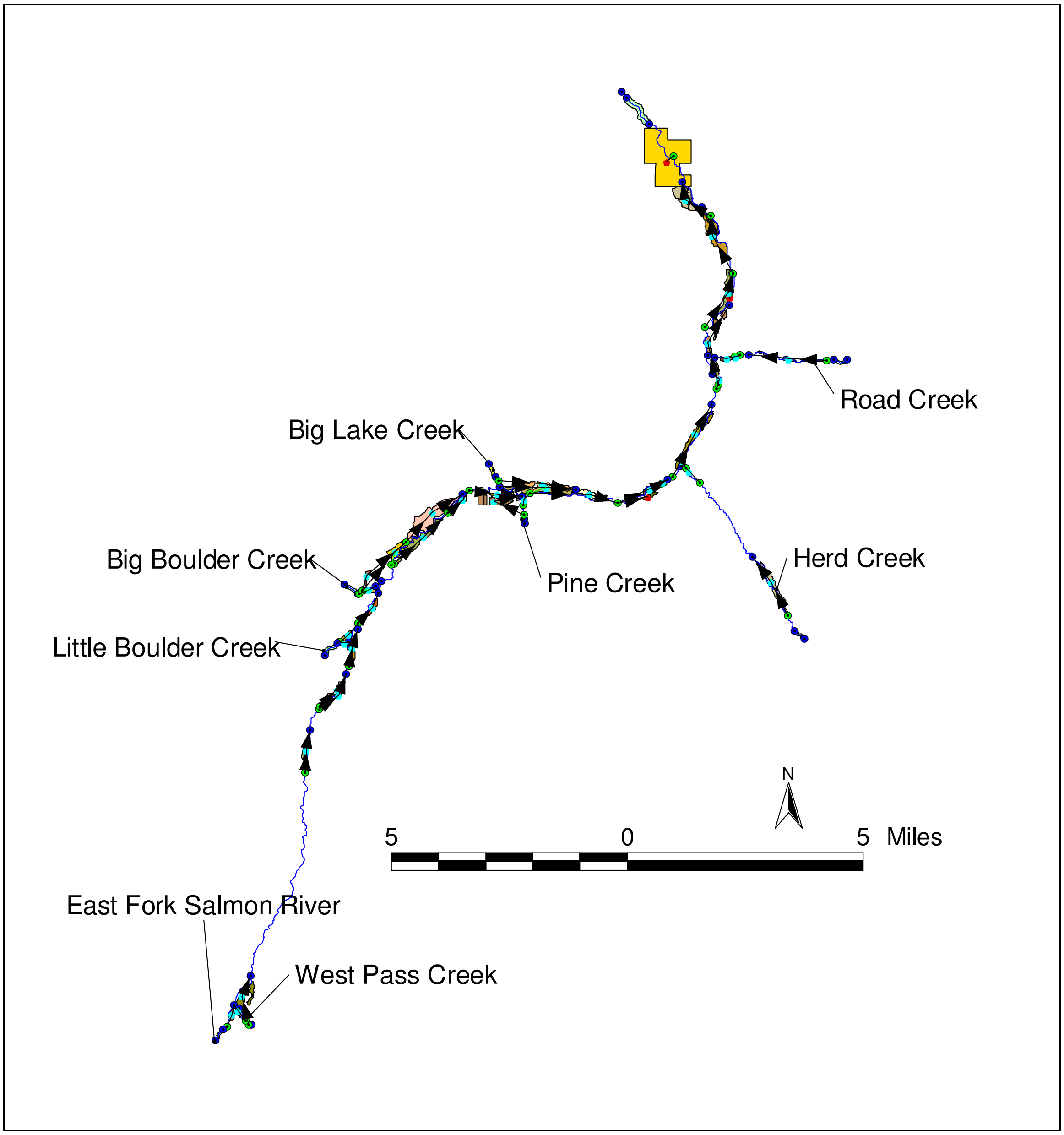

Figure 2. EFMBM network. Thick blue lines represent streams. Two different types of circles representing nodes are located on the thick blue stream lines, with green representing offtake nodes (irrigation diversion locations), blue are general computational nodes. Light blue and red pentagons represent irrigation nodes, thin black and green lines represent connections between the river and irrigation nodes, and the colored polygons represent places of use. Note the thin black and green lines do not follow the exact path of ditches. Figure 3 presents a more detailed view of the middle portion of this figure.

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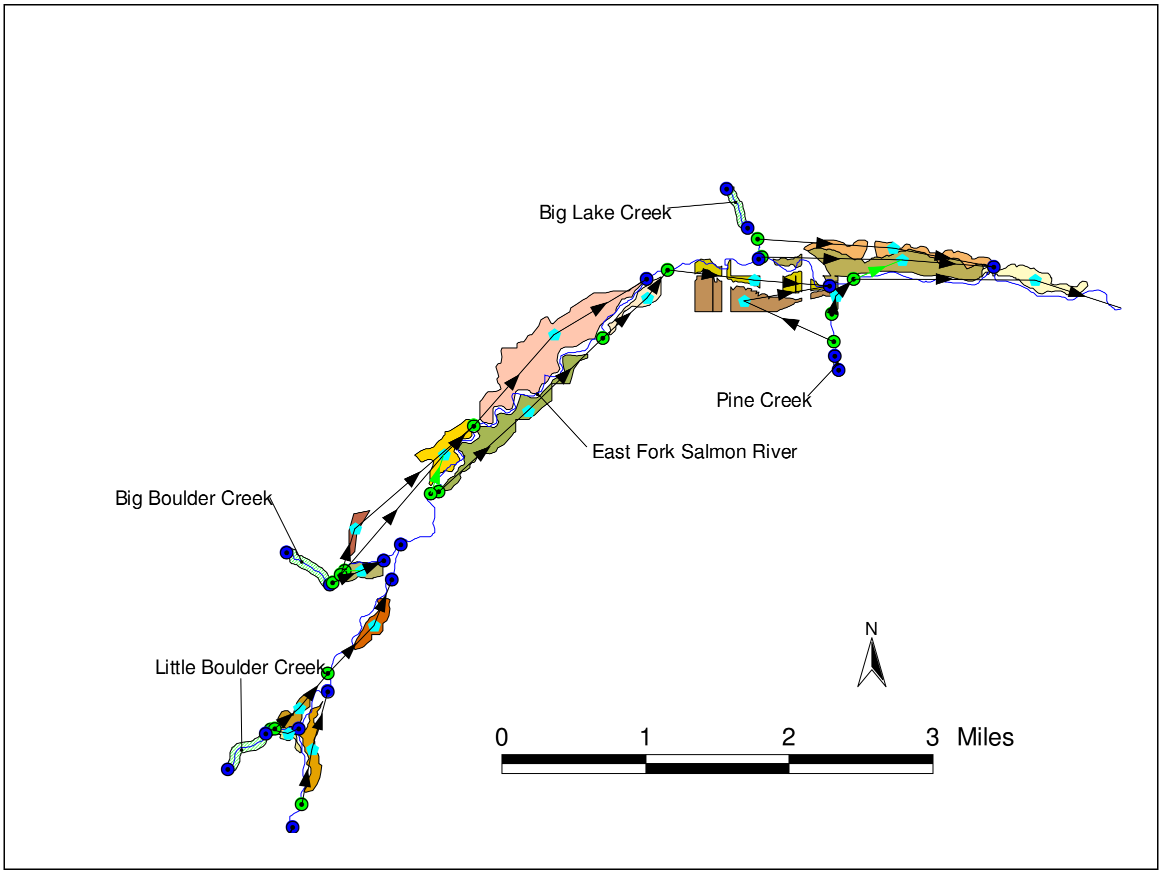

Figure 3. A portion of the EFMBM network providing greater detail for the items described in Figure 2.

For some offtake nodes (diversions), multiple irrigators share the diverted water throughout the irrigation season. In the EFMBM, all irrigators using water from an offtake node are represented by a single irrigation node because the water is being applied to fields in the same general area; further, the authors are unaware of any records identifying location and timing of irrigation applications within an irrigation area during the study period.

Location, timing, and quantity of return flow are functions of irrigation practices and the physical conditions of the irrigated area. In many cases, irrigation returns re-enter the river through both surface and subsurface paths that are dispersed along reaches bordering the irrigated fields. In the EFMBM, return flow nodes were associated with respective irrigation nodes and were located at a downstream point along the East Fork Salmon River or the selected tributary where the majority of the return flow is expected to return. Diverted water that is not lost to evapotranspiration and does not re-enter the stream by the return node enters either the intermediate ground water system (IGW) or the regional ground water system (RGW). The IGW system returns to the stream within the study reach; the RGW system contains water assumed to no longer interact with the surface water river system and, consequently, is no longer tracked within the EFMBM simulation model.

To provide unique identities to offtake nodes (representing PODs) and irrigation nodes (representing POUs), labels were attached to each for easing recognition in the EFMBM, naming time series files, and labeling for the MS-Excel interface. Offtake node labeling is based on the IDFG diversion nomenclature. Labels along the mainstem East Fork Salmon River are labeled EF-3 through EF-24. Format for the diversion labels on tributaries is the creek name followed by a number, except for Big Boulder Creek, Little Boulder Creek, and Big Lake Creek which are reduced to *BBC*, *LBC*, and *BLC*, respectively. Numbers generally start with 1 for the furthest downstream diversion and increase upstream. For example, diversions along Herd Creek are denoted Herd-1, Herd-2, and Herd-3.

Catchment nodes are placed in locations where water is gained or lost directly to the river system. For the EFMBM, catchment nodes were placed above the uppermost diversions of interest on the East Fork Salmon River and the select tributaries. In addition, a catchment node was placed at the gaging station on the East Fork Salmon River just upstream of its confluence with the Salmon River near Clayton, Idaho. For future calibration, this gage will be used to calculate reach gains that represent precipitation, tributary underflow, and other components that are not explicitly included in the model and were assumed to represent residual between simulated and observed streamflow measurements at a gaging station.

Time Series Input Data

In MIKE Basin, the movement of water into and out from the river system is specified with time series data. Catchment and irrigation nodes require time series data in the EFMBM. Catchment nodes represent stream inflow and reach gains and losses. Time series input information is required for the irrigation nodes to define irrigation demand, ground water fraction (fraction of demand satisfied by ground water), return fraction (fraction of demanded water that returns to the stream at specified return locations), and lag time (the linear routing of return flow from the irrigated fields back to the river). In the context of the EFMBM, irrigation *demand* is defined as the quantity of water diverted from the stream.

At the completion of the first phase, only a subset of the required data was available. However, time series files necessary to run the EFMBM have been developed and are linked to MS-Excel spreadsheet that automates loading data. The following section describes the available and missing data for the catchment and irrigation node time series data set required.

Catchment Nodes

Catchment runoff - represents locations in the model where water is introduced directly to the stream system. For the EFMBM, this is the upstream boundary of the tributaries and at gaging stations. In the EFMBM, very limited time series input information from streamflow gaging station records is available. As of December 2004, only one active gaging station is located within the East Fork Salmon Basin, located on the East Fork Salmon River upstream of its confluence with the Salmon River near Clayton, Idaho. This gage was only recently installed, and data are not yet available.

A rainfall/runoff model recently developed by DHI for the Stanley and East Fork Salmon River basins was used to provide simulated discharges into tributary catchments (DHI, in progress). Parameters for the model were calibrated for the Valley Creek at Stanley gage. Due to an inadequate supply of consecutive streamflow and climate measurements in the East Fork Salmon River basin, it was not possible to provide calibrated parameters for the East Fork. Therefore, parameters developed for Valley Creek along with climate data from the Galena Summit and Lost-Wood Divide weather stations were applied to the East Fork Salmon River drainage to provide estimates of tributary stream flow. As additional gage data becomes available in the East Fork drainage, rainfall/runoff model parameters can be calibrated on a local basis. This model has the added benefit of allowing users to examine different climatic conditions when studying water distributions throughout the basin. It must be clearly understood that these inputs to the tributaries do not represent actual measurements of stream flows, but are applied as a means as introducing flow into the system in order to obtain coarse model results.

Reach gains/losses - account for contributions to the East Fork Salmon River from precipitation, ground water gains/losses, and tributary inflow. In the EFMBM, the reach gains/losses are a residual between the measured streamflow at the gage location and the accumulated inputs and outputs specified up to that location in the model. Data collected at stream gages can in the future be used to assist in determining gains and losses. However, due to the lack of tributary gages and of diversion measurements, adjustments in the reach gains/losses remain uncalibrated.

Irrigation Nodes

Irrigation Demand - Daily diversion data was unavailable at the completion of the modeling effort. Therefore, to provide a coarse demonstration of the system, all diversions are assumed to demand the full amount of their water right for the entire irrigation season. However, water rights for several diversions including EF-15, EF-16, EF-17, BBC-1, & BBC-3 are complex and commingled, making it very difficult to determine a flow rate to associate with each individual diversion. In these cases, it is assumed that 0.03 cfs per acre is demanded with acreage based on the associated place of use. The value of 0.03 cfs per acre is selected as this is near the average decreed rate per acre in the East Fork Salmon River basin.

Ground Water Fraction – Ground water was not identified as a significant source for any irrigated lands included in the EFMBM. Therefore, the ground water fraction is zero for all irrigation nodes.

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Return Fraction - The quantity of water returning to the system at the downstream return node is a function of antecedent soil moisture, initial ground water levels, crops irrigated, irrigated area, evapotranspiration rates, distance from the river, ditch loss, and the portion of the infiltrated water that seeps into the intermediate ground water system. The IGW system for these calculations represents the portion of the diverted water that will infiltrate to the subsurface but is not expected to return to the East Fork Salmon River and selected tributaries, in this particular model, until the next downstream gaging station node.

For the EFMBM, a return fraction calculator was developed in Microsoft Excel to assimilate these factors and compute the return fraction on a daily time step. The return fraction calculator equation is:

$$RF = Demand * DL * IGW_{DL} + (Demand + ER * \sum_{i=1}^{n} A_{CT} - DL - (\sum_{CT=1}^{n} (ET_{CT} * A_{CTS})) * IGW_{IS} + (\sum_{CT=1}^{n} (ET_{CT} * A_{CTF})) * IGW_{IF})$$

RF is the return fraction.

Demand is the diverted water.

DL is the fraction of the demand that is lost to ditch loss.

CT denotes the crop type (pasture, grass hay, and alfalfa hay in the Lemhi River basin); in this equation, this value is constant.

ET_{CT} is the evapotranspiration associated with the crop type.

A_{CTS} is the irrigated area for a crop type for sprinkler irrigation; here, this value is constant.

A_{CTF} is the irrigated area for a crop type for flood irrigation; in this equation, this value is constant.

ER is the effective rain.

n is the number of crop types.

The variables IGW_{DL}, IGW_{IS}, and IGW_{IF} are the portions of the infiltrated flow from ditch loss, sprinkler, and flood irrigation that enter the IGW.

The return fraction equation is simply the mass balance of the water entering an irrigation node. Irrigated area was calculated from the shapefiles developed primarily by the authors. For simplicity at this time, the crop type was assumed to be pasture for all irrigation nodes in the study basin.

To determine the irrigated areas (A_{CT}) associated with each diversion, the POD and POU GIS shapefiles developed as part of the Snake River Basin Adjudication were linked by water right number. The POU shapes together with associated water rights were used to determine the number of irrigated acres. Assignment of the place of use areas to a point of diversion was confirmed during a meet with Doug Baker, East Fork Salmon River wateruser (Baker, 2004).

Some individual points of diversion serve several places of use. For modeling purposes, multiple places of use associated with an individual point of diversion were aggregated. Precipitation, evapotranspiration, amount of water applied, losses to ground water, etc., were determined for each aggregate polygon.

Evapotranspiration *(ET)* can be determined by using the Allen-Brockway (A-B) method, Agrimet stations, SEBAL, or METRIC data. Agrimet station data is not available for the East Fork Salmon River study area. However, in order to provide fairly reasonable estimates of daily ET for the study area, data from the Fairfield, ID Agrimet station is used. This data has been included in the course demonstration.

Conveyance loss (DL) is the loss of water during transport from the point of diversion (at the source) to the on-farm places of use. Water is lost through seepage through the soil layer lining the ditch, leakage through headgates and other structures, evaporation from the water surface, and transpiration from plants growing in or near the channel. For the soil loss, a calculator was developed to implement the Worstell method seepage loss estimation (Hubble 1991), a method commonly used by IDWR. This method requires an estimation of the soil seepage rate, measurement of the top width of the water surface at various points along the canal, and the canal length. The estimated seepage loss is multiplied by the canal length (miles) to determine the canal's total conveyance loss. Tables in the *Guidelines for the Evaluation of Irrigation Diversion Rates* (Hubble 1991) are useful in determining soil textures and the appropriate seepage rates. For this coarse demonstration, ditch loss was not calculated.

The intermediate ground water portion (IGW) of the *return fraction* is difficult to measure and thus is a parameter used for calibration in the EFMBM. For the coarse demonstration, the IGW value for all irrigation nodes was 0.10.

Lag Time - Timing of return flows from irrigated lands to the East Fork Salmon River and selected tributaries depends on the irrigated field's location in relation to the closest water, the degree of channel surface flow returns, and ground water flow direction and rate. In MIKE Basin, delayed return flow is described using a linear reservoir equation (DHI 2003). The MIKE Basin user can specify the lag time to control the timing of the return fraction. In the EFMBM, lag times are expected to vary for each irrigation node and will be used to calibrate the model. For the coarse demonstration, the lag time for all irrigation was 1 day.

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Microsoft Excel Interface

To expedite the processing, formatting, and entering of data into the model, DHI personnel developed a Microsoft Excel file and associated macros that interface with the EFMBM. The file and macros provide a more user-friendly platform and help automate repetitive tasks, organize data, and minimize errors in data handling. The Microsoft Excel file:

- **EFMBM_InputFiles.xls –** Organizes the input data for all irrigation and catchment nodes. It contains the daily values for the parameters required by irrigation nodes: demand, ground water fraction, return fraction, lag time, and deficit carryover. This workbook contains the return flow calculator for irrigation nodes and macros that automatically load the data into the proper EFMBM input files. This workbook should be used when running scenarios where diversion schemes are altered and need to be loaded into the EFMBM. In addition, the file contains the daily stream flow values for the inflow locations in the system. Stream data can be pasted into the Excel file so that macros automatically load the data into the appropriate MIKE Basin time series files. A summary table of all the parameters for each diversion and catchment can be generated using a macro.

Coarse Demonstration of the EFMBM

A course demonstration of the EFMBM was created for public demonstration purposes and to ensure the model was correctly constructed. At the conclusion of this phase, the EFMBM is missing required times series data and remains uncalibrated. Except for conceptual demonstration, no results should be used from the model until the proper data has been input and the EFMBM calibrated. The course setup can be used to demonstrate the capabilities of the model, is a repository for the current data available, and can help identify data gaps to guide future data collection efforts.

Recommendations for Further Development of the EFMBM

Though IDWR and DHI personnel completed the initial phase of the EFMBM, additional analysis and data collection are required to develop a calibrated model. These recommendations do not reflect any additional data and analysis that may be required to address specific question posed to the model in the future. However, implementing these recommendations will provide greater insight into water movement in the East Fork Salmon River and its tributaries, and thus can provide a greater foundation for the EFMBM.

Data Collection

The quantity and location of data collection will be a function of time, budget, and the questions users would like to address using the EFMBM. As the limiting element in the calibration of the EFMBM is the stream flow and diversion discharge time series information, these are of utmost importance for development of the model.
Specific data needs are:

- *Daily inflow rates for all tributaries* - At the completion of the first phase, no current discharge data exists for any of the tributaries in the study area. Inflow quantities were approximated using a rainfall/runoff model developed for the Stanley and East Fork Salmon River basins, further described in the *Catchment Nodes* section. This model provides approximate inflows for selected tributaries, but remains uncalibrated for areas outside of Valley Creek at Stanley. Installation of permanent gages on select tributaries in the East Fork Salmon River drainage would allow for local calibration of the model.
- *Stream gaging upstream and downstream of sensitive areas* –The EFMBM does not account for contributions to the East Fork Salmon River from precipitation, ground water gains/losses, and tributary inflow except for those specifically included in the model. Therefore, to determine the absolute quantity of water in the river throughout the system, the model must be "updated" by using observed flow in the stream: The difference between the observed and simulated results is the reach gains/losses. To obtain the observed values, stream gaging is necessary. At the completion of this first phase, only the permanent gage at the bottom end of the East Fork Salmon River near Clayton, Idaho was operational and permanent. It is recommended that stream gages be placed upstream of any sensitive areas in order to insure that the model simulates the correct discharge in the river when diversion operations are being evaluated. For the EFMBM, this implies that the primary tributaries of concern, such as Herd and Road Creeks, be monitored.
- *Daily diversion discharge* – Operation of irrigation diversions significantly influences flow in the East Fork Salmon River and its tributaries. To quantify the influence of diversions, daily measurements of discharge should be made and recorded. In the future, IDWR may require installation of measuring devices on diversions in the East Fork Salmon basin. Measurements of diverted water can be imported into the EFMBM_InputFiles.xls Excel interface.

Modeling

The primary remaining modeling tasks are populating the EFMBM with data and calibrating the model. Calibration involves adjusting the lag times and IGW values to attempt to match the simulated and observed water discharges. Other potential future tasks include incorporation of ditch conveyance capacity and seepage losses, and refinement of crop consumptive uses (ET).

Additional Analysis

Analysis is not crucial to development of a calibrated model, but would increase the understanding of water movement in the basin, studies of precipitation, seepage runs, and ground water.

Seepage Run - A concurrent seepage run and simulation would provide greater foundation for calibrating and refining the EFMBM. Seepage runs are recommended at the onset of the irrigation season when streamflow

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becomes reduced and again late in the irrigation season. This investigation may be most useful in tributaries that experience critically-low flow levels.

Conclusions

From July until December 2004, IDWR and DHI personnel completed the first phase in the surface water budget model development for the East Fork Salmon River, Idaho. The surface water budget model is developed in MIKE Basin, a river network model that is based on an ArcView platform. In general terms, MIKE Basin is a mathematical representation of the river basin encompassing the configuration of the main rivers and their tributaries, the hydrology of the basin in space and time, and existing as well as potential major water use schemes and their various demands for water.

The completed first phase in the EFMBM development has resulted in a skeleton surface water budget model and Microsoft Excel interface. The primary limiting factors in the development of a calibrated model are the streamflow and diversion time series data. Once collected, MS-Excel interfaces allow users to automate loading of time series data and expedite calibration of the model. The complex ground water-surface water interaction in the basin may also prove to be a limiting condition.

Upon calibration, this tool will enable the user to evaluate operation plans by viewing the simulation results with a GIS background that can show the river, points of diversion and return flows, irrigation canals, and canal service areas superimposed on aerial photography of the area. The Microsoft Excel interface was developed to facilitate input and output operations to the EFMBM. These interfaces also allow users, having little operational knowledge of MIKE Basin, to run scenarios from Microsoft Excel interfaces and to use MIKE Basin as the computational kernel instead of having to interact directly with MIKE Basin.

Developing the skeleton EFMBM involved building the river network and compiling, computing, formatting, and inputting the data. The river network configuration primarily reflects a combination of the hydrography GIS layer supplied by IDWR, IDWR water right POU and POD shapefiles, together with Doug Baker's knowledge of the East Fork Salmon River and its tributaries. The EFMBM encompasses the East Fork Salmon River upstream from its confluence with the Salmon River near Clayton, Idaho and selected tributaries within the basin including Big Boulder, Big Lake, Herd, Little Boulder, Pine, Road, & West Pass Creeks.

The model network has 39 offtake nodes along the Pahsimeroi River and its tributaries and 39 irrigation nodes (representing the irrigated area associated with the offtake nodes). Multiple irrigation nodes are used on several offtake nodes where water is applied in several distinct locations. Return locations for each irrigation node represent the downstream location where the majority of the return fraction is expected to have returned to the East Fork

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Salmon River and select tributaries. Catchment nodes at the upstream end of the East Fork Salmon River and selected tributaries represent direct flow input into the model.

Model data required includes stream gage records; daily discharge data for each diversion; and irrigated area, ET rates, crop type, and area serviced by sprinkler irrigation within each irrigated area. At the completion of the first phase of the EFMBM development, insufficient time series data existed to develop a calibrated model. For the course model development, catchment inflow is based on rainfall/runoff model simulations. Daily diversion rates were estimated based on water right decreed amounts. To calculate the quantity of return flow, a calculator was developed in Microsoft Excel to determine the daily return rate to the river system based on ET rate, irrigated area, crop type, ditch loss, sprinkled area, and loss to the intermediate ground water system. Microsoft Excel sheets were developed to augment data processing, data population into the time series files that support MIKE Basin, calibration of the EFMBM, and analysis of alternatives.

Though IDWR and DHI personnel have completed the first phase in the EFMBM development, additional analysis and data collection are needed to develop a fully calibrated model. Further data collection for stream and diversion flow is essential to accurately quantify water movement throughout the basin. Areas of concern where data is limited or poorly understood should receive additional streamflow measurements.

The EFMBM is a dynamic model that can be refined and expanded as data becomes available and as new questions are identified. The EFMBM's first phase of development was intended to establish a skeleton surface water budget model that could later be populated with data to demonstrate how the East Fork Salmon River and its tributaries system can be operated to meet streamflow targets. With data and further analysis, the EFMBM can be used to develop irrigation operations for later in the irrigation season.

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