SIMULATION OF FLOW AND SEDIMENT IN THE LOWER COEUR D' ALENE RIVER:

A DEMONSTRATION

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TABLE OF CONTENTS

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1. INTRODUCTION

This report describes an initiative by the Idaho Department of Environmental Quality (IDEQ) to develop a demonstration of numerical modeling technology for routing of water and sediment discharge through the lower Coeur D'Alene (CDA) River. Included in this report is 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, and the data gaps that need to be filled in order to develop a calibrated model for the study reach. The model setup for this project is only a demonstration, but is anticipated to provide the foundation for developing a fully calibrated model that could be used as a tool for management decisions in the CDA River remedial activities.

IDEQ is interested in establishing a model in the Basin to understand fundamental processes acting in the River and to assist in the evaluation of remediation alternatives being put forth by other entities involved in the CDA River Basin. A few of the questions that could be addressed using modeling include evaluation of flood and low flow characteristics; influences of lake levels on flows and water elevations; exchange between river, floodplain, and lateral lakes; sediment transport-scour and deposition including streambed and bank stability; effects of lake outlet management on flood risk; and impacts of channel/floodplain alterations on flow conditions. Any modeling can be used iteratively to adaptively manage the Basin.

The purpose of this simulation was to demonstrate a numerical modeling in the lower CDA River and illuminate potential uses of the modeling in remediation efforts. The model simulation extended from the confluence of the North Fork CDA River and South Fork CDA River to the CDA River's outlet into Lake CDA. The specific tasks involved in this project include:

- Demonstrate 1-d model capabilities for sediment transport and water discharge in the lower CDA River;
- Identify data available for modeling;
- Determine data gaps in the available data for producing a fully calibrated model; and
- Assess CDA River's course stability from aerial photographs.

Due to the lack of input data available for the modeling effort, the results generated from this effort are only to demonstrate the capabilities of a model for the CDA River and are not intended to be used to evaluate management activities. The data required to refine the model to a management tool is described. It is also recognized that a 1-d simulation will be able to give a broad understanding of flows and sediment, but more detailed 2-d or even 3-d modeling may be necessary to simulate local problems. Specific examples might include the geomorphic evolution of a selected meander or the detailed deposition and erosion patterns within a lateral lake. In this situation, the 1-d model will be used to simulate the entire system and to generate boundary conditions for the higher order local models that would be nested within the 1-d model.

2. BACKGROUND

A plethora of environmental studies have been conducted along the study reach by the federal, state, and local governments, tribes, and private entities. The authors, however, are aware of only one numerical model that routes water discharge through the study reach. In the mid-1990's, the U.S Geological Survey (USGS) set up a FOURPT model to route water discharge from the USGS gauge at Cataldo to the USGS gauge at Harrison. This model evaluated in-channel flows, but did not attempt to model the interaction between the floodplain and lateral lakes. The authors are unaware of any attempt to route sediment through the study reach.

3. MODEL USED IN THE SIMULATION

The software used for this simulation is the MIKE suite of programs (MIKE11, MIKEView, and MIKE-GIS) developed by DHI Water and Environment (www.dhi.dk). From this suite, MIKE11 is the computational kernel that routes water (hydrodynamic) and sediment discharge through the modeled system. MIKE11 is a 1-d model that can be used as a pseudo 2-d (planform) by linking a series of branches to simulate the interaction between the main channel and adjoining floodplains, tributaries, and lakes. For the hydrodynamic component, the drainage system is modeled as a series of alternating water elevation and discharge computational points. MIKE11 solves the momentum equation and continuity equation between water elevation and discharge points, respectively (DHI Water and Environment, 2000). MIKE11 is capable of modeling steady-state (constant discharge) and fully dynamic (a flood hydrograph or time series) scenarios. The program is run through a graphic user interface (GUI) that allows easy data input and model setup.

Sediment routing is determined through the *Sediment Transport Module* (ST) or the *Advection Dispersion Module* (AD). These modules use the results from the hydrodynamic modeling to determine the transport rate of sediment through the modeled reach. Sediment transport rates can be calculated for either total load, bedload, or suspended sediment transport rates. Total load calculations in the *ST Module* are determined by one of three equations: Ackers and White, Engelund and Hansen, and Smart and Jaeggi (DHI Water and Environment, 2000). Bedload transport rates, also calculated in the *ST Module*, offer five equations to choose from including Engelund and Fredsoe; Van Rijn; Meyer-Peter and Muller; Sat, Kikkawa, and Ashida; and Ashida and Michiue (DHI Water and Environment, 2000). Suspended sediment can either be calculated in the *ST* or *AD Modules*. For non-cohesive suspended material, the *ST Module* offers equations by the Lane-Lalinske equation and the Ashida and Michiue equation, and the *AD Module* offers equations by Engelund and Fredsoe, and Van Rijn (DHI Water and Environment, 2000). Cohesive sediments are calculated using the *AD Module*. In this module, the user sets the entrainment and depositional velocities to dictate the transport of the fine material and uses the advection-dispersion equation to computationally route the material (DHI Water and Environment, 2000).

MIKEView is the post-processor for viewing the output file from MIKE11. A few of these display features include the longitudinal routing of the floodwave, hydrographs at a cross-section, stage at a cross-section, longitudinal sediment (aggradation/degradation), flow velocities, and concentrations of suspended sediment. The output may be displayed at a specified time or animated through the hydrographs being simulated. Again, these features are driven by GUI windows for easy display and manipulation of the software.

For incorporating GIS into the modeling, DHI Water and Environment has created MIKE-GIS. MIKE-GIS uses ESRI's ArcView and Spatial Analyst as its kernel for GIS analysis. The benefits of MIKE-GIS include easy input of floodplain data and creating data output from digital elevation maps (DEMs). Using DEMs, the floodplain cross-section and aerial elevation curve can be calculated and merged with a surveyed channel cross-section to incorporate the additional storage provided by the floodplain during flood events. This allows the user to forego time and resource intensive floodplain surveys. For data output, superimposing the water elevations over the DEMs allows the user to generate flood-elevation maps that show the extent and depth of inundation. These images can be combined to create animation of the flood event in either a planform or 3-d "fly by" view. In addition, the flood-elevation maps can be superimposed on digital orthoquads of an area for use as a powerful visual tool during public presentation.

4. MODELING DATA REQUIREMENTS

4.1 HYDRODYNAMIC –

For most 1-d hydrodynamic models, including MIKE11, the data required includes the river geometry, floodplain topography, and hydraulic boundary conditions. Topographic requirements include channel and floodplain cross-sections, DEMs of the floodplain, and the cross-sections and locations of side channels or low points in the levees connecting the main channel and the flood plain. For the lateral lakes, bathymetric (underwater topography) studies are necessary for generating the storage potential and calculating deposition within the lakes from suspended sediment. Because MIKE11 solves hyperbolic system equations for the hydrodynamic component of the model, both the upstream and downstream ends of the model path must have hydraulic boundary conditions (discharge, stage, or a stage-discharge relationship). Usually this is specified as a river discharge at the upstream boundary and a water surface elevation (or stage-discharge) relationship downstream. In addition, the lateral lakes' initial water levels are important since these lakes potentially account for significant floodplain storage. In the case of the CDA River, the discharge from the USGS gauging stations (Section 5.1.4) and the lake levels were used at the upstream and downstream boundaries respectively.

4.2 SEDIMENT TRANSPORT –

For the bedload and non-cohesive sediment transport modeling, input data includes the incoming sediment transport rate and particle size distribution, bedload material density, the streambed's particle size distribution, and the maximum depth of scour possible. For the cohesive sediment transport modeling, input includes the entrainment and depositional flow velocities and the maximum depth of scour possible. If sediment transport is believed to occur in the lateral lakes and along the floodplain, then lateral distribution of parameters must also be known throughout each one.

4.3 CALIBRATION/VERIFICATION DATA –

Calibration and verification data is used to adjust the model parameters so that observed conditions can be accurately simulated. For example, an independent data set from a different period of record is used to verify the model performance. This process must be done for both the hydrodynamic and sediment transport components in the model simulation.

5. RESULTS

5.1 DATA AVAILABILITY –

Government, tribal, academic, and private organizations have conducted environmental studies in the Basin for several decades. As a result of these studies, sufficient information about the lower CDA River exists to provide a basis for the demonstration modeling effort. Because these studies have been conducted by each entity independently, no central data "warehouse" exists that contains all available information. Therefore, the University of Idaho has compiled the following summary of the information, and its location, available for the modeling effort. Due to the extensive quantity of studies and large number of entities and individuals working on the CDA River, and the short duration of this demonstration project, this list may not be exhaustive.

5.1.1 Cross-section Information

Twenty-nine measured channel cross-sections exist along the study reach. From the USGS modeling effort, twenty-five cross-sections were measured from the USGS gauge at Cataldo to the USGS gauge at Harrison (Figure 1). Twenty-one of these twenty-five are concentrated between Cataldo and the confluence of July 4th Creek. Golder Associates measured the four other cross-sections upstream of Cataldo, two along the main channel and one in both the North and South Fork CDA Rivers. While these cross-sections provide an accurate profile of the channel, they are not connected to an elevation consistent with the rest of the channel.

In addition to the two cross-sectional data sets presented above, TerraGraphics and the University of Idaho collected seventy-two cross-sections along the mainstem and in the lateral lake connections during August and October 2001. These cross-sections will be used to supplement the cross-sections that already exist and will allow the modeler to expand the floodplain network and sediment transport calculation accuracy. These recently surveyed cross-sections are not included in the demonstration version of the model shown in this report. Details of the sampling effort are presented in Appendix A of this report.

5.1.2 Floodplain Elevation Information

Floodplain topography was determined by creating a mosaic of the USGS 7.5-minute Digital Elevation Models (DEMs) that cover the lower CDA River. The DEMs have a 30 m grid and 1 m vertical resolution. The elevations associated with each grid cell are an interpolation from the corresponding 7.5-minute topographic maps with 40 ft. contour intervals. The seven quadrangles that cover the lower CDA River are Kellogg West, Cataldo, Rose Lake, Lane, Medimont, Mount Coeur d' Alene, Black Lake, and Harrison. No measured cross-sections extending across the floodplain are available. Federal Emergency Management Agency (FEMA) maps covering the study reach are based on elevations surveyed following the 1996 event.

5.1.3 Lateral Lake Bathymetry

Lateral lake bathymetry is available from maps constructed by the Idaho Department of Fish and Game (IDFG) (Harvey, 2001) and IDEQ (1993). The IDFG bathymetric maps are created from sounding studies and are only available in paper copy (Harvey, 2001). The IDEQ map is of Rose Lake. These bathymetric maps were not incorporated into this simulation.

5.1.4 River Discharge Data

For the hydrodynamic boundary conditions, the USGS has five gauging stations throughout the study reach: Enaville, Pinehurst, Cataldo, Rose Lake, and Harrison (Table 1). The gauge location, gauge number, parameters collected, and period of the stage-discharge records are found in Table 1. The Lake CDA gauge is located near the dam at the outlet to the lake and was used as the lower boundary condition in this simulation.

5.1.5 Sediment Data

Sediment transport rates and the particle size distribution are available from the USGS gauges at Enaville, Pinehurst, Rose Lake, and Harrison (Table 1) (Clark and Woods, 2001). These transport rate curves are based on 8 to 12 points collected between February 1999 and April 2000 and encompass a 2-year storm event. Particle size distributions of the riverbed are available for the Golder Associates cross-sections for the upper sections of the study reach.

Table 1. Availability of hydrodynamic and sediment boundary condition data.

USGS Gauge Location	USGS Gauge Number	Parameters Collected			Period of Record for Stage-Discharge
		Stage	Discharge	Sediment	
Enaville	12413000	X	X	X	10/01/1986-09/30/2000
Pinehurst	12413470	X	X	X	8/12/1987-9/30/2000
Cataldo	12413500	X	X		5/1/1911-9/30/2000
Rose Lake	12413810	X			Not available
Harrison	12413860	X		X	Not available
Lake CDA	17010303	X			Not available

5.2 MODELING RESULTS –

5.2.1 Animation of Model Simulation

Modeling results are on the CD-Rom accompanying this report. File cda3.avi is an animated view of the 1996 hydrodynamic simulation results and includes the longitudinal view of the flood wave, hydrographs at three locations along the main channel, a cross-section, and the longitudinal view of Killarney Lake. File cda2d.avi is an animation of a series of floodmaps created from the 1996 hydrodynamic simulation results and file cda3d.avi, is a 3-d “fly by” for the same event. Both files were created in MIKE-GIS. Suspended sediment and bedload sediment routing results are in files cda4sed.avi and cda5sed.avi, respectively. Figures 1 a, b and c present a plan view of the current and proposed model routing paths and channel cross-section distributions.

With the data available, the MIKE11 model set up for the 1996 flood event showed:

- Attenuation of the flood wave as it progressed downstream through the system;
- Lateral extent of flood waters;
- Discharge in and out of the lateral lakes;
- Migration of the pulse of suspended sediment through the study reach;
- Variable sediment transport rate along the mainstem CDA River; and .
- Importance of the lake level for flooding in the lower CDA River.

These water and sediment discharge simulations through the lower CDA River are based on the channel geometry, hydraulic, bed and bank composition, and sediment transport data obtained from the data compilation efforts. Due to the limited data available, many assumptions and extrapolations were made to permit the model to run. Below is a description of the parameters and assumptions used in the simulations.

The lower CDA River’s longitudinal course and its branches were input by tracing USGS topographic maps. The discharge is primarily routed down the mainstem CDA River and the lateral lakes are branches extending off the mainstem (Figure 1). The branches act as storage reservoirs that help attenuate floods as they proceed through the study reach. The exception is Swan Lake, where the model has been set up to enter over a levee at the upstream end and exit through a stream outlet at the bottom end during flood events. This dynamic linkage between the flow over the floodplain and the main channel is more accurate than simulating Swan Lake as an offstream storage reservoir. Figure 1 illustrates other sections of the River that probably should be modeled in a similar manner as Swan Lake when sufficient data is available.

In the mainstem CDA River, twenty-nine measured channel cross-sections (twenty-five from the USGS and four from Golder Associates) and twenty-two interpolated cross-sections are used in the simulation (Figure 1). The four Golder Associates cross-sections were not surveyed to benchmarks, so their elevations were estimated to correspond with the DEMs. The interpolated cross-sections were created to aid in the numeric computations when the spacing between measured cross-sections was too large or at locations where a branch connects with the mainstem CDA River. The interpolated cross-sections were based on the nearest measured cross-section, though their elevations were adjusted to ensure that the channel progressed downhill.

Additional floodwater storage on the floodplain was determined by either extending the cross-section across the floodplain, developing an area/elevation curve associated with a cross-section or, for the lateral lakes, creating a terminal branch off the mainstem CDA River. Cross-section extensions and area/elevation curves were created from the DEMs using MIKE-GIS. Terminal branches were setup by tracing branches from the middle of the lake to the mainstem CDA River from USGS topographic maps; estimating representative channel cross-sections for the connecting channel; assuming the endpoints were no flow boundaries; and creating area/elevation curves at their endpoints for storage. The lakes were assumed to be 0.5 m deeper than the DEM elevations and the area/elevation curves were created from the DEMs.

The hydrodynamic boundary conditions used in these simulations are from the 15-minute stage and water discharge data for the Enaville, Pinehurst, and Cataldo gauges and the 15-minute stage data for the Rose Lake, Harrison, and Lake CDA gauges for the 1996, 1998, and 1999 water years. The USGS does not report discharges from the Rose Lake and Harrison gauges due to the backwater effect from Lake CDA (Lipscomb, 2001). Peak flows in the 1996 water year period are associated with a rain-on-snow event that occurred on February 6 through February 12, 1996 and produced flows with an 82-year return period.

Data for the suspended and bedload transport rates boundary conditions was obtained from the sediment rating curves generated by Clark and Woods (2001). The maximum flow observed during this set of data had a return period of two years, so the curves were extrapolated to account for the water discharges observed during the simulation period. Only suspended sediment transport rates are available for the downstream end of the study reach at the USGS gauge at Harrison. The water discharge rates for this area were determined from the modeling. The riverbed's median particle size upstream and downstream of Mission Flats was assumed to be 25.0 and 0.1 mm, respectively. For the bedload transport simulation, the lateral lakes were designated as "passive branches" and, therefore, no bedload discharge was calculated out of them into the mainstem CDA River.

The *AD Module* requires the erosive and depositional velocity to route coherent suspended sediment. The erosive and depositional velocities used for the simulation are 0.7 and 0.005 m/s, respectively. The erosive velocity was based on the velocity observed in the model at several different locations during the bankfull conditions in the lower mainstem CDA River.

Due to the lack of data, and because this is only a demonstration of technology, the model has not been rigorously calibrated or verified with separate data sets. However, for a working model, calibration of the channel roughness and attenuation along the study reach can be achieved using the water discharge data for the USGS gauge at Cataldo and the stage data for the USGS gauges at Rose Lake and Harrison. Verification of the model's accuracy can be tested by routing other events through the study reach and comparing the time series for the different flows.

5.2.2 Data Gaps –

The available data in the Basin provides a good basis for modeling the lower CDA River, however, a targeted sampling effort is needed to support the working model. Data gaps include channel geometry, flood paths across the flood plains, floodplain topography, lateral lake bathymetry, sediment transport rates, and particle size distribution of the bed and banks. In addition, monitoring at a range of discharges to calibrate the model coefficients such as roughness should be collected to calibrate the model. The following text specifically illuminates each of the aforementioned deficiencies.

Cross-sectional geometry in both the main channel and channels connecting the main channel, and the flood plains and lateral lakes needs to be bolstered. As currently modeled, the main channel has good channel cross-sectional coverage between USGS gauge at Cataldo and Rose Lake, but there is a paucity of cross-sections in the remainder of the channel. The minimum density of cross-sections should be one every kilometer and, preferably, a cross-section at the junction of any node connecting the flood plain or lateral lake to the main channel. No cross-sectional information is currently included for the connecting channels or low points in the levees. The seventy-two cross-sections surveyed by TerraGraphics and the University of Idaho in September 2001 should fulfill a significant portion of the cross-section deficiencies in the modeled reaches.

Routing floods over the floodplain requires knowledge of the floodplain topography and where levees are breached during flood events. For establishing the branch system, the maps from Bookstrom et al. (2000) and anecdotal history are useful sources. This should be augmented with a DEM created from 2 ft. contour intervals or less that encompasses the floodplain to the 500-year flood stage. The high resolution DEMs are important for coupling MIKE11 and MIKE-GIS in determining flooding extent and how the lateral lakes, channels, and floodplain interact during flooding. The high resolution DEMs will also be a valuable tool for determining areas where a 2-d flow model is necessary for understanding local flow conditions. Potential methods of obtaining this information are from aerial photographs flown by URS in 2000, or using LiDAR.

Additional sediment data that needs to be collected includes extending sediment-rating curves for larger flow events; determining the particle size distribution of the riverbed, lateral lakes, and floodplain; and determining the erosive velocity required to mobilize the colloidal and silt size sediments. Extending the sediment rating curves can be done by either sampling during higher flow events, or by applying derived sediment transport curves at the boundary locations. Of these two choices for extending the sediment rating curves, the former is more accurate, but may not be practical due to the rare occurrence of large storm events and the logistics and hazards of properly sampling during such an event. The latter choice can be one with little time and resource requirements, but would introduce greater error to the working model, as the precision of the sediment transport equations is less than field observations. For the colloidal and silt size sediment modeling, the erosive velocity needs to be determined empirically.

At the time of this report, University of Idaho personnel had not reviewed the bathymetric maps for the lateral lakes. Paper copies of maps currently available from the IDFG may be sufficient to determine a volume versus stage relationship. The sufficiency is based on the question attempting to be answered in future modeling efforts.

6. REVIEW OF TRENDS IN CHANNEL PLANFORM CHANGES

Aerial photographs available for the entire study reach include those taken by USFS and URS. The USFS aerial photographs are taken at a scale of 1:2,400 from 1937, 1959, 1965, 1975, 1983, 1991, and 1996 and are available in their CDA office. URS took aerial photographs in 1999 of the entire lower reach and up the South Fork CDA River Valley. The scale of these photographs is unknown as they were not available during the timeframe of this study.

Idaho Department of Transportation (ITD) reportedly takes aerial photographs of U.S. Highway 90, which follows the CDA River around the Mission Flats area and again near the confluence of the North and South Fork CDA Rivers. The frequency and scale of the ITD photographs is unknown, as they were not investigated for this review.

A qualitative comparison of the 1937 and 1996 aerial photographs revealed little change course of the CDA River channel downstream of Mission Flats. During this period the CDA River's course, connecting channels for lateral lakes, channel restrictions, and man-made structures are nearly identical. By 1937, the current railroad alignment was in place, restricting flow along the southern boundary of the CDA River. Floodplain deposits appear to be more extensive based on the absence and presence of vegetation (light areas on the flood plain are assumed to be associated with sediment deposits). The author presumes the channel stability exhibited throughout this reach is a result of the backwater effect from Lake CDA, which has raised the base level, thus, lowering the gradient. Changes in the CDA River's width were not examined as part of this analysis.

In contrast, the CDA River from the confluence of the South Fork and North Fork CDA River to Mission Flats showed significant changes including lateral bar creation and erosion, anastomosing channel branches, and lateral migration of the main channel. These changes are more pronounced in the reaches of the section where the Valley widens at Kingston and around Mission Flats. Around Kingston, the CDA River has switched the mainstem from the right to the left anastomosing branch and the smaller channels are not apparent in the 1996 aerial photographs. Where a narrow valley confines the CDA River, lateral movement of the channel is relatively minor.

Channel stability has implications in modeling. Static channel systems, where the channel remains unchanged throughout a range of flow events, are easier to model as the channel's course does not change over time. Channels that are highly dynamic, constantly changing their planform and channel geometry, require more frequent updating to keep them relevant and are less accurate in predicting the channel's response to a large storm event. A monitoring plan can be used to assess the accuracy of the model and the frequency and spatial extent of surveys to verify the model predictions are accurate.

As a future step in the modeling, the simulated shear stresses on the channel could be compared to the rate of channel migration to establish criteria for rates of channel change.

The analysis of aerial photographs also indicates which reaches of channel are relatively stable and which are the most active parts of the floodplain. These different processes could have a significant impact on management alternatives.

7. CONCLUSIONS

A numerical simulation was set up to route water and sediment discharge along the lower CDA River. Given the information available from studies previously conducted along the CDA River, the model reasonably replicates the CDA River's behavior during flood events for the water discharge. The results from the sediment modeling are less certain due to the lack of sediment data input into the model.

For a working model to be established, more data is required. The significant data deficiencies that need to be addressed include greater density of mainstem CDA River and lateral channel cross-sections; a higher resolution DEM that covers the floodplain; knowledge of the connection between the mainstem and floodplain (flow paths); extending the sediment rating curves on the upstream boundary to include high flow events; and a better characterization of the riverbed and lateral lakes sediments. If these deficiencies are addressed, then a working model can be constructed that would allow entities in the Basin to better understand fundamental processes acting in the CDA River, evaluate remediation alternatives and management actions.

Management of the CDA River system will require a combined approach of monitoring, analysis, and modeling. It is unlikely that a definitive and comprehensive solution can be developed *a priori*. More likely, an adaptive strategy will be developed that will require analysis and modeling of possible alternatives; the establishment of measurable performance criteria; monitoring to ensure these criteria are achieved; and analysis or modeling tools to evaluate the performance and trends of the implemented plan. The model will be very useful in addressing "what-if" scenarios. For example:

1) Can sediments be remobilized from the lateral lakes, if so, under what conditions?

2) If the elevation of the lake outlet is managed to keep a high water level to avoid remobilization of bed sediments, what will be the flooding implications upstream?

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APPENDIX A: COEUR D' ALENE RIVER CROSS-SECTION SURVEYS

A.1. Selection of Location of Cross-Sections

Forty-eight cross-sections were surveyed along the main channel and side tributaries to support the lower Coeur d' Alene (CDA) River modeling effort. This modeling effort extends from the confluence of the North and South Forks CDA Rivers to the mainstem CDA Rivers outlet into Lake CDA. Cross-sections were collected to augment the USGS cross-sections along the mainstem CDA River, support the branch networks used to simulate flow paths over the floodplains and lateral lakes, and provide cross-sectional data for the side channels connecting the mainstem and lateral lakes. TerraGraphics and University of Idaho personnel conducted the work in the period August - October 2001. Future modelers, in updating the current CDA River model, will use these cross-sections to refine the hydrodynamic component of the MIKE11 model.

Of the forty-eight cross-sections collected, thirty were situated in the mainstem CDA River and eighteen were collected from the channels connecting the lateral lakes to the mainstem CDA River. We selected the cross-section locations to be representative of the surrounding channel and to support the channel network for the branch modeling. For example, at the confluence of the mainstem and a connecting channel to a lateral lake, a cross-section along the mainstem and one along the connecting channel would be surveyed near the confluence. The cross-section in the mainstem CDA River would be sited a few hundred meters upstream or downstream to get a representative cross-section for the subreach. Sections were surveyed upstream and downstream of confluences with smaller channels only in the rare instance of the tributary significantly influencing the cross-sectional area downstream of the confluence.

Connecting channels between lateral lakes or wetlands adjacent to the CDA River had a minimum of two cross-sections along the channel. This minimum representation of the connecting channel is a requirement of a “branch channel” in the MIKE11 model. All of the channels were fairly homogenous in size, shape, bank composition, and vegetation between the two cross-sections. Additional cross-sections were included for locations that became flow control points during high flow events. These flow control points usually coincided with road and railroad bridges.

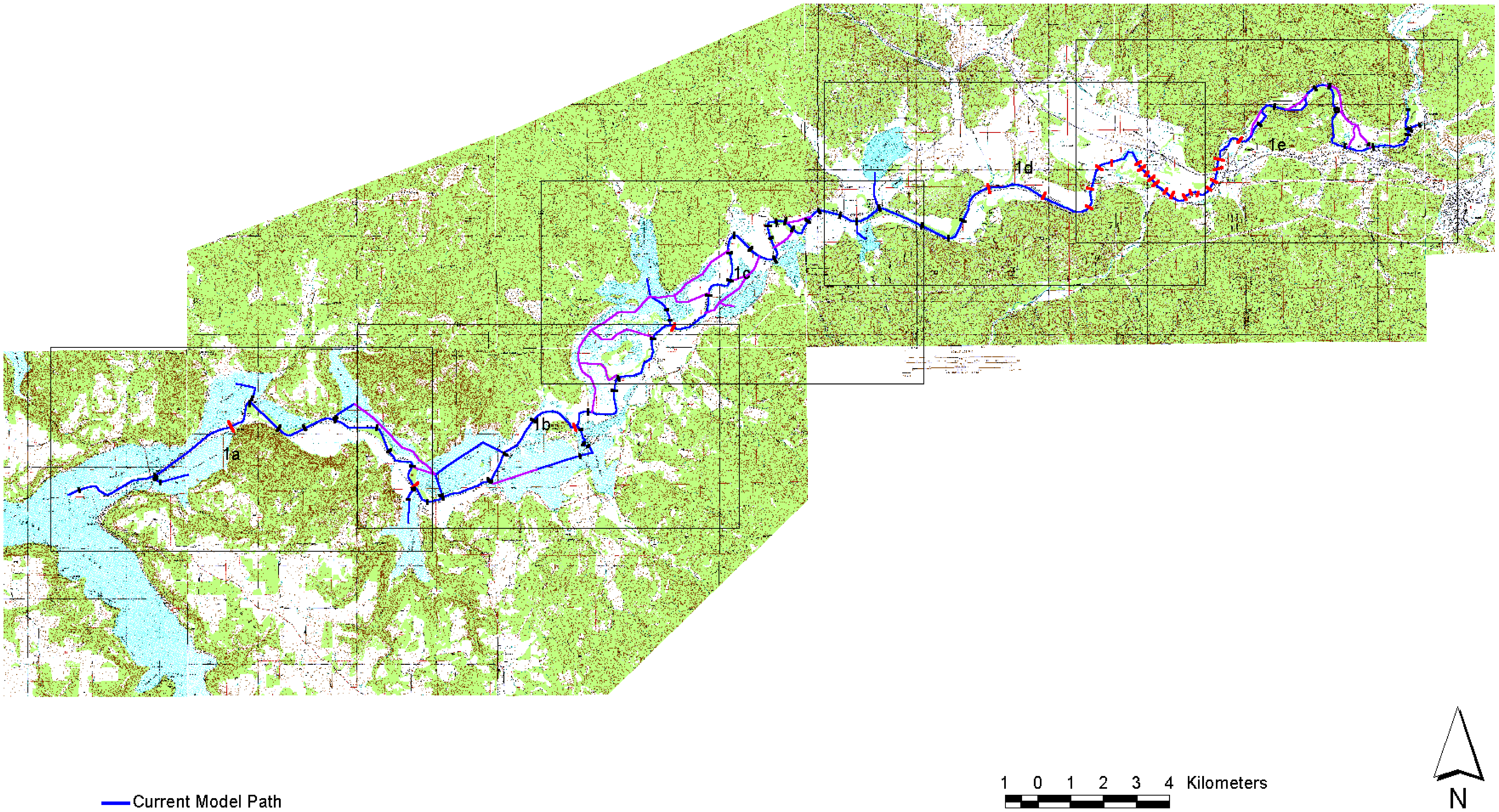
A.2 Surveying Methods

The surveying was undertaken with a survey grade GPS unit for the cross-sections. Translation of the GPS ellipsoid to the local geodetic coordinate system was established by occupying five horizontal benchmarks, seven vertical benchmarks, and two GPS benchmarks within and around the study area. The geodetic coordinate system used to record the horizontal and vertical locations are UTM 11, NAD 27, and NGVD 29, respectively. This calibration procedure allowed for an accuracy of 0.1 ft. and 2.5 ppm.

Cross-sections extended from the top of bank on either side of the CDA River. The endpoints were monumented with 2 ft. rebar pins driven flush with the surface and capped with annotated aluminum caps. The banks and shallow sections of each cross-section were surveyed using a Leica 530 roving GPS unit. Survey points were collected at every break in slope and at the water’s edge. Banks were usually defined by five to eight points, and channel bottoms were typically characterized by fifteen to twenty points.

For non-wadable portions of the cross-section (thalwegs ranged from 5 to 17 m deep along the mainstem), the GPS unit was connected to an InnerSpace Technologies Model 455 echo sounder to provide a bathymetric profile of the bottom. The echo sounder employs an 8° transducer to measure an area of the channel bottom to obtain an average depth. This method is advantageous over a point measurement in that the channel depth measurement is unaffected by ripples and dunes that may cover the channel bottom. For a typical depth of 10 m, this would result in a bed elevation averaged over an area of diameter 1.4 m.

A tag line for marking the cross-section line could not be strung across the channel due to the width of the CDA River, averaging between 100 and 200 m, and the large quantity of boat traffic present on the CDA River. Therefore, bathymetric data was collected by running the boat by "eye" between the markers established on either bank. Wind and boat wakes created deviations from the cross-section line. The maximum deviation, however, was within a ±1.5 m corridor surrounding the line. The GPS surveying technique does allow the exact horizontal position of the measurement to be known. Given the large width of the River and the longitudinal homogeneity of the streambed, this variation made little difference in the cross-section profile.

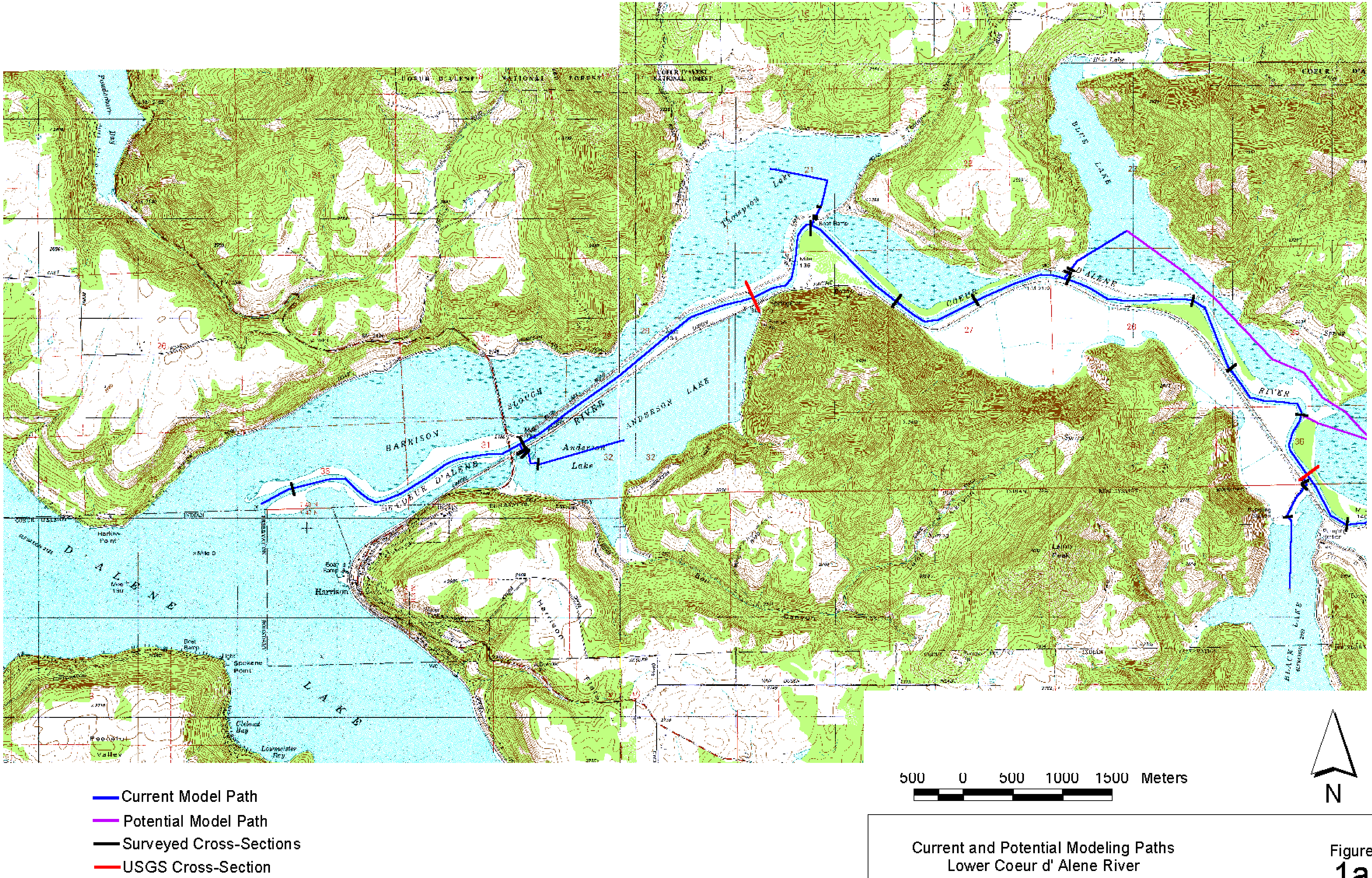


— Current Model Path
— Potential Model Path
— Surveyed Cross-Sections
— USGS Cross-Section

Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

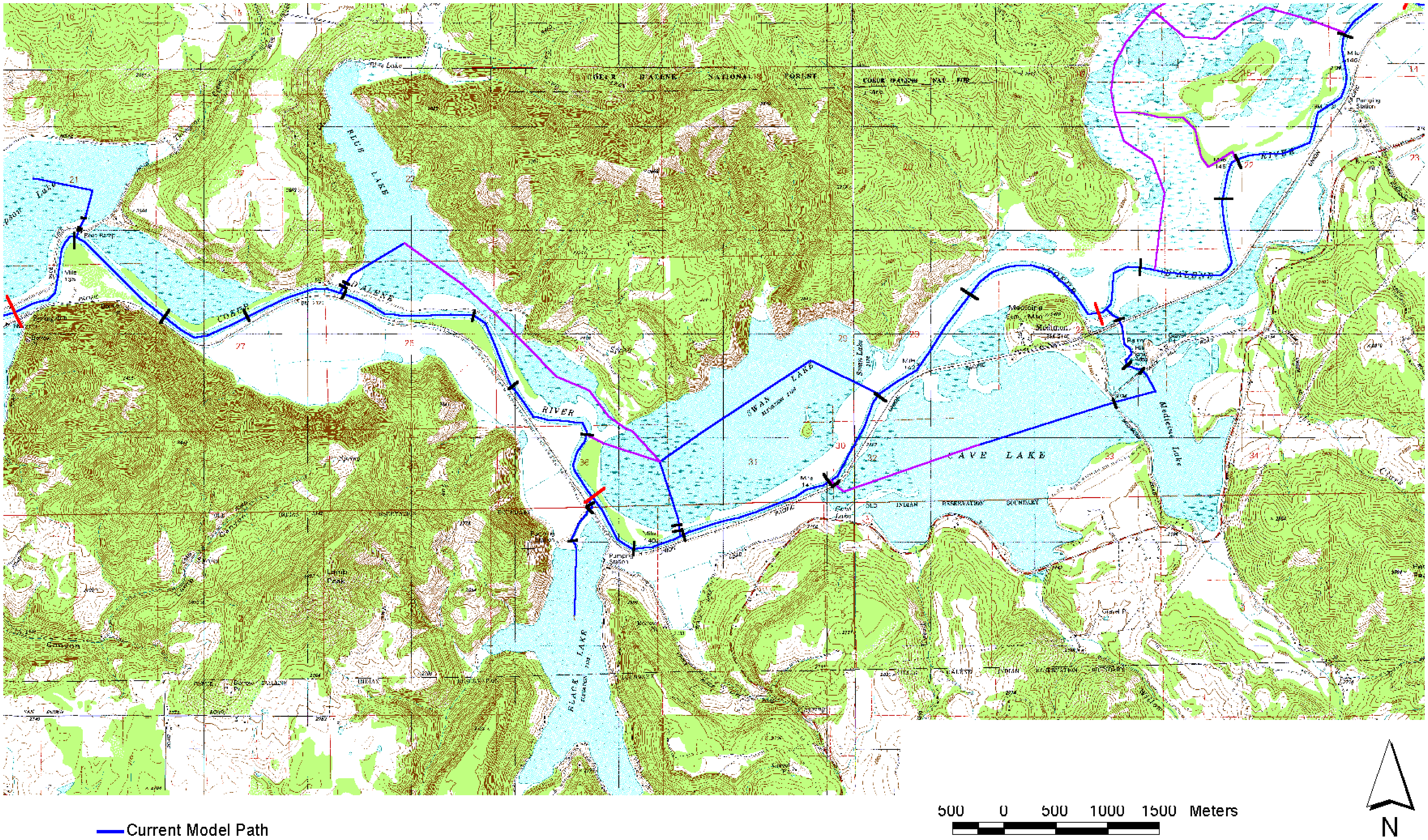
Figure
1



Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

Figure
1a

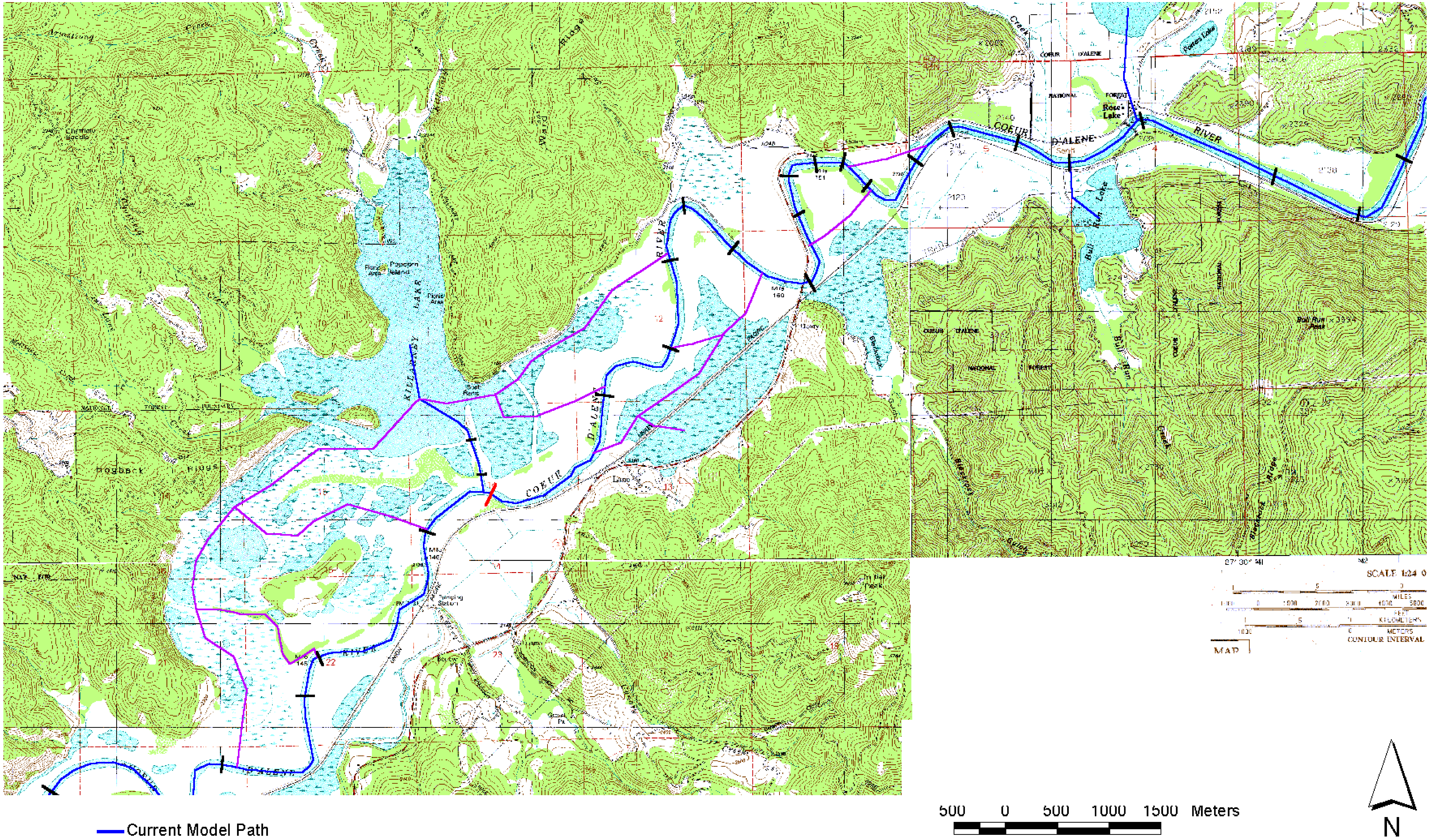


— Current Model Path
— Potential Model Path
— Surveyed Cross-Sections
— USGS Cross-Section

Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

Figure
1b

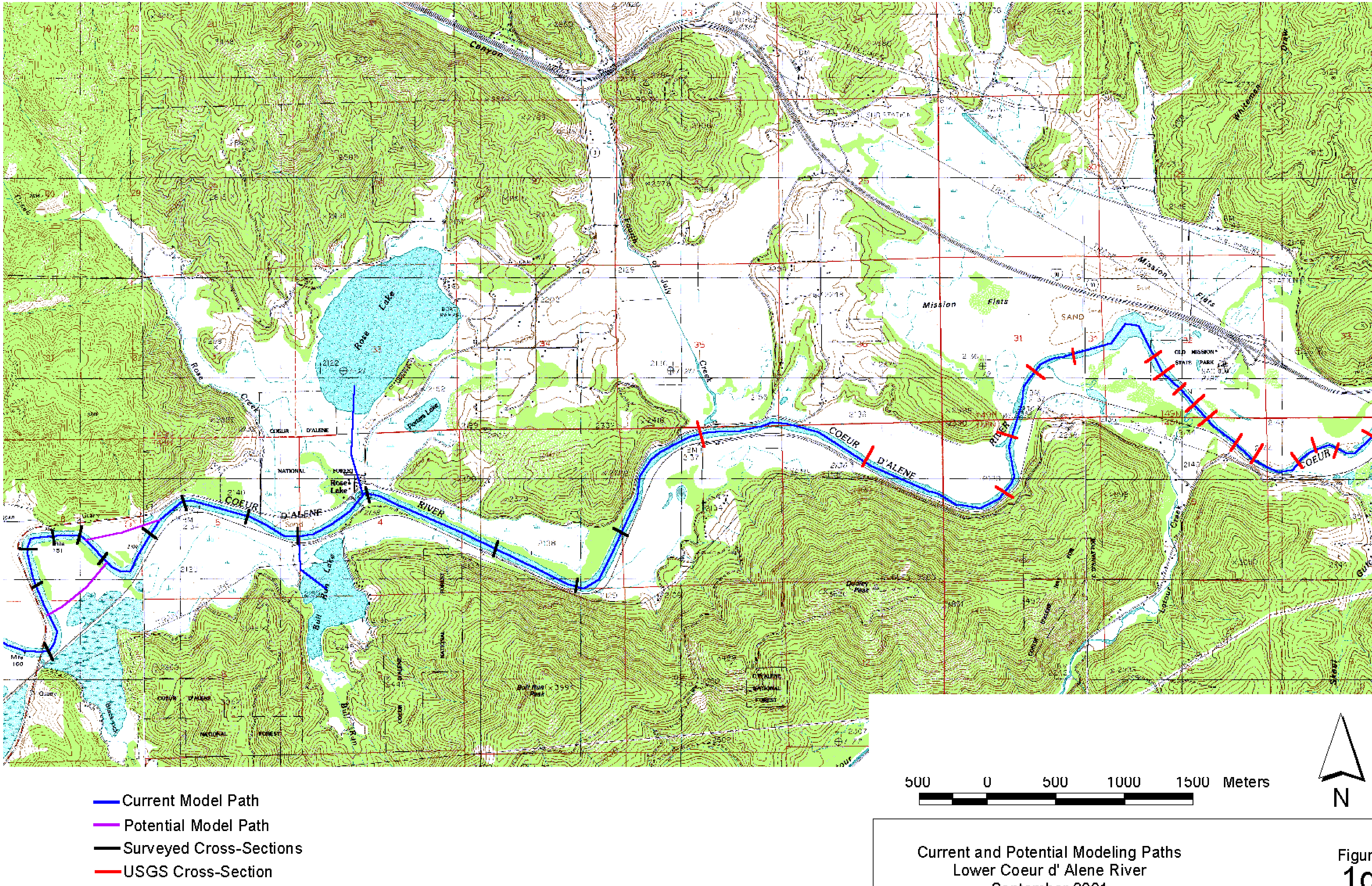


▬ Current Model Path
▬ Potential Model Path
▬ Surveyed Cross-Sections
▬ USGS Cross-Section

Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

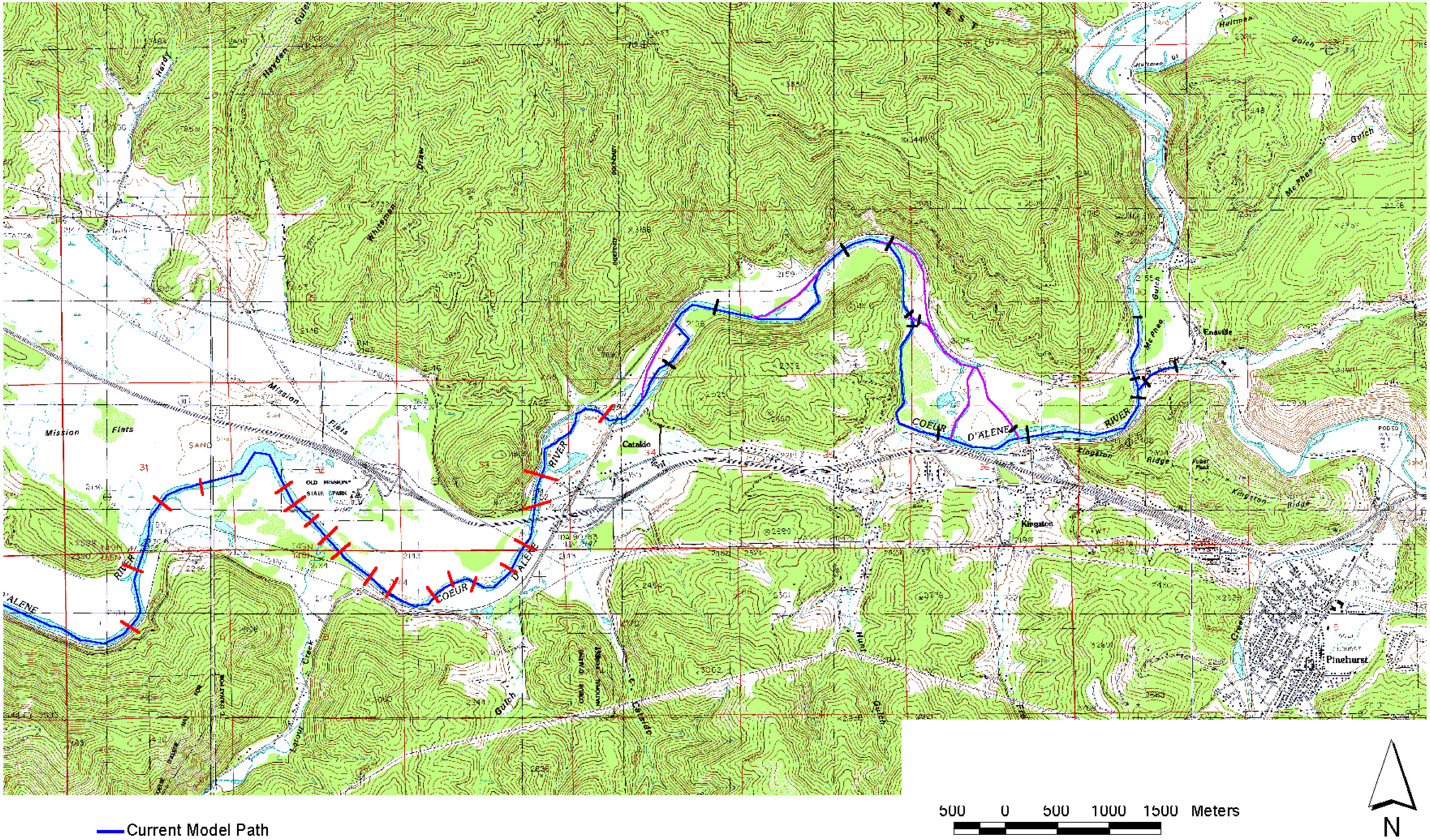
Figure
1c



Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

Figure
1d



- Current Model Path
- Potential Model Path
- Surveyed Cross-Sections
- USGS Cross-Section

Topographic Maps from the USGS 7.5' series.

Current and Potential Modeling Paths
Lower Coeur d' Alene River
September 2001

Figure
1e