LOWER SNAKE RIVER DRAWDOWN STUDY

APPENDIX B
TECHNICAL MEMORANDA

Submitted to

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Technical Memorandum No. 1

Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources

This technical memorandum lists and summarizes the reference sources and databases used to develop the computer models that helped form the analysis and findings for the Eastern Washington Intermodal Transportation Study (EWITS) by Washington State University and the Eastern Washington Freight Mobility Study by Lund Consulting, Inc. and HDR Engineering, Inc.

The EWITS work, which includes 35 reports and papers, was completed under the direction of Professor Ken Casavant between 1991 and 1998. These reports include information on the production and shipment of wheat and barley through Eastern Washington, including commodity movements, origin-destination patterns, transportation system characteristics, basic economic variables, and transportation operations. The EWITS compiled and analyzed these data into two models:

1. *An ARC/Info GIS database containing production centers, transportation systems, and transportation operating variables; and*
2. *A GAMS (General Algebraic Modeling System) econometric optimization model for testing the distribution, and more significantly, potential diversion of commodities from barge to rail and truck under a drawdown of the four lower Snake River dams scenario.*

The Eastern Washington Freight Mobility Study for the Legislative Transportation Committee (LTC) was completed in 1998, and included an Executive Summary Report and eight technical memoranda on subjects ranging from the evaluation and costs of rail capacity improvements to port access studies. These efforts utilized the EWITS database, as well as the traffic data and grade crossing information compiled and prepared by WSDOT, local transportation information, personal interviews, and other local and statewide transportation performance/operations information.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts.

Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

TM#	Topic
2.	Annotated Bibliography of Newly Acquired Data Sources
3.	Description of EWITS Model and Features
4.	Summary of Geotechnical Implications of Drawdown on Parallel Transportation Facilities
5.	Summary of Assumptions and Affected Corridors
6.	Summary of Corridor Impacts and Costs
7.	Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake River Reservoirs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction

As of July 1998, the Eastern Washington Intermodal Transportation Study (EWITS) produced twenty-six research reports and nine working papers focused on the transportation networks and commodity flow patterns of Eastern Washington. In the course of seven years of research, EWITS has compiled an extensive data library covering many topics related to the transportation of farm and forest products. Much of the data gathered by EWITS is available to the LTC for its Lower Snake River Drawdown Study.

The analyses completed for the *Eastern Washington Freight Mobility Study* are summarized in an Executive Summary report and eight technical memoranda. These documents, which were completed for the LTC in 1998, examined the projected infrastructure and operational needs in Eastern Washington freight transportation systems (i.e., freight rail, highway, and marine systems), and identified and recommended corridor, facility and system solutions which addressed those needs. Much of this data will also be helpful to the LTC for its Lower Snake River Drawdown Study.

The bibliography that follows is divided into three sections. The first section contains a list of sources compiled by EWITS in the last seven years. The second set contains information, utilized by EWITS, which was provided by outside sources and is readily available to the public. The third section contains descriptions of the technical memoranda produced as part of the *Eastern Washington Freight Mobility Study*. An appendix at the end of this memorandum contains data sets which were included as a part of the literature review for this study, but which were not directly used in the analyses for the LTC Snake River Drawdown Study.

I. EWITS Compiled Data Sources

The original data collected and analyzed by the EWITS team includes surveys of grain elevators, grain exporting companies, barge lines, and forest products production and shipping companies. In order to get accurate and detailed information in all of these key areas, EWITS researchers guaranteed that the responses to individual surveys would remain confidential. As a result, the study team could not easily verify much of the information referenced in the EWITS reports. While the study team benefited from the insights provided in the EWITS reports, they have largely been relegated to the Appendix.

ArcInfo/ArcView databases
These data files are most useful for the spatial information they contain relating to the orientation of roads, cities, ports and grain elevators. The EWITS researchers compiled these files from WSDOT and the U.S. Census Topologically Integrated Geographic Encoding and Referencing (TIGER) files, which are essentially maps of the road networks in Washington. EWITS researchers added nodes representing township centers and grain elevator locations to these TIGER files. This data set isintegral to the calculation of routes between all of the essential nodes in Eastern Washington as well as the length, speed limits, grades, and other physical characteristics of those routes. This information was also used to determine least-cost shipping alternatives.

ASCS production data organized by township and range
The Agricultural Stabilization and Conservation Services (ASCS) was a branch of the United States Department of Agriculture until recently when it was absorbed into the Farm Service Agency. The ASCS state office in Spokane provided EWITS with raw data on the 1994 wheat and barley harvest. The data includes the number of acres in production for both wheat and barley, as well as the number of bushels produced. Normally, the ASCS aggregates this data by county, but EWITS researchers coded individual farm records to correspond to a township and range. This more detailed level of data improved the value of the information since commodities could be grouped and assigned to more specific locations and travel routes. Because of the complexity involved in trying to replicate this process, the study team reused this information after indexing it to more recent data in order to account for changes over the last four years. To this end, the study team acquired data on wheat and barley production by county for the last 5 years (1992 through 1996).

Grain Elevator Survey
This survey is central to the EWITS' assessment of the modal split and transportation costs associated with the shipment of grain in Eastern Washington. This survey includes storage capacity, shipment modes, fees for storage and handling, and breakdown of percentages of grain shipped via each mode. While some of the information in this survey is confidential, the location, capacity, and available shipping modes were all used as the study team removed inconsistencies in the GIS database and econometric model.

Eastern Washington Road Needs Survey
EWITS researchers issued this survey to owners/operators of grain elevators in Eastern Washington. The survey contains information on rail transportation access, destinations, rates charged for storage and handling, percentage of grain received and shipped during

two-month periods, and geographic service areas. This data was available for the LTC study, however, much of the information is confidential, and could not be cited verbatim in the published analysis. The data files received from EWITS staff incorporate the results of this survey into the tables developed for the Grain Elevator Survey discussed above. As with the Grain Elevator Survey, this information was used to double check changes the study team made to the GIS database and the econometric model.

Washington State Freight Truck Origin and Destination Study
EWITS and the Washington State Department of Transportation (WSDOT) implemented this study which contains information about cargo type, tonnage, route, and use of intermodal facilities. In total, this Origin and Destination (O-D) Study is based on approximately 28,000 surveys gathered in 1993-94. WSDOT and the Eastern Washington Freight Mobility study team updated this data set for Eastern Washington in 1997, which is discussed in Section III of this memorandum under Technical Memorandum No. 5. Due to the size and scope of this database it is considered to be a robust and extremely useful set of data. For the purposes of this study, however, the survey results were used only to ground truth the routes selected by the model during its "existing conditions" run, to ascertain that identified routes were consistent with actual shipping patterns.

II. Other Data Utilized by EWITS

Lock Performance Monitoring System, NWCDC/BTS
The National Waterborne Commerce Data Center (NWCDC) produces this database, which is published by the Federal Bureau of Transportation Statistics. The data includes monthly and annual information on every barge passing each lock, including its tonnage, commodity type (by SIC code), and direction of travel. This data set was used by the study team to determine the flows of commodities other than wheat and barley. By providing the tonnage of all goods passing the locks in each direction, a rough estimate of the origin and destination of commodities on the river was possible. There were some serious discrepancies in this data which were identified during the verification phase of this project. These problems included missing data, and underprediction of commodity tonnages. Conversations with Corps of Engineers' Portland District staff revealed that they have had difficulty verifying the data during its preparation due to staffing shortages. The study team largely overcame these limitations by comparing the data with information provided by barge operators, grain growers, shippers, and the National Agricultural Statistics Service.

Oregon's Forest Products Industry, Timber Resource Statistics for Eastern Washington and Forest Statistics of the United States, USDA
The United States Department of Agriculture produced these reports in order to provide information on the ownership, quantity and production location (by county) of wood products in the Pacific Northwest. EWITS used this data extensively in an effort to study the collection and shipping of forest products. The study team used this information in order to better understand the flow of timber products to river ports. Because the Lower Snake River Drawdown Study only includes wood products which were shipped on the river, this document was used solely to verify the project's data on the movement of wood products.

III. Eastern Washington Freight Mobility Study

This study for the LTC is a compilation of an Executive Summary report and eight technical memoranda that was completed in 1998. The study examined infrastructure and operational needs in the Eastern Washington multimodal freight network (i.e., freight rail, highway, and marine systems), and identified and recommended corridor, facility and system solutions which addressed those needs. The databases and other reference sources used for each technical memorandum that was reviewed for the Lower Snake River Drawdown Study are presented below.

Technical Memorandum No. 5 - Eastern Washington Freight Truck Origin and Destination Study Update, HDR Engineering, Inc. and Casavant Consulting
This memorandum summarized the results of a truck origin-destination survey of 3,687 truck drivers at ten locations along the State highway system in Eastern Washington. This survey builds on the solid base of data on truck flows and commodity characteristics developed by EWITS researchers in their 1993/1994 truck survey. Information collected in the survey included truck and load weight, configurations, commodities, origin, destinations, specific route used, etc. The 1997 survey indicated that: 1) traffic volumes increased significantly on many segments of the highway system since the 1993/1994 survey, 2) that more trucks were carrying loads, and 3) that on average those loads were heavier. The study team used this data for the highway operations tasks completed for the Lower Snake River Drawdown Study.

Technical Memorandum No. 6 - Snake River Port Access Study, HDR Engineering, Inc. and Casavant Consulting
This memorandum provides a profile of each river port along the Columbia and Snake rivers between the Tri-Cities and Lewiston, indicating the principal commodities moved and the modes used. The report provides a fairly broad picture of the activities at each port, and identifies the planned and/or desired freight mobility projects identified by each port. The study team benefited from this report during the modeling and verification phases of this project when port activities needed to be identified.

Technical Memorandum No. 7 - Impact on Grain Movements from Columbia-Snake River Drawdown, HDR Engineering, Inc and Casavant Consulting.
This memorandum identified the results of an initial analysis of a drawdown of the Lower Snake River dams. The analysis reports on the methodology and variables used to evaluate how wheat and barley might be diverted from barge under a drawdown scenario. The description of the methodology contained in this document was helpful to the study team's understanding of how the EWITS optimization models work, however, the data contained in this memorandum was not used by the Team for any additional analysis.

APPENDIX

This appendix is intended to provide sources of additional information related to the transportation of commodities in Eastern Washington. These sources were identified during the data collection task for the LTC Drawdown Study, but were not used in the subsequent analysis.

Mill Shipment Survey
With this survey EWITS researchers attempted to gather information about the shipping patterns of timber products mills. The questions in the survey specifically target the final destinations of logs cut at the mills as well as log origins, and shipping and handling fees. This survey is confidential, and therefore was not evaluated by the study team.

Raw Log Shipment Survey
This confidential database contains information on the origins and destinations of raw logs shipped in Eastern Washington. Although this information has not been provided to the study team, a sample questionnaire included in EWITS report #15 indicates that it includes truck types, distance traveled, shipping rates and roads used. This survey is confidential, and therefore was not evaluated by the study team.

Commercial Shipments Survey
This survey is the third in a series, following the Mill and Raw Log Shipment Surveys described above. EWITS researchers designed the survey to measure the transportation of logs by commercial shipping firms, particularly those which specialized in the shipment of logs and timber products. The questionnaire indicates that EWITS researchers gathered data for freight quantities, final and originating destinations, and shipping rates. This survey is confidential, and therefore was not evaluated by the study team.

Industry Survey by Sector
EWITS researchers constructed input/output tables for Eastern Washington with the data from this survey. The information in these tables depicts the economic interrelationships between different economic sectors in Eastern Washington. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Survey of Eastern Washington Fruit, Vegetable and Hay Industries
This EWITS research was focused on the production and shipment of hay, apples and potatoes. A survey sent to producers and shippers garnered information about monthly fluctuations in product received and shipped, modality, destination location, capture area, and desired road improvements. Excluding grain, these three industries make up 80% of the agricultural production of Eastern Washington. While the information in this survey would have been useful to the Lower Snake River Drawdown Study because it reports on additional commodities, the data is confidential, and was not available to the study team.

Survey of Grain Merchandising Firms
EWITS researchers designed this survey to gather additional information about modes of transport and quantities shipped for grain. By surveying the points of collection before

grain is shipped overseas, this survey provides a supplement to the information gathered in the Grain Elevator Survey. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not necessary for the analysis performed by the study team.

Survey of New Businesses
This survey, which researchers prepared for EWITS Report #1, gathered information about the transportation needs of new businesses particularly in Eastern Washington. The questions in the survey focused on recent and future growth opportunities available to the surveyed companies, as well as on the transportation modes favored by business owners in Eastern Washington. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Survey of Residents in Communities Affected by Highway Bypasses
This data was gathered as part of a case study of three regions in Eastern Washington which were affected by highway bypasses that directed traffic away from their historic centers. The researchers interviewed business owners and public figures in three Eastern Washington communities. Results are primarily qualitative, and while valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Rail Waybill Data, STB
The Surface Transportation Board produces the Rail Waybill data from an approximate 1% sample of waybills for all railroads with more than 4,500 carload terminations each year. The sample provides information on the types and tonnage of commodities shipped between points. While the data is aggregated to protect the confidentiality of the rail operators, it is of very high quality. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not necessary for the analysis performed by the study team.

Cross Border Data, U.S. Bureau of the Census
This data is produced by the United States Bureau of the Census to document the flow of goods between the United States and Canada. The data includes information on value, volume and port of entry for both imports and exports. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Technical Memorandum No. 1 – Stampede Pass Corridor Grade Crossing Study, HDR Engineering, Inc
This memorandum utilized available highway and railroad traffic volumes, and highway accident data, to build an exposure value and index of delay score for each grade crossing in the Stampede Pass corridor. This data was used in conjunction with other subjective evaluation criteria to establish priorities for implementing projects for mitigating the impacts of increased train movements on the local communities accommodating the Stampede Pass alignment. Data on volumes and accidents, and information on the type and location of grade crossings, were provided in a database compiled and prepared by the Federal Railroad Administration in association with the WSDOT Rail Program Office. In addition, the resulting exposure values were compared with estimated delay values developed under the FAST (Freight Action Strategy for the

Seattle-Tacoma corridor) Study. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Technical Memorandum No. 2 – Lind to Ellensburg Rail Corridor Infrastructure Study, HDR Engineering, Inc

This memorandum reviewed the feasibility of reopening the Lind to Ellensburg rail corridor to relieve some of the grade crossing congestion that began occurring in Eastern Washington communities after the Stampede Pass rail corridor was opened. The memorandum identifies and evaluates the infrastructure improvements that would be necessary to reopen the corridor, and established concept level budgets for those improvements. The memorandum also described some of the relevant environmental, jurisdictional and economic issues that would need to be addressed prior to reestablishing train operations between Lind and Ellensburg. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Technical Memorandum No. 3 - I-90 Capacity Improvements, HDR Engineering, Inc.

This memorandum summarized the results of the May 1996 Route Evaluation Study prepared by the WSDOT South Central Region which analyzed proposed I-90 capacity improvement concepts. Four separate concepts for adding an additional lane in each direction of the 55-mile long segment of I-90 between Hyak and Ellensburg were considered ranging from: the least expensive alternative involving a widening of the existing pavement while maintaining the existing alignment (portions which are designed only for 50 mph); to a high cost alternative involving upgrading both the horizontal and vertical alignments to full interstate design standards and a 70 mph design speed. Traffic data and characteristics which supported this analysis, were provided by the WSDOT Travel Data Office and the Olympia Service Traffic Office for their 5/96 Route Evaluation Study. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Technical Memorandum No. 4 - Highway Strategic Corridor Update, HDR Engineering, Inc.

This memorandum summarized the methods used to develop and verify truck movements on state highways in eastern Washington that were collected by traffic recording equipment in 1996. These data were checked for reasonableness by reviewing historical records, as well as different sets of truck volume data for similar highway sections that were collected by other agencies (i.e., 1) Benton-Franklin Regional Council, 2) Spokane Regional Transportation Council, 3) International Border Customs Offices at all POEs between US and Canada, 4) Origin-destination data collected by EWITS, and 5) Transportation data collected by Washington Water Power. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

***Technical Memorandum No. 8 - Eastern Washington Freight Mobility Project Prioritization*, HDR Engineering, Inc.**
This memorandum summarized the methodology that was developed by the Eastern Washington Freight Mobility Advisory Committee (Eastern Washington FMAC) to identify, evaluate, and prioritize potential freight-related projects throughout eastern Washington. High priority Eastern Washington projects identified through this process were recommended to the LTC for state funding as part of a proposed state mobility program. While valuable for providing context for the LTC Drawdown Study, the data provided in this document was not relevant to the analysis performed by the study team.

Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 2

Annotated Bibliography of Newly Acquired Data Sources.

This technical memorandum addresses the data that the HDR study team has reviewed for the Lower Snake River Drawdown Study beyond that provided by EWITS and the Eastern Washington Freight Mobility Study (described in Technical Memorandum No. 1). These data sources are available in the public domain, and include information prepared by the U.S. Army Corps of Engineers.

These data sources were used to update and refine much of the foundation data present in the optimization model initially prepared by EWITS for downbound wheat and barley products. In addition, these data describe the production and flow patterns of other commodity types moving on the river system which were also analyzed under the Lower Snake River Drawdown Study. Much of the information described here is also central to the Corps of Engineers' (COE) analysis for its EIS of the lower Snake River dams' System Operation Plan.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four Lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts.

Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

TM#	Topic
1.	Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources
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7.	Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake River Reservoirs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction

This bibliography is intended to provide a brief description of the authors and data types of a number of reports and datasets which supported the analyses completed by the study team. The bibliography provided below describes the data sources used by the study team in its analyses, and includes sources which were beneficial for the raw data they provided, as well as other sources which simply provided context for the analysis. Both types of sources are included below.

The analyses completed for the Lower Snake River Drawdown Study were built from a wide variety of data sources in the public domain that allowed the study team to assess the impact of a drawdown on the movement of the commodities in that region. As described *in Technical Memorandum No. 1-Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources*, much of the data and findings provided by the Eastern Washington Intermodal Transportation Study (EWITS) and *the Eastern Washington Freight Mobility Study* have value and relevance to this current analysis. The information required for this Lower Snake River Drawdown Study, however, called for a different set of analyses and a broader range of commodity types and transportation variables than those presented in these earlier studies. The study team augmented and verified the existing data as the analytical findings of the current study were formulated.

National Waterborne Commerce Data, NWCDC

The National Waterborne Commerce Data Center compiles these statistics from federally mandated reports that barge shipping companies are required to fill out for every trip they make. The reports are particularly useful for the origin/destination data they contain, however, they are also valuable because of their comprehensiveness. Data includes origin/destination, tonnage and commodity type. According to Jim Fredericks of the U.S. Army Corps of Engineers (COE), Portland District, there are some flaws in this dataset; such as: 1) the coding system for identifying specific docks can be quite confusing, and 2) COE staff who have worked with the data have said that some of the numbers are clearly wrong (i.e., grain shipments indicated as destined for locations where there are no handling facilities, and locations which are unknown to shippers or producers). The data available to the study team is aggregated by year, however, the monthly summaries, which would be most useful, are available only to federal agencies. This data is similar to that gathered for the Lock Performance Monitoring System (described in *Technical Memorandum No. 1-Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources*) which gathers information for all barges passing each individual lock. The NWCDC data, however, indicates an exact origin and destination, rather than simply the number of barges passing a particular location. The study team found this data difficult to use because of confidentiality restrictions which aggregate results when there are fewer than three companies providing service of a commodity to a dock. Because of the limited number of barge operators, and the nature of their contracts with particular operators, this dataset could only be used as a check on the LPMS data on an annual level. Specific assumptions about tonnages to a specific dock were not drawn.

1992 Drawdown of Lower Granite Dam, COE Walla Walla District

This report describes the objectives, methods, and results of the 1992 test drawdown at the Lower Granite Dam on the Snake River. The report does not deal extensively with transportation issues. The drawdown lasted only a month, and two of those weeks involved the closure of the dam for its regular annual lock maintenance procedure. According to Greg Graham, Project Manager for the COE EIS on the Lower Snake River System Operations Review, since river navigation was only forced to close for two additional weeks, shippers probably stored and delayed most of their shipments during the period. The COE did not expect alternative modes of transport to play an important role during this short period. The report is focused on the general effect that the drawdown had on adjacent roads and railroad tracks.

Port Series #34, NDC
The Navigational Data Center is affiliated with the COE in that they share information resources. Port series #34 is one of a set of manuals providing information on individual ports. The #34 report covers ports in the Columbia River Basin. Each manual in the series includes information pertaining to location, port owner/operators, grain elevator names, addresses, and storage capacity. The report was particularly important because it was used to determine which docks were within the pool of a particular dam as well as the commodity handling facilities available at those docks. The report also provided contact names and numbers for each of the docks.

System Operation Review Transportation Model, COE Walla Walla District
This report has been identified as the blueprint that the COE is using for its analysis of transportation impacts resulting from a lower Snake River drawdown. The report was used primarily as a benchmark for the methodology pursued by the study team, however, the report and its numerous appendices contain a significant amount of information culled from some of the above named resources which was used to check information from other sources, and to verify certain characteristics of the transportation system.

1993-1995 and 1997 Crop Acreage for Wheat and Barley, Washington State Farm Service Agency
This dataset contains the 1993-1995 and 1997 totals for crop acreage planted for wheat, barley and numerous other commodities. The Farm Service Agency (FSA) is the Agricultural Stabilization and Conservation Service under a new name The FSA underwent a restructuring in 1996, and did not collect crop acreage data for 1996. The data is aggregated at the county level. This data set provided information which allowed the study team to index the township range data prepared for EWITS to 1997 levels in order to keep the econometric model as close to current as possible without the complex task of recreating the 1994 database.

1987-1997 Timber Harvest Summary, Department of Natural Resources
The study team has procured this data as part of its effort to add the transportation of forest products to the econometric model created by EWITS. This data details timber production in board feet for each county in Washington, and identifies it as coming from private, state, tribal, forest service or other federal lands.

1996 Washington Timber Harvest, Washington State Department of Natural Resources
This study contains much of the same information presented in the National Timber Harvest Summary described above. This data has the additional benefit of dividing the information by tree species within each county.

Washington Mill Survey, 1988, 1992 series reports numbers 11and 13, WS DNR
The study team has reviewed these surveys which provide the most recent published information on the quantities of different types of lumber used at mills throughout Washington State. The 1992 survey was first published in March of 1998, no data was collected for 1994. As with the above two documents, this survey added to the study team's understanding of the movement of timber products in the region.

Tri-Port Economic Impact Study

This study, commissioned by the Ports of Clarkston, Lewiston, Whitman County and the Northwest Power Planning Council, provides information about the direct and indirect economic impacts to the ports from the proposed drawdown. This information includes an input output model which identifies potential job shifts out of the region, and an itemization of the contributions of various sectors to the cities' total economy. This information was used contextually in the study, and was important for identifying some of the effects of adrawdown which were not within the scope of the LTC Drawdown Study.

Economic Impact Study for Eastern Oregon: Opportunity Costs of Columbia River Management Actions

This report is similar in content to the "Tri-Port Economic Impact Study" described above. It examines the impact of both water restriction and navigation closure on the Columbia River. It provides an input/output model for this region similar to others prepared for the Tri-Ports, and by EWITS for Eastern Washington as a whole.

1995 Marine Cargo Forecast: Technical Report

This study was prepared for the Public Ports Association and the Washington State Department of Transportation. This study was used primarily for information regarding the current and projected capacities of the ports along the Columbia River, as well as for a general look at some of the infrastructure needs of both upriver and export ports in the Columbia Snake system.

Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 3

Description of EWITS Model and Features

This technical memorandum summarizes the project team's evaluation of the Eastern Washington Intermodal Transportation Study (EWITS) Commodity Flow Model produced by the EWITS team between 1991 and 1998, and reviews the potential for expanding the model to include not only wheat and barley products, but other upbound and downbound commodities.

This evaluation outlines the steps that the project team took to construct an updated and revised set of commodity flow models. These models use software packages that are more accessible to the general public than those used by EWITS, and perform more effectively and efficiently with the ArcInfo and ArcView GIS platforms which are necessary for completing and displaying the results of the analysis.

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Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

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In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction

This technical memorandum summarizes the study team's evaluation of a set of computer models developed at Washington State University under the direction of Dr. Ken Casavant, with major contributions by his former research associates Dr. John Ellis and Dr. Eric Jessup. These models, particularly the commodity flow model[1], were developed to support the Eastern Washington Intermodal Transportation Study (EWITS), and to provide insight to policy makers as to how a range of environmental and transportation policies may impact local roadway usage and local economies.

Modeling the Transportation Networks of Eastern Washington

The proposed removal of four dams on the lower Snake River will change the way goods flow from producer to market in Eastern Washington, as the Snake River would cease to be navigable by barges. In order to accurately assess these changes, it is necessary to identify the factors which contribute to the current system, and to determine how those factors would be influenced by the removal of the dams. A model simplifies a complex system to the point where the variables can be changed and a reasonable outcome can be hypothesized. In the case of commodity flows in Eastern Washington, the basic assumptions shaping the commodity flow model are: 1) that commodities will continue to be produced at current levels, and, 2) that minimization of transportation costs will be the determining factor in the selection of a route and mode for shipment of goods to market. When the options for shipment are changed by removing the Snake River barge route as an option, it is possible to hypothesize the subsequent impacts to alternative routes. This basic goal can be achieved with a variety of assumptions and modeling systems. This memorandum evaluates the assumptions and modeling architecture/system developed by the EWITS researchers.

The EWITS Commodity Flow Model

The commodity flow model can more precisely be described as a modeling system, which consists of three distinct steps, incorporating three separate computer procedures:

1. The first step in these procedures involves the Geographic Information System (GIS) package ArcInfo which is used to re-create the extensive farm-to-market roadway network of Eastern Washington, including all primary and secondary roadways. ArcInfo is then used to develop an extremely wide range of possible truck routes for shipping agricultural commodities from all production areas of Eastern Washington to their respective market destinations. These destinations include local grain elevators, elevators with rail connections, and ports along the lower Snake and Columbia rivers.

   The specific agricultural commodities considered in the model are wheat and barley, which comprise the vast majority of commodities shipped down-river. The model is configured to use Portland, OR as the ultimate destination for all wheat produced in Eastern Washington for export. It also assumes that a portion of the barley production is exported, with the balance fed to livestock at various feed lots across Eastern Washington. The output of this GIS component includes identification of all possible truck routes from wheat (and barley) producing areas to local grain elevators, to elevators with rail connections, and to river ports. The output also includes the distance associated with each route, which is subsequently used to estimate a cost for shipping grain along this route, expressed in dollars per bushel ($/bu).

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1 "*A GIS Commodity Flow Model for Transportation Policy Analysis: A Case Study of the Impacts of a Snake River Drawdown.*" EWITS Research Report #18. 1997.

2. The output from the above GIS model is used as input for a linear programming model that identifies the transportation routes and modes which minimize the overall cost of shipping grain to its ultimate destinations. This route and modal assignment component of the modeling system is what is commonly referred to as the EWITS commodity flow model. The linear programming (LP) model, which was assembled using the GAMS[2] software package, is an extensive, yet simple, tool for minimizing transportation costs on a statewide scale. Input to the LP model includes:

   - Identification of all truck routes, and their respective mileage and posted speed limits, for transporting grain (wheat and barley) from farm to market. The markets include local elevators, elevators with rail connections, and river ports;
   - Identification of truck routes and costs for shipping barley to regional feed lots;
   - Costs of trucking grain from local elevators to ports and railheads;
   - Cost of shipping grain by rail from elevators to Portland;
   - Cost of shipping grain by barge from river ports to Portland;
   - Wheat and barley production levels, expressed in bushels, from individual townships in Eastern Washington;
   - Capacities of local elevators; and
   - Capacities of elevators with rail connections.

   The above information is described in the LP model, which subsequently calculates the combination of routes and modes which minimize overall shipping costs. If the costs identified above are accurately estimated, the resulting routes and modes will result in truck, rail, and barge shipping flows which closely resemble historic patterns. However, there are inherent difficulties in accurately estimating the "true" costs of transporting grain, in the sense that there are many non-quantified costs such as value of the farmers' time during harvest, local marketing protocols, and other road and elevator capacity constraints. As a result, there is no guarantee that the LP model will accurately replicate historic patterns without some outside assistance from the model developer (i.e., post-processing, or manually adjusting the processes and results produced by the model). This is a common practice with linear programs and should not be interpreted to mean that the model produces erroneous results. Modifications to the model, identified in a later section, can partially overcome these problems.

3. Finally, the output from the LP model is input into an ArcView GIS framework for purposes of mapping routes and frequencies. Each route used in the LP model is then translated into a roadway segment so that the volume of grain moving on each roadway segment can be shown graphically. Later sections of this memorandum include sample output maps.

Obtaining and Using the EWITS Model

The EWITS model was obtained from the EWITS study team in June, 1998. Study team members have successfully "re-run" the model on local hardware and software, reproducing the same results that were obtained by the EWITS staff. Since then, a range ofobservations about the modeling system's mechanics and data inputs have been made based upon these initial test runs. These observations are summarized below.

[2] GAMS is an acronym for Generalized Algebraic Modeling System, which describes the specific software package used to develop and solve the LP model.

The Architecture of the EWITS Model. Overall, the GIS-LP modeling system runs in a logical sequence and works correctly, producing feasible and optimal solutions to alternative transportation system and wheat production scenarios. This was a significant accomplishment by the EWITS team, however, there are a number of refinements that can assist in making the model more efficient and effective, as follows:

- *The modeling system is not linked electronically.* Currently, the system needs operator assistance in order to electronically extract roadway routes and their costs from the GIS model for use in the LP model. The LP model is also designed to require the modeler to extract LP output for mapping in the ArcView platform. This results in the analyst having to run three separate processes to reach a single solution. This labor intensive process results in the analyst spending a significant amount of time waiting for computer programs to complete runs. The primary explanation for this is that the computer software packages are not fully compatible with each other.

- *The software requirements of the system require a unique set of computer skills.* The GAMS computer language tends to be used in academic research and for highly specialized optimization applications. It is not a commonly used software package and is not very compatible with other software. The GIS packages, ArcInfo and ArcView, are very common and well-used but tend to be operated by GIS specialists. Thus, the EWITS modeling system requires proficiency in all three packages, which is a set of skills very few individuals possess. As a result, it may take several specialists to use the system. It is doubtful that this was the intent of the model sponsors or developers. At the time of the model's development, GAMS was the most practical software application for the relatively large EWITS model. However, since then there have been several innovations made in spreadsheet-based LP packages, and converting the GAMS model to a spreadsheet-based application is now an appropriate course of action. This is discussed in more detail below.

- *The modeling system's graphical output is not standardized.* Computer coding necessary to develop ArcView's graphical representations of the system's results was not saved for future modification. The graphics were prepared in an inconsistent manner, and while this is not a serious shortcoming for those proficient with ArcView, it does require a set of unnecessary steps to reproduce this process.

- *There were still errors in the LP model.* The EWITS team's quality control review of the LP model eliminated many of its errors, but not all. Several errors were discovered in which more wheat or barley were demanded from regions than were actually produced, or where grain would become "stuck" at an elevator without any means of getting to a port or railhead. These errors were not sufficiently severe to "crash" the model or discredit its overall results. However, care must be taken when reviewing analyses of specific regions of Eastern Washington.

- *The LP model is not equipped to "solve" for all circumstances.* The only method considered by the LP model for getting grain to the Portland area is by barge or rail. There is no opportunity to truck grain to its final destination. In addition, the constraints embodied in the model, discussed below, preclude the possibility of significant increases in truck traffic towards the Tri-Cities ports resulting from a drawdown scenario. The analyst needs to correct for this by manipulating data outside of the model.

The EWITS Model Input Data. Discussion regarding the modeling system's data input is focused upon data used in the LP model to determine least-cost routes for moving grain to port. Much of the information used by EWITS in 1994 is not suitable for use today (for a more detailed description of these changes refer to *Technical Memorandum #5 Summary of Assumptions and Affected Corridors)*. The model's input data requirements are summarized below:

- *The costs of transporting commodities are outdated.* All costs are expressed in dollars per bushel of grain transported and include trucking costs, rail costs, and barge costs. These costs were updated based on conversations with industry groups, shippers, and current tariffs.

- *Estimates of local commodity production are outdated.* Wheat and barley production rates are based at the township level. Although this data is probably accurate for the 1993-94 season, there is no rigorous method for updating these values because this commodity data is not commonly collected at the township level. In an effort to better understand the localized distribution networks, the State Office of the Agricultural Stabilization and Conservation Service (ASCS) compiled township production data for wheat and barley, specifically for the EWITS model. As an alternative to replicating this data collection process, township production levels were indexed based upon a comparison of 1994 and 1996 county production levels.

- *There is no data regarding port capacity for handling Eastern Washington grain.* Given the relative costs of transporting grain by each route to its ultimate destinations, the model is configured to truck grain from the farm directly to the nearest port, for barging to the Portland area. This may not be physically possible given the volume of grain and the handling facilities at ports. The EWITS team attempted to overcome this issue by limiting the number of producers who would move grain in this manner only to those producers located within approximately 20 miles of the Snake River. The model then forces all other producers to truck grain to a local or regional elevator for eventual shipment down river.

  The EWITS team's trucking constraint appears to have worked for their baseline scenario but it hampers the model's ability to predict what may happen to truck traffic with a drawdown, or any other transportation system scenario. Based on the assumption that handling facilities would be improved to meet demand in the long run, capacity at the ports was not restricted. This has the effect of overpredicting the quantities of grain that would flow to some ports, especially the Tri-Cities ports of Pasco, Kennewick and Burbank. While demand at some ports is overpredicted, the assumption that facilities could be improved to handle additional grain is a reasonable one. In addition, while the constraint on trucking to ports calibrates the results of the model under the base scenario, it is not certain that the same constraint would describe behavior under a drawdown scenario.

Converting from GAMS to Excel to Run the Model. As mentioned above, the LP model was developed at Washington State University (WSU) in the GAMS programming language. GAMS is a relatively expensive software package and requires a period of training in the package to develop proficiency. During the early stages of this evaluation it became apparent that converting the model to a spreadsheet-based software package would significantly reduce the overall costs of model development, model usage, and future modifications. In addition, converting the LP model to a common application also increases its utility in the sense that it makes the model more accessible to a greater number of potential users.

The model was converted to the spreadsheet package Excel and uses the LP software "What's Best" as an add-in to assist in the complex calculations completed by the model. A further benefit of this conversion is the potential for substantially streamlining the modeling system's operation. Excel is a more compatible software package, which is easily linked to the ArcInfo and ArcView GIS components. These future linkages will reduce the time and labor required for examining a model scenario. The EWITS model system developers at WSU agree with this assessment and support its conversion.

Development of Additional Model Components. A greatly simplified version of the LP model was used to assess the impacts of upbound commodities and additional downbound commodities. Upbound commodities included fertilizers and petroleum products. In addition to wheat and barley products, downbound commodities included forest products and containers.

These additional model components were developed based on the same shipping cost minimization premise used in the wheat and barley LP models, except with a limited set of production and destination points due to limitations in the available data and the complexity of the pre-market movements of some of these products. Movement of these additional commodities was represented using a spreadsheet-based LP model. Each commodity was also given a port of origin and a final destination along the river. Transportation routes and modes were identified between these points, and the least cost routes from origin to destination were selected. All model output, including the wheat and barley models and the models developed for these additional commodities, was directly linked to the ArcView graphics component to illustrate traffic levels under the baseline conditions and under alternative conditions.

Using the Model to Determine the Impacts of Barge Restrictions

As previously mentioned, the modeling system, as obtained from the EWITS team, was installed and run successfully on local hardware and software. Baseline scenario tests resulted in identical results to those produced by EWITS staff. After conversion to the spreadsheet-based LP package, the model was run again, and once again successfully reproduced the EWITS results.

After achieving identical model results, the system was given a "trial run" for wheat. That is, a scenario that restricted lower Snake River barge traffic was developed and evaluated. This "no barge" scenario specifically eliminated the ability to ship wheat from ports upriver of the Tri-Cities to the Portland area. However, it allowed for the option of alternatively shipping this upriver wheat to Portland by rail, trucking the grain directly to the Tri-Cities for subsequent barging to Portland, using rail to ship grain to the Tri-Cities, or trucking directly to Portland.
For a description of the LTC Lower Snake River Drawdown Study model and the study team's results refer to *technical memoranda Nos 5-7*.

Further Model Development

Several conclusions were made about the EWITS commodity flow model which led to further model development:

- From an operational standpoint, the modeling system works the way it was intended to: i.e., it determines the least-cost transportation modes and routes to get Eastern Washington grain to final destinations. However, the historical use of incompatible software packages makes the system a challenge for a single analyst to manage. Converting the LP component to a spreadsheet-based application was the first step in making the system available to a wider range of users.

- As expected, much of the data in the EWITS LP component was obsolete. Truck, barge and rail shipping costs were all updated to 1998 rates.

- Wheat and barley production levels were also out of date. Indexing EWITS township level data based on 1996 county level data remedied this situation.

- The model is too large. It contains about 16,000 possible routes for shipping grain from its production areas to the Portland area. The baseline analysis indicates that about 800 of these routes are used. The drawdown analysis used about 1,000 of these routes. It appears that the majority of the possible routes are too circuitous to be used under any conditions, or are otherwise not plausible. Several criteria, including cost and origin-destination, were used to significantly reduce the size of the LP model without adversely influencing its results. This size reduction reduced the cost of the system's software needs.

- Electronic computer linkages between the LP model and the ArcView graphics package did not exist. The study team efforts integrated these two components.

- The Peer Review panel was asked to evaluate the project team's methodologies, and to help in selecting the appropriate analytical variables. The LP model is almost entirely driven by outside assumptions made by the analyst, such as the amount of grain that can be trucked directly to port, the potential price responses by railroads to a drawdown, the availability of additional rail capacity, and the ability of Tri-Cities ports to handle additional grain. These assumptions are extremely important and needed to be "brought into the light" and critically reviewed by the Peer Review panel.

HDR
Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 4

Summary of Geotechnical Implications of Drawdown on Parallel Transportation Facilities

The purpose of this technical memorandum is to provide an evaluation and opinion regarding the potential impacts on transportation infrastructure adjacent to the existing Snake River reservoirs that may result from the proposed drawdown. The scope of work consisted of a review of available geotechnical documentation from dam and impoundment construction as well as estimations drawn from aerial photographs of the affected areas and observation of existing conditions during a limited number of site visits.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four Lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts.

Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

TM#	Topic
1.	Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources
2.	Annotated Bibliography of Newly Acquired Data Sources
3.	Description of EWITS Model and Features
5.	Summary of Assumptions and Affected Corridors
6.	Summary of Corridor Impacts and Costs
7.	Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake River Reservoirs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Summary

The 1992 drawdown of the pools behind Little Goose and Lower Granite Dams demonstrated that the impacts of a drawdown to adjacent embankments and bridges would be significant. A dramatic change in the water level could trigger major failures in the railroad and highway systems which travel parallel to the Lower Snake River. This failure could shut down significant transportation corridors in Eastern Washington for an unknown period of time and cause significant damage to the region's economy. Figure 1 is an idealized map that indicates the relative location of the various transportation infrastructure units discussed in this report.

This report identifies in broad terms, the likely effects that a drawdown would have on the embankments and bridges along the Snake River through an examination of the design plans for these structures, and through on-site observation of some sections deemed to be particularly sensitive. Because the factors leading to failure of a structure can change significantly over a relatively short distance; it is impossible to ascertain the actual costs of mitigation without a major and thorough investigation of all of the structures adjacent to the river. The figures arrived at for this report are meant for general planning purposes, a much more detailed report needs to be prepared before a drawdown is actually undertaken.

The cost of mitigating damage to roads, railroads and bridges prior to a drawdown is estimated to cost between $82 and $162 million. If mitigation is performed to restore service after failures have occurred, the costs are estimated at between $48 and $192 million. However, the cost for repair of the facilities after failure does not include those costs associated with loss of service while the track, roads and bridges are repaired which could drive up the total cost considerably.

As demonstrated in Table 1, much of the cost of mitigation would go towards repair of the Camas Prairie and Union Pacific Railroads. Figure 2 presents a generalized overview of the areas most likely to be affected by the drawdown including much of the Camas Prairie railroad track along the north side of the river, portions of the Union Pacific track between Ice Harbor Dam and Ayer, and to a lesser degree, sections of the Burlington Northern and Santa Fe track on the north side of the river above Ice Harbor Dam. Although costs for mitigating damage to roadways are not estimated to be as high as costs for railroads, damage to a section of State Route 12 (U.S. Highway 12) west from Clarkston could have serious ramifications given the high traffic load predicted for this section of roadway (see *Technical Memorandum No. 6- Summary of Corridor Impacts and Costs)*.

The first section of this technical memorandum is an annotated bibliography of the reference sources used to develop an opinion regarding the impact of the proposed drawdown on transportation facilities adjacent to the Snake River with respect to geotechnical conditions. The second section provides a discussion of the conditions described by the reference sources and a comparison to the conditions observed during the 1992 drawdown at the Little Goose and Lower Granite Dams. The final section of this memorandum describes the types of mitigation proposed for embankments along the river, and elaborates on the calculations used to generate the costs for this mitigation. Furthermore, this section provides the costs associated with mitigating for the effects of a permanent drawdown of the four dams.

I. Annotated Bibliography

Ice Harbor Lock and Dam Project

Design Memorandum 16; "Embankment Protection of Spokane, Portland, and Seattle Railway;" Ice Harbor Lock and Dam; Snake River Project, Oregon, Washington, and Idaho; U.S. Army Engineer District, Walla Walla; Corps of Engineers; 28 February 1958
This design memorandum presents the plans and cost estimate for protection of approximately 13 miles of existing railroad grade on the right (north) side of the Ice Harbor pool. Some portions of this alignment were constructed on high fills that extend into the pool. Generally these high fills were constructed over wind-blown sandy silt or silty sand. The embankments were constructed in the early 1900s using horse-drawn equipment and were constructed with locally available materials without regard to selection or lift thickness. The embankments are composed of silt, sand, gravel, rock, and mixtures of these materials. The design memorandum includes the results of field and laboratory investigations conducted on the materials from the embankments.

Design Memorandum 17.1; "Relocation Union Pacific Railroad - Part I;" Ice Harbor Lock and Dam; Snake River Project, Oregon, Washington, and Idaho; U.S. Army Engineer District, Walla Walla Corps of Engineers, 8 October 1958
This design memorandum presents the plans and cost estimate for slope protection and relocation of approximately 13 miles of the Union Pacific Railroad. Slope protection was proposed for about 3 miles of existing embankment that were to be inundated by the rising Ice Harbor pool. Total relocation was required for 10.2 miles. Subsurface investigations included drilling of exploratory borings, seismic investigations, and sampling from test pits. Laboratory testing was performed on selected samples for classification and strength testing. The overburden soils are generally silty sand to sandy silt or silt. Underlying materials consist of sandy gravel and basalt bedrock. Embankments were to be constructed from both fine-grained and sand and gravel materials. Where fine-grained materials were to be used in embankments below pool level or where fine-grained materials were encountered as the foundation materials, a granular drainage blanket or transition zone was required.

Design Memorandum No. 17.2; "Relocation Union Pacific Railroad - Part II;" Ice Harbor Lock and Dam, Snake River Project, Oregon, Washington and Idaho; U.S. Army Engineer District, Walla Walla Corps of Engineers, 10 March 1959; (C-H2-M: Cornell, Howland, Hayes & Merryfield Consulting Engineers), Corvallis, Oregon and Boise, Idaho
This design memorandum presents the plans and cost estimate for slope protection and relocation of the approximately 23 miles of Union Pacific Railroad upstream of the section covered in design memorandum 17.1. Results of field explorations and laboratory testing indicated the presence of silt and silty ash in some areas that is unsuitable as foundation material or for use in construction of the embankments below pool elevation. Design recommendations included excavation of the silt and silty ash from the foundation areas. Insofar as possible, embankments were designed to utilize materials from the required excavations and were primarily designed to be constructed from rock, gravel, or talus. Granular materials were specified for use in embankments below pool elevation.

Design Memorandum 18; "Embankment Protection, Northern Pacific Railway;" Ice Harbor Lock and Dam, Lower Snake River Project, Oregon, Washington, and Idaho; U.S. Army Engineer District, Walla Walla Corps of Engineers; 9 July 1959

This design memorandum presents the plans and cost estimate for slope protection on approximately 14 miles of the Northern Pacific Railway's Snake River Branch. Existing fills along this reach consist of silty materials, gravel, and rock fragments in variable proportions. Embankments constructed on fine-grained materials were considered as most critical because of the potential for settlement during inundation. Design parameters were based on these critical conditions.

Lower Monumental Lock and Dam Project

Design Memorandum No. 6; "Relocation Union Pacific Railroad, Hinkle-Spokane Main Line;" Lower Monumental Lock and Dam, Lower Snake River Project, Oregon, Washington, and Idaho; U.S. Army Engineer District, Walla Walla for U.S. Army Engineer District, Seattle Corps of Engineers; 27 March 1961

This design memorandum presents the results of studies performed for relocation of approximately 15 miles of the Hinkle-Spokane main line from Matthews to Chew that lies within the reservoir created by construction of the Lower Monumental Lock and Dam project. Investigations included limited drilling along the preferred alignment and testing of selected samples in the laboratory. Foundation excavation was proposed for all embankments founded on fine-grained material. Construction of embankment was limited to use of granular materials within the zones to be inundated.

Design Memorandum No. 6, Supplement 1; "Relocation Union Pacific Railroad, Hinkle-Spokane Main Line;" Lower Monumental Lock and Dam, Lower Snake River Project, Oregon, Washington, and Idaho; U.S. Army Engineer District, Walla Walla for U.S. Army Engineer District, Seattle Corps of Engineers; 2 Nov 1962

This supplement to the design memorandum presents the modifications to the alignment and grades presented in Design Memorandum No. 6. Also included in the supplement are the results of additional field and laboratory investigations conducted along the new alignment. Recommendations included removal of loose wind-deposited soils, silt and talus deposits, and existing heterogeneous fill materials in foundation areas inundated by the pool.

Design Memorandum No. 14; "Union Pacific Railroad Relocation, Tekoa-Ayer and Tucannon Branches;" Lower Monumental Lock and Dam, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 13 March 1962

This design memorandum presents the plan of relocation for approximately 18 miles of branch line. The design memorandum includes the results of investigations, analyses, and a cost estimate for the relocation of the branch lines. The relocation includes about 2,300 feet of embankment that will be influenced by the pool on the Tekoa-Ayer Branch and about 1,500 feet of alignment on the Tucannon Branch that will require foundation excavation in the pool area.

Design Memorandum No. 14, Supplement 1; "Design and Cost Revisions, Union Pacific Railroad Relocation, Tekoa-Ayer and Tucannon Branches and Camas Prairie Railroad Tie Line;" Lower Monumental Lock and Dam, Snake River, Washington; U.S. Army Engineer District, Seattle Corps of Engineers; 19 May 1965

This supplement to the design memorandum presents major changes made to the proposed relocation of the Tekoa-Ayer and Tucannon branches and discusses the construction of a Camas Prairie tie line. Also included is information regarding relocation of Columbia and Whitman County roads. Information regarding geotechnical field and laboratory investigations is included in the supplement. Recommendations for foundation excavation were presented for embankments constructed where wind-deposited silts, alluvial silts or ash materials, mixtures or layers of silt and rock fragments, or where lake bed materials encountered below pool elevation would cause stability and settlement problems.

Design Memorandum No. 15.2; "Northern Pacific Railway Relocation, Snake River Branch, Part 1;" Lower Monumental Lock and Dam, Snake River, Washington; Prepared for U.S. army Engineer District, Walla Walla and U.S. Army Engineer District, Seattle Corps of Engineers; 31 December 1962

This design memorandum presents the plans and cost estimate for the relocation of approximately 22 miles of the Northern Pacific Railway along the right (north) side of the Snake River from Burr Canyon to just below Joso Bridge. Limited subsurface information is included in this design memorandum.

Design Memorandum No. 21; "Relocation of Columbia County Road No. 42 (Now SR 261);" Lower Monumental Lock and Dam, Snake River, Washington; Prepared by U.S. Army Engineer District, Walla Walla, for U.S. Army Engineer District, Seattle, Corps of Engineers; 3 August 1962

This design memorandum presents design and construction recommendations for relocation of approximately 4.5 miles of Columbia County Road No. 42 (now State Route 261). Much of the relocation was to be constructed in conjunction with the Union Pacific Railroad Tekoa-Ayer and Tucannon Branch relocations. Embankments were to be constructed riverward of the railroad embankment. No special foundation treatment or design was provided in the area near Lyons Ferry to the mouth of the Tucannon River. Foundation excavation was recommended for hillside fills over silt or silty sand foundation materials.

Design Memorandum No. 21; "Relocation of Washington Secondary State Highway 11-B (Now SR 261);" Lower Monumental Lock and Dam, Snake River, Washington; U.S. Army Engineer District, Seattle, Corps of Engineers; 5 May 1965

This design memorandum presents design and construction recommendations for relocation of State Highway 11-B (now State Route 261). Foundation excavation was proposed for areas of the relocation with alluvial silt or sandy silt foundation soils where influenced by the pool. Along the Snake River where embankments were to be within the influence of the pool, rip rap protection was to be provided.

Little Goose Lock and Dam Project

Design Memorandum No. 5; "Camas Prairie Railroad Relocation;" Volume 1 of 2, Little Goose Project, Snake River, Washington; U.S. Army Engineer District, WallaWalla Corps of Engineers; 31 August 1965

This design memorandum presents plans and cost estimates for relocation of approximately 39.5 miles of the Camas Prairie Railroad along Little Goose reservoir from Riparia, Washington to the vicinity of the Lower Granite damsite. The design memorandum includes results of subsurface investigations conducted along the proposed alignment. Much of the new alignment was to be inundated by the Little Goose pool. In areas where inundation will occur, foundation excavation was to be required.

Design Memorandum No. 5; "Camas Prairie Railroad Relocation;" Volume 2 of 2, Appendix A - Laboratory Test Data, Little Goose Project, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 31 August 1965

This volume contains the results of the extensive laboratory testing program conducted during preparation of the design memorandum.

Design Memorandum No. 11; "Relocation Washington State Highway No. 3 (now SR 127);" Little Goose Project, Snake River, Washington; Prepared for U.S. Army Engineer District, Walla Walla Corps of Engineers, by Washington State Department of Highways District No. 5, Yakima, Washington; 15 August 1966, REVISED 23 September 1966; REVISED 17 July 1967

This design memorandum presents design information for construction of new bridges at Meadow Creek, Deadman Creek, and the Snake River on State Highway 3 (now State Route 127). It also presents information regarding the design and construction of a Camas Prairie Railroad overcrossing and for the realignment of the highway.

Design Memorandum No. 25; "Relocation Whitman County Roads;" Little Goose Project, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 18 April 1966

This design memorandum presents design and construction information for the relocation of portions of Whitman County Roads 810 (now known as Little Goose Dam Road; Road 7010) and 830 (now known as Granite Road; Road 8290). Embankments were designed to be constructed of random materials both below and above pool elevation. No foundation excavation was planned. Embankment slopes were designed to be 1.5 or 2 to 1.

Design Memorandum 9.1; "Grading and Drainage, Camas Prairie Railroad Relocation; Almota to Wawawai, and Damsite Shoofly;" Lower Granite Lock and Dam, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 8 March 1965

This design memorandum presents plans and cost estimates for grading 6.4 miles of the Camas Prairie Railroad and construction of a damsite shoofly. The design memorandum includes the results of subsurface investigations conducted along the proposed relocation and shoofly alignments and descriptions of the materials encountered. The predominant soil typesexpected to be encountered along the alignment are silt, silty to sandy gravel and basalt bedrock. Embankment sections up to 50 feet high were designed to be constructed from all of these materials. Foundation preparation was included for high embankments on silt sections where the embankments would be impacted by the pool.

Design Memorandum No. 9.2; "Camas Prairie Railroad Relocation," Including Supplement No. 1; Lower Granite Project, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 9 August 1966

This design memorandum presents the results of investigations, analyses, and a cost estimate for the relocation of the Camas Prairie Railroad along the Lower Granite reservoir. Subsurface investigations included seismic studies and auger borings. Limited laboratory testing was conducted to classify the materials obtained from the auger borings. At the time this design memorandum was prepared, soils classification and strength testing had not been completed; therefore, some of the design assumptions relied upon soils parameters from earlier studies at the McNary, Ice Harbor, Lower Monumental, and Little Goose projects. All indications are that the soil conditions are very similar.

Design Memorandum No. 12; "Relocation Whitman County Road No. 900 (Now Road No. 9000);" Lower Granite Project, Snake River, Washington; U.S. Army Engineer District, Walla Walla Corps of Engineers; 31 October 1966

This design memorandum presents design and construction recommendations for the relocation of Whitman County Road 900 (now Road 9000). The alignment of Road 900 (9000) parallels the Camas Prairie Railroad for the entire length of the relocation. The embankments were to be constructed from random materials. Where the railroad and county road were to be located jointly on a single embankment, material was to be zoned to provide the best foundation under the railroad with less desirable materials used under the road where more settlement could be tolerated. Rip rap protection was to be provided 5 feet above and 5 feet below normal pool elevation.

Design Memorandum No. 14; "Relocation Washington State Route 12 (U.S. Highway 12) Alpowa Creek to Clarkston;" Lower Granite Project, Snake River, Washington and Idaho; U.S. Army Engineer District, Walla Walla Corps of Engineers; Basic Information and Technical Data Furnished by Washington State Department of Highways District No. 5, Yakima, Washington; T.G. Gray, District Engineer; 24 March 1972

This design memorandum presents design and construction recommendations for relocation of approximately 7.4 miles of State Route 12 (U.S. Highway 12) near Clarkston, Washington. Embankments were to be constructed with materials from off-alignment borrow sources. Embankment heights for much of the length of the relocation range from about 5 feet to about 45 feet. The longest sections average about 45 feet in height. No foundation excavation was proposed for these embankments. Granular materials were to be used to construct the embankments. Rip rap protection was to be provided over most of the alignment.

Design Memorandum No. 14.1; "Grade Raise and Protection of Washington State Route 129 and Asotin County Road Connection;" Lower Granite Project, Snake River, Washington and Idaho; U.S Army Engineer District, Walla Walla Corps of Engineers; 13 January 1972

This design memorandum presents design and construction recommendations for raising the grade on 1300 feet of SR 129, and for providing slope protection to about 13,000 feet of embankment along the Snake River from south of Clarkston to Asotin, Washington.

Drawdown Report; "1992 Reservoir Drawdown Test;" Lower Granite and Little Goose Dams; Appendix I- Road and Railroad Embankments; U.S. Army Corps of Engineers, Walla Walla District; December 1993

This report presents the results of monitoring performed on the Camas Prairie Railroad along the Little Goose and Lower Granite reservoirs and Whitman County Road 9000 embankment from Steptoe Canyon to Wawawai Canyon along the north shore of the Lower Granite reservoir.

II. Discussion of Information Reviewed

The information reviewed consisted primarily of design memoranda prepared during the design phase of each of the lock and dam projects. These design memoranda tended to build upon each other, and numerous references to earlier studies are included in the later documents. The documents reviewed described the plans and design criteria for the proposed construction. The larger documents, particularly those addressing the relocation of railroads, included extensive data on the field explorations to investigate soil conditions along the alignments, and the results of large laboratory testing programs completed to characterize the soils.

Subsurface Conditions

Based on these studies, the soils expected to be encountered along the alignments of the major railroad and road relocations proposed for construction included four general soil conditions. The properties of each of the general classifications, as determined from the field and laboratory testing programs, were nearly the same for the soils encountered along the entire length of the Lower Snake River project. The Lower Snake River Project includes the Ice Harbor, Lower Monumental, Little Goose, and Lower Granite lock and dam facilities and the resultant reservoirs.

The description of general soil and rock units encountered were:

A. **Wind-deposited sandy silt or silty sand.** These low-plasticity, fine-grained soils comprise most of the overburden soils along the alignments of each of the major relocation features. Gradation tests indicate these soils commonly have 65 to 80 percent passing the No. 200 sieve.

These soils were most frequently identified as being loose to firm. Consolidation testing on undisturbed samples obtained from exploratory test pits indicated total settlement at natural moisture content plus saturation at a load of 4 tons per square foot to be in the range of 6 to 20 percent.

Shear strength test results indicate that these materials have both low cohesion and very little shear strength under quick loading conditions where pore pressures cannot be relieved rapidly. Design shear strength based on internal friction angles of $\phi = 17°$ to $26°$ were generally used in foundation evaluations for the upper reaches above Lower Monumental, Little Goose, and Lower Granite. Closer to Ice Harbor, the materials appeared to be more sandy along some of the railroad alignments and internal friction angles in the range of $\phi = 29°$ to $33°$ were used to calculate the shear strength. In addition to the low strength wind-deposited silts, low strength, very fine-grained ash was also encountered at a number of locations.

B. Alluvial deposits. The history of the Snake River valley is one of repetitive erosion and deposition. Large terraces of sand, gravel, lake deposits, and debris deposited byoutwash from Ice Age glaciers of northern Washington, Idaho, and Montana are present along the entire length of the Snake River in this area. Flood deposits from the modern river system also contributed to the terraces. In the terrace reaches, embankment foundations were generally sandy gravel or alluvial sands covered with flood-plain silts ranging in depth from a few feet to 15 feet or more. The soils range from well to poorly graded mixtures of silt, sand, and gravel up to, and including, cobbles and boulders.

The gravel terraces are generally characterized as dense to very dense and represent competent foundation materials. These terraces provide excellent borrow sources for embankment materials.

C. Basalt bedrock. The river and major drainage canyons are cut into basalt flows to form the river valley. Bedrock of the region consists of a series of basaltic lava flows and associated fragmental strata that were laid down as extensive plateau lava sheets during the Miocene Age. Individual flows are generally less than 100 feet thick; however, the total thickness of the basalt exceeds several thousand feet. The flows have a general regional dip to the northwest. However, there are local areas near Almota and Lewiston where the basalt is sharply folded and faulted.

The basalt is generally competent; however, brecciated zones and flow interbeds are frequently encountered. An unusual area of highly jointed and fractured basalt was encountered above Little Goose dam that required significant design modifications. These "platy flow" areas were located along the alignment of the relocation of the Camas Prairie Railroad and presented a particularly difficult cut slope design problem.

D. Talus Slopes. Although the talus slopes are not a distinct soil type, they represent a condition that had to be addressed during design and construction. Because the transportation corridors, particularly the railroads, that occupied both banks of the Snake River before construction had to be relocated above the normal pool elevation, many of the routes intersected the talus slopes below the high basalt cliffs. The talus slopes are generally comprised of silty fines and basalt fragments. The talus cover generally lies on an irregular bedrock surface. Because the steeply sloping deposits are predominantly rock fragments, they provide satisfactory embankment foundations. However, because of theheterogenous mixture, some precautions were necessary in certain areas to prevent development of sinks that could result from infiltration of fines into the open talus rock. Additionally, in many areas, deposits of low density, non-plastic silts lie at the toe of the talus slopes that could result in stability and settlement problems where they form foundations for embankments.

Embankment slopes were generally constructed at 1.5 Horizontal to 1 Vertical (1.5H to 1V) or 2H to 1V in most areas. The design factor of safety with regard to slope stability on embankments was generally not less than 1.20 for normal pool and 1.05 for critical pool. It was recognized that the most critical period was during the initial pool raising when saturation of the embankments and foundation materials would occur under relatively high head conditions. The analysis assumed simultaneous saturation and a reduction of shear strength throughout the stratum from river to critical pool elevation.

Most of the design documents indicated that foundation excavation would be required where the foundation soils were wind-deposited silts or soft, fine-grained alluvial deposits. In many of the documents, it was recommended that embankments below pool elevation be constructed using granular materials or rockfill. However, the construction records were not reviewed to determine if this was actually carried out. Conversations with construction personnel familiar with the activities were not conclusive regarding compliance with these recommendations.

In a number of areas, existing railroad embankments were not reconstructed but were provided with slope protection. Many of these embankments were constructed in the early 1900s using random fill and little compactive effort. Information regarding the performance of these embankments during initial pool raising was not available or reviewed.

Drawdown of Little Goose and Lower Granite Dams

In addition to the design information, the results of the 1992 drawdown of Little Goose and Lower Granite dams were also reviewed. Appendix I of the Drawdown Report included results of observations made on Whitman County Road 9000 from Steptoe Canyon to Wawawai Canyon along the Lower Granite reservoir and the Camas Prairie Railroad embankment along the north shore of both the Lower Granite and Little Goose reservoirs. The drawdown was conducted from 1 March to 31 March 1992.

Several potential problems were identified and monitored for visual signs of distress during the drawdown. Of particular interest were the many ponds and embayments between the embankments and the surrounding canyons. Seepage from the embankments was also a concern because of the fine-grained materials that may have been included in the embankments.

The rate of drawdown was also considered with regard to the road and railroad embankment slope stability. The embankments were considered susceptible to failure if the drawdown rate exceeded the ability of the materials to drain.

Typical embankment sections in the areas observed during the drawdown included those constructed on moderate to steep slopes where a significant depth of the embankment was inundated by the adjacent pool. Most were constructed from random fill that included fine-grained and granular materials. The slopes of the embankments were typically protected by 27 inches of rip rap for at least 5 feet above normal pool elevation except where the embankments were rockfill or gravel.

Analysis of Information Reviewed

The mechanism whereby railroad and road embankments could potentially be impacted by the relatively rapid drawdown of the reservoirs primarily involves drainage of water out of the soil system. These reservoirs have been full for 25 to 40 years. During that time, the inundated embankments and the canyon walls have become saturated. An induced water table extends into the soil and rock structures of the canyon; this water table will be lowered when the reservoir pools are lowered. Water stored in these walls and embankments will flow toward the river through rock joints and cracks, the talus slopes, and through the constructed embankments. Depending on the rate of drawdown, this movement of water out of the soil could result in large seepage forces and reduced soil strengths that could contribute to slope failure conditions. The slope failures could impact the operation of the roads and railroads, and may cause damage ranging from minor to significant settlement that would require additional maintenance, to catastrophic failure or landslides. Closure of these transportation links and extensive repairs would be required under failure conditions.

The results of the 1992 drawdown were used to calibrate our model of the potential impact on the transportation facilities with regard to geotechnical issues. Significant impact, particularly to Whitman County Road 9000 was observed. Thirty-three areas with extensive and significant movement as evidenced by cracking, depressed and raised areas within the road, and guardrail movements were documented during drawdown and reimpoundment. Most of the cracks were longitudinal. Movement was primarily toward the reservoir and to a lesser extent vertically downward toward the river. Settlements up to 18 inches were noted. Cracks became longer and wider throughout the reimpoundment period varying in width from 1/8 to 15 inches. Sloughing of the slope was observed in two areas. At one of these areas, toe seepage and boils were observed. The road was closed for a period, then reopened with reduced speed restrictions.

The railroad embankment experienced some lateral and vertical movements during the drawdown that required realignment and raising of the ballast at several locations. Based on the log provided by the railroad, considerable effort was required to keep the line open to traffic. Although it was not closed, speed restrictions were imposed during the drawdown and reimpoundment.

Based on the above information, we evaluated the potential for impact to other transportation features, particularly the railroads operating along the reservoirs. Several miles of track extend on both sides of the river from Lewiston to Ice Harbor. Although the old Northern Pacific and Seattle, Portland & Spokane alignments on the north side of the river are not currently in use, there is the potential that at least parts of these routes could be reopened at some later date. The Camas Prairie Railroad does operate along the north side of the river. The Union Pacific route along the south side of the Ice Harbor and Lower Monumental reservoirs is extensively used at this time.

Although the design memoranda indicate that construction of embankments would utilize material selection to place only granular materials in the sections of the embankments expected to be inundated, the potential still exists that this was not fully accomplished. Therefore, the potential for fine-grained material being located in the embankments exists, and the potential for causing larger seepage forces and settlement resulting from drawdown also exists to some extent.

Many sections of railroad embankment were constructed over steep talus slopes where the underlying materials were a mixture of silt and rock fragments. These areas have the potential for settlement, when drained, because of the opportunity for fines to transport out of the matrix if the embankment were constructed from granular materials containing fine-grained soils.

Road embankments were, in some areas, constructed from random materials with no selective placement of granular materials below pool elevation. Based on the conditions observed along Whitman County Road 9000 during the drawdown, damage to other roads along the reservoirs may also be expected.

There is also the potential for impact on bridges crossing the Snake River or tributaries resulting from increased velocities in the channels. The bridge foundations and foundation protection were designed based on slower velocity conditions. There is a potential that scour resulting from the increased velocity of a low water condition could result in damage to the bridge foundations.

In addition, a drawdown could have a significant impact on bridges supported by deep foundations. If deep foundations are located at or near the riverbank or on embankments, the lateral movement caused by a drawdown could impose a large horizontal force on the deep foundations and the foundation cap. Also, the vertical settlement caused by drawdown may impose a large downdrag load on the deep foundation.

III. Mitigation, Costs and Conclusions

Based on our review of the available data and information, it is our opinion that the proposed Snake River drawdown could have a significant impact on the adjacent transportation facilities with respect to the geotechnical conditions. The most significant impact will be the instability of embankments and the settlement and movement of the foundations resulting from unbalanced pore water pressures or seepage forces in the soil as water moves out of the saturated soils. Unbalanced pore water pressures or seepage forces can occur within all soil types if the rate of drawdown is faster than the ability of the soil to dissipate the pore water pressures. The degree of instability and movement that results in any area will be largely dependent on the rate of drawdown and the characteristics of the soil. If the rate of drawdown is excessive for the subsurface conditions, significant, and possible catastrophic, failures may occur.

Discussion of Remedial Measures and Estimated Costs to Mitigate Impacts

A number of remedial measures may be employed to mitigate the magnitude of the impact from the seepage forces. Lowering the reservoir levels at a rate compatible with the existing soil conditions is one of the most effective methods available. Determining the most appropriate rate of drawdown, however, would require extensive investigation of the soil conditions in the embankments, road beds, railroad grades, and canyon walls. Based on the currently available information regarding the construction of the facilities, it is estimated that investigative costs could be in excess of $1 Million. This investigative program would consist of drilling exploratory borings along the "at risk" alignments at approximately 1,000 feet between borings, with minimal laboratory testing, thorough engineering analysis, and report preparation.

If it is not possible or practical to draw down the reservoirs at a rate that is compatible with all of the different soil conditions, measures may be taken to increase the strength and stability of the soils, thereby reducing the potential settlement, movement, and damage. Embankments constructed with fine-grained soils are generally more difficult to respond to various soil improvement techniques.

Measures such as installation of stone columns (Vibro replacement) may be taken to increase the strength and stability of the soils, thereby reducing the potential settlement, movement, and damage. Stone columns, when properly installed, provide improved drainage within the embankment, thereby reducing the potential for unbalanced pore pressures that may result in instability. Stone columns are installed along the face of an embankment, particularly an embankment constructed from fine-grained soils, by inserting a vibrating probe to a predetermined depth and backfilling the hole with free-draining gravel. Placed under continuous vibrating conditions the gravel in the stone columns will allow water to move out of the embankment more readily. Installed at spacings of 6 or 8 feet along the face of an embankment, approximately 3-foot diameter stone columns can provide improved drainage and reduce the seepage forces. In addition, because stone columns are much denser and stronger than the soil replaced, they provide much more resistance on the embankment slope.

Alluvial deposits and talus slope materials may also be improved using vibro-replacement, vibro-compaction, or deep soil mixing to increase the density and strength of the in-place materials.

The cost to improve the soil by vibro-replacement, vibro-compaction or deep soil mixing is estimated to be about $10 per cubic yard of embankment improved. These costs are based on the volume of the entire section of embankment stabilized. Thus, for a section of embankment that contains 1 million cubic yards of material, the soil improvement costs would be about $10 Million.

Compaction grouting is effective in improving the density and strength of alluvial deposits or embankments constructed from granular materials or the talus materials in more limited areas. If settlement and movement that would impact the integrity of localized areas such as at bridge abutments or structure footings founded on alluvial or talus deposits are expected, compaction grouting can be used to improve the strength of the soils. Compaction grouting improves the strength of the soils by displacement and replacement of the looser materials. It has been used effectively to lift and stabilize a footing at a fish facility at Lower Monumental Dam that was founded on an embankment constructed from granular materials.

Increased scour at bridge foundations that result from higher velocities in the river may require extensive retrofitting of foundations or foundation protection features such as rip rap to reduce the impact.

The costs associated with remedial actions such as compaction grouting or rip rap placement at the bridges are expected to be in the range of $1 Million to $2.5 Million or more per bridge. The costs for the remedial measures are dependent on the existing soil conditions, the type of foundation system supporting the structure, proposed operating conditions after drawdown, and the remedial measures taken. Three major highway bridges, SR 261 at Lyons Ferry, SR 127 at Central Ferry, and SR 127 at Deadman's Creek bridges could be impacted by a drawdown. Two major railroad bridges at Lyons Ferry are located within the study area that could also be impacted by a drawdown. Several other minor structures are also located within the study area. Costs for mitigation at the structures could range from $6 Million to $15 Million.

To more accurately estimate the quantity of embankment that may need to be evaluated, a review of aerial photographs of the alignments and on-site observations was performed. The review and observations were used to determine which sections of railroad embankment would be at risk based on the proximity of the embankment to the reservoir pools. The estimate is based on proximity because of limited access, budget, and time constraints. Some sections of the embankment areas are only accessible by rail or boat. In these areas, the aerial photographs were used as the basis for determining if a section should be considered at risk. The sections of railroad and road alignment determined to be at risk are indicated on the enclosed map. In order to determine a more definitive quantity of embankment requiring stabilization, detailed studies would need to be undertaken along the entire length of each of the at risk alignments.

To estimate the quantity of embankment that may require stabilization, an average cross-section was used based on various cross-sections presented in the Design Memoranda discussed above. The average cross-section includes a 30-foot crest width, 1.5H to 1V side slopes, and an average height of 10 feet. Based on these general dimensions, a quantity of 176,000 cubic yards per mile of alignment would need to be evaluated.

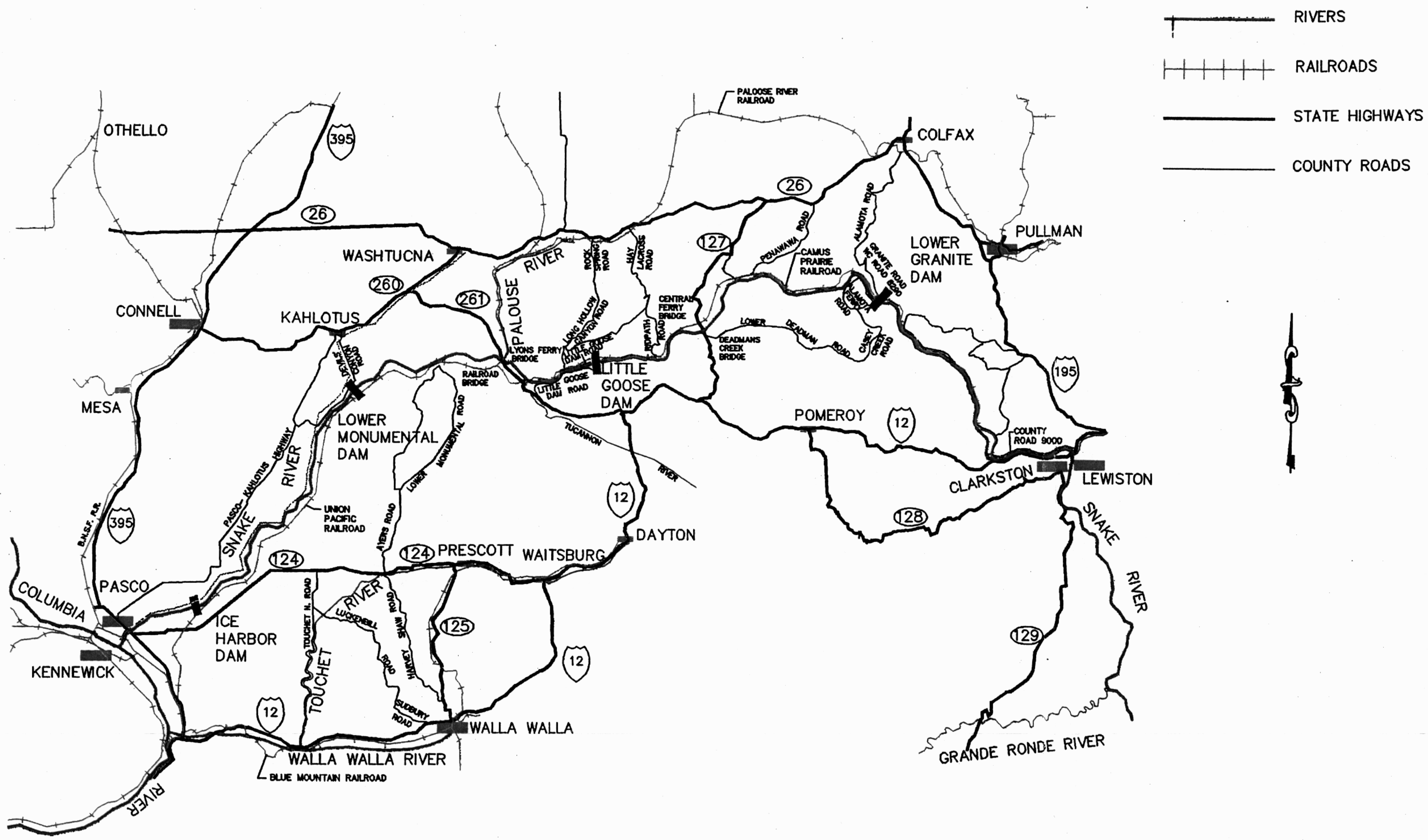
The estimated costs of mitigation are based on the above general parameters, information from various available sources, and the most recent observations. The potential costs for mitigation of impacts to railroads, roads, and bridges are summarized in Table 1.

TABLE 1

Unit	Section	Total Length, Miles	"At Risk" Length, Miles	Potential Mitigation Costs - Stabilize Before Drawdown	Potential Repair Costs - Repairs After Drawdown
Union Pacific Railroad	South Side of River Ice Harbor Dam to Lyons Ferry	45	26	$25 to $45 Million	$12 to $53 Million
Camas Prairie Railroad	North Side of River Lyons Ferry to Clarkston	70	46	$40 to $80 Million	$24 to $93 Million
Northern Pacific Railroad (BNSF), Abandoned	North Side of River Ice Harbor to Lower Monumental Dam	30	6	$5 to $10 Million	$1 to $6 Million
Total for Railroads		**145**	**78**	**$70 to $135 Million**	**$37 to $152 Million**
State and County Roads	Various short sections of State and County Roads	20	10	$2 to $4 Million	$2 to $10 Million
Whitman County Rd. 9000	Wawawai to Clarkston	30	20	$4 to $8 Million	$3 to $15 Million
Total for Roads		**50**	**30**	**$6 to $12 Million**	**$5 to $25 Million**
Bridges (Highway)	SR 261 at Lyons Ferry			$1 to $2.5 Million	$1 to $2.5 Million
	SR 127 at Central Ferry			$1 to $2.5 Million	$1 to $2.5 Million
	SR 127 at Deadman's Creek			$1 to $2.5 Million	$1 to $2.5 Million
	Various Minor Structures			$1 to $2.5 Million	$1 to $2.5 Million
Bridges (Railroad)	Union Pacific Joso Bridge at Lyons Ferry			$1 to $2.5 Million	$1 to $2.5 Million
	Union Pacific Bridge at Lyons Ferry			$1 to $2.5 Million	$1 to $2.5 Million
Total for Bridges				**$6 to $15 Million**	**$6 to $15 Million**
Total				**$82 to $162 Million**	**$48 to $192 Million**

In summary, the costs associated with mitigation of the potential impacts on the existing transportation facilities (roads, bridges, and railroads) are estimated to be in the range of $82 to $162 Million. The costs associated with the repairs or total reconstruction of the railroad and roadway embankments under the "do nothing" alternative are estimated to be in the range of $48 to $192 Million. However, these costs do not include costs related to the loss of the services of the transportation systems during the repair or reconstruction periods. All of the conditions requiring mitigation may not occur immediately thereby necessitating an increase in on-going maintenance. Part of the on-going maintenance will likely result from the impact of increased traffic loads on the highways and railroads resulting from the loss of barge capacity. We have not estimated these additional potential costs at this time.

To better define the mitigation costs, a more detailed investigation of the existing conditions, including subsurface explorations of the embankments, slopes, and cut sections, and engineering studies will be necessary.



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HDR
Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 5

Summary of Assumptions and Affected Corridors

This technical memorandum summarizes the technical and procedural assumptions used to develop the Lower Snake River Drawdown Study's commodity flow/transportation diversion model, as well as the highway and railroad corridors that, according to this model, would be affected by the drawdown scenario. Earlier technical memoranda described the reference sources and data that were used to construct this model, and the potential geotechnical impacts of a drawdown.

The use of assumptions in technical analyses is a common practice to substitute fordata which is either unavailable or inconsistent with other like data sources. It is essential that analysts disclose these assumptions clearly to allow readers to appreciate how the analysis was constructed before reviewing findings. The discussion herein documents the assumptions that were used and the techniques employed to support those assumptions.

These techniques include: verification of publicly available information with representative shippers, transportation providers, and ports; comparison of results with other relevant studies; and review of the inputs and methodologies used in the model by a three member Expert Review Panel.

The list of highway and railroad corridors that would be affected by the drawdown scenario represent the results of the transportation analysis completed with the commodity flow/transportation diversion model. That is, those corridors which would experience higher and lower levels of highway and rail traffic demand due to the diversion of commodities from Snake River barges forced off the river as a result of the proposed drawdown of that river's dams. It is important to note that some corridors would experience decreased levels of traffic as commodity shipments from production areas would be rerouted to utilize the most cost effective corridors that would be available without barge transportation. That is, some of the existing routes that are oriented toward the river may experience reduced demands.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four Lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts, and to have a clear understanding of the impact analysis being completed by the U.S. Army Corps of Engineers in their Snake River System Operation Plan EIS.

Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

TM#	Topic
1.	Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources
2.	Annotated Bibliography of Newly Acquired Data Sources
3.	Description of EWITS Model and Features
4.	Summary of Geotechnical Implications of Drawdown on Parallel Transportation Facilities
6.	Summary of Corridor Impacts and Costs
7.	Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake River Reservoirs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction

The purpose of this technical memorandum is to summarize: 1) the assumptions that were used to construct the commodity flow/transportation diversion model, 2) the highway and railroad corridors that would be affected by a drawdown scenario, and 3) the comments received from the Peer Review Panel who reviewed the team's methodology and data inputs.

This memoranda is organized around the three study purposes identified above. The intent in beginning with the assumptions in the model is to provide for the reader a sense of the credibility of the inputs that were utilized before disclosing the anticipated impacts. This section identifies the final assumptions that were used in the model; i.e., those that were recommended and accepted from the peer review process.

The documents describing the peer review process are provided last because of the detailed nature of those discussions and the protocol used to complete the review. Readers may want to cross check information described in the first section on the model's assumptions with the deliberations by the peer review panel in the third section.

Impact Analysis Time Frame

An important and distinguishing feature of the *Lower Snake River Drawdown Study* is that it focuses on the potential impacts of a drawdown under 1998 conditions. That is, what would happen to the transportation systems and economy of Eastern Washington if a drawdown were to occur today, without any time to allow shippers, transportation providers and handlers to adjust their processes in anticipation of a drawdown.

If a drawdown does occur, it is likely that some combination of interested parties would initiate infrastructure and other transportation system improvements. These improvements would eventually be adequate to allow products to travel to their intended markets in the most efficient manner possible given the constraints of the system. In fact, the environmental impact statement being completed by the U.S. Army Corps of Engineers (COE) considers the impact of a drawdown in the year 2008, not 1998, in order to account for the adjustments that would need to be made.

The decision was made to evaluate a 1998 scenario since information on commodity types and movements and economic conditions today are better understood by decision makers than would be under a forecasted scenario of the year 2008. Such forecasts are built on datasets that often become the principal focus of such analyses, with less effort placed on the potential impacts. The fact is that a 2008 scenario might need to adopt a series of mitigation measures to allow goods to flow smoothly, and the level of mitigation could only truly be understood by reviewing an existing conditions context; as is done here. In other words, while the region would be given ample time to prepare for a drawdown, a 1998 impact year allows for a clearer understanding of the level of effect that would occur under a drawdown scenario.

I. Assumptions Used in the Construction of the Commodity Flow/Transportation Diversion Model

While there are a vast assortment of data sources available that could meaningfully contribute to the development of the transportation model, many inconsistencies exist between those datasets with respect to analysis year, impact areas, commodity data, origins and destinations, estimated transportation rate changes, etc. These inconsistencies, as well as incomplete datasets, force analysts to substitute information, or utilize assumptions, to complete evaluations. While assumptions can suggest uncertainty to some, they are normally used in such assessments, and are refined through a series of sensitivity analyses, calibration techniques, and through substitution of certain variables.

The assumptions that are described below were subjected to those analytical steps before being advanced for the final analyses and publication here.

A. Commodities

This study considers six commodity groups: wheat, barley, forest products (woodchips and logs), containers, petroleum products and fertilizer. Combined, these goods make up over 90% of all of the goods shipped on the Snake River. All of the grain which is considered in this study either originates in Washington, or is trucked into Washington for shipment by barge. This limitation excludes grain which travels by rail from the Midwest to the coastal ports. This exclusion allows the model to consider only those flows of grain which will be directly affected by changing transportation costs resulting from a drawdown of the Snake River. For the other commodities under consideration, only those quantities which are shipped on the river today are considered. Movements by rail and truck are excluded, again as a way of focusing the model on the direct changes stemming from a drawdown.

Commodity Volumes and Flows

The base data for this study was drawn from a number of different sources which are described in detail below. Except for wheat and barley, all of the volumes used to calculate impacts are drawn from 1997 data sources. Wheat and barley are based on 1996 data. These data sources were checked against alternative sources where possible including industry data, phone calls with parties associated with the commodity, and public organizations which monitor or study the commodity. For the purposes of this study it was assumed that all of the commodities currently shipped via the Snake River would continue to be shipped between similar origin and destination points. In this way, diversion could be measured based on a study of alternative routes, and their costs relative to the current method of transportation.

Some shippers believe that the types and quantities of commodities produced would change dramatically under a drawdown scenario. These potential effects are discussed *in Technical Memorandum No. 7- Summary of Commodity Shifts Out of Region*. For the diversion analysis that is discussed here, scenarios which identify changed volumes or final destinations have not been incorporated into the modeling aspect of this study.

Commodity Shipping Patterns

The analysis of shipping patterns is based on the assumption that shipping costs and the most direct routes are the only variables that drive decisions about which mode and which route will be used. That is, producers will ship to certain modes on the basis of the shipping cost only; and motor carriers and railroads will utilize the most direct routes.

The shipping patterns simulated in the commodity flow/transportation diversion model were discussed in detail with major shippers, relevant trade associations, ports and transportation providers (barge operators, truckers and railroads) for each commodity type. Some of these modeled shipping patterns involved basic assumptions developed by the analysis team about the general collection and distribution locations for fertilizer, some forest products (logs, pulp, paper), and petroleum. However, these assumptions were confirmed as "reasonable" by the representatives described above. In the case of wheat and barley products, the production centers and route and mode usage established during the EWITS studies were confirmed by these representatives as well: i.e., confirming original research on origins and destinations collected by EWITS in 1993 and 1997.

With the important exception of wheat and barley, all commodities considered in this study will continue to be handled at the port facilities where they are currently handled. Even with commodities that would divert from one mode to another as a result of the drawdown, they would divert only after reaching their present day origin port. That is, commodities were assumed to continue to use their present ports even under the drawdown scenario because of the fact that significant capital investments have been made in facilities along the river that would continue to attract each of these commodities; e.g., mills. Over time, these facilities might be relocated if transportation costs increased to a level where such an action became a practical economic decision.

Downbound Commodities -- all destined for Portland

- Wheat and Barley -- Wheat and barley are modeled based on 1996 data from the National Agricultural Statistics Service. At the time of this study, this was the most recent data available for production and harvested acres for wheat and barley. It should be noted that 1996 was a year of particularly high rainfall for some counties in Eastern Washington; resulting in a record harvest production year.
- Forest Products -- Forest products refers only to wood chips and logs handled at facilities located at the ports of Wilma, Lewiston and Clarkston. Because the study area for this project includes only those facilities within the State of Washington, the important shipment point of Lewiston (i.e., located outside the study area) was combined with the tonnages shipped at Clarkston. Shipments of paperboard and other paper products fall in the category of container traffic. This distinction was necessitated by the lack of specific SIC codes available in the Corps of Engineers' Lock Performance Monitoring System Data (LPMS). Pulp shipments from these regions were not included in the model, because data for this commodity could not be accurately ascertained. The tonnages for these commodities represent a small proportion of the total amount of commodities shipped on the Snake River.
- Containers -- According to ports and barge operators, containers largely refers to paper and allied products. The data is taken from a 100% count of containers shipped out of Lewiston and Clarkston - the only ports handling containers on the lower Snake River. Only full containers heading downbound are included.

Upbound Commodities

- Petroleum – Petroleum would continue to be barged to Pasco, Wilma, and Lewiston, with no adjustment for potential changes in shipping due to the proposed pipeline between the Puget Sound and Pasco. Moreover, the LPMS data and records from the American Waterways Association indicate a significant discrepancy; i.e., the barge operators indicate that they are moving in excess of 186,000 tons/year, whereas the LPMS data predicts about 115,000 tons/year, even after being corrected for missing months of data in the dataset. For the purpose of constructing the model, the analysis team used the data provided in the LPMS data.

- Fertilizer -- Under the drawdown scenario, the model trucks fertilizer from the Tri-Cities area to Central Ferry. There were discrepancies between the LPMS data and the information provided by the American Waterways Association and the barge operators. The LPMS data was used after adding in the two months of data missing from the 1997 dataset from the same period in 1995.

B. Availability of Transportation Systems and Services

For the purposes of this analysis, there are no significant changes in the availability and types of modes, transportation services or systems, transportation or processing technology, or any other procedures that could influence the shipment of goods into and out of Eastern Washington.

C. Market Demand for Eastern Washington Commodities

For the purposes of this analysis, there are no significant changes in the markets that import and export goods traveling through Eastern Washington.

D. Flow of Commodities Into Eastern Washington

For the purposes of this analysis, grain entering Washington State from Montana or Idaho, and destined for Lewiston and the Snake River by truck, will continue to travel in that manner with a choice of Spokane or Clarkston as the entry point; i.e., depending on the most direct route and least cost.

Rail shipments from the east will continue to have priority over trains originating in Eastern Washington, and will therefore continue to run at current levels despite increased demand for rail in Eastern Washington under a drawdown scenario. Some consideration for possible changes in rail rate structure has been modeled for the purpose of completing sensitivity analyses.

The commodities (containers, forest products and grain) and shipping facilities available at the ports of Lewiston and Clarkston are modeled as one single port in the model.

E. Shipping Rate Changes

The shipping rates used in the commodity flow/transportation diversion model by mode are:

- Barge -- used the 1998 tariff sheet, provided by each of the four common carriers on the Snake River, which in their opinion represent the true rates that are actually charged on the Columbia and Snake rivers.
- Trucks -- used shipping costs provided directly by the motor carriers moving the product as described below:

    - 0.25 cent/bushel/mile, for wheat and barley on a 105,000 lbs. tractor-trailer.
    - $3.73/mile for a 9,500 gallon load of petroleum, which includes an average for the costs of diesel fuel and gasoline.
    - $1.62/mile for each load of forest products within the range of 62,000-65,000 lbs./truck.
    - $1.85/mile for each load of fertilizer within the range of 60,000 -70,000 lbs./truck.
    - $1.62/mile for each container, which weigh between 50,000-60,000 lbs./truck.

- Rail -- used the 1998 published tariff sheet rates, and modeled scenarios showing a 10% below tariff rate for the maximum railroad use scenario - which is equivalent to approximately a $100/car discount.
- Port handling fees – fees were developed through conversations with elevator operators, and added to the tariff rates published by the barge operators. Handling fees are roughly ten cents per bushel for wheat and barley.[1]

II. Affected Highway and Railroad Corridors

Under the auspices of this study, the study team examined two scenarios, one maximizing the impacts to the highway infrastructure, and another maximizing the impacts to the rail infrastructure. The combination of these two scenarios provides, in effect, a worst-case scenario for estimating impacts to rail and highway corridors. In these two scenarios three highway corridors were identified as severely impacted: US 395, SR 124/US 12, and the Pasco-Kahlotus/SR-26 system (The SR 124/US 12 corridor was identified as facing significant increases under both scenarios). The Palouse River and Camas Prairie shortline railroads as well as the Class 1, Union Pacific and Burlington Northern and Santa Fe railroads were significantly affected under the rail-maximizing scenario. More complete details of these impacts are discussed in *Technical Memorandum No. 6- Corridor Impacts and Costs.*

III. Comments by Peer Review Panel

The findings of the Peer Review Panel are documented in Appendix A.

[1] The Peer Review Panel recommended consideration of changed handling fees at ports in high demand under a drawdown scenario. The idea was that ports would be able to increase their rates significantly, and that this would impact both the overall cost of shipping, and also the ability of these ports to provide the necessary infrastructure improvements. This portion of the study did not pursue a methodology for determining how handling fees might change, however, through the use of scenarios which captured a relative change in the rates for barge and rail modes, the effects of increased handling fees were identified.

LOWER SNAKE RIVER DRAWDOWN STUDY PEER REVIEW PANEL REPORT

On October 26, 1998, Philip Baumel, Ph.D. of Iowa State University, Denver Tolliver, Ph.D. of North Dakota State University, and Richard Gardner, Ph.D. of the Idaho Rural Partnership met with HDR Engineering Study Team members to review the Washington Legislative Transportation Committee's Lower Snake River Drawdown Study. The following comments represent the consensus summary report of this independent Peer Review Panel.

The discussion is organized around five major topics: 1) the general methodology of the study, 2) the appropriateness of data inputs and related modeling issues, 3) potential scenarios and sensitivity analysis, 4) additional research and data verification to solidify model inputs and assumptions, 5) potential regional economic impacts of drawdown, and 6) strategies for presenting findings and caveat statements regarding the projected impacts.

GENERAL METHODOLOGY

Linear Programming Approach. The Peer Review Panel feels that the linear programming (LP) approach is an acceptable and recognized method for conducting an impact study of this type. The flow pattern reflected in the optimal solution will minimize transportation and handling costs after drawdown. This flow pattern should reflect the reactions of shippers to a drawdown and thus reflect post-drawdown impacts on shippers and infrastructure.

Transformation of EWITS Model. The original EWITS model is the starting point for the LP impact model to be used in the drawdown study. Enhancements to the EWITS model and transformation from a GAMS to a spreadsheet environment have improved the original model and allow it to be linked and interfaced with *ArcView* and *ArcInfo*. The Panel agrees with the programming approach and compliments the contractors on their efforts to improve the programming ease and thus, accessibility of the model.

Instantaneous Versus Phased Impacts. The EWITS model has been updated and applied to 1996 grain and 1997 non-grain data to reflect a "snapshot" of potential traffic diversions and post-drawdown flow patterns. The Panel feels that the use of 1996 grain production data and 1997 data for other commodities is appropriate, as is the assumption of "instantaneous impacts" after drawdown for a baseline impact estimate. However, some cautions should be expressed about the years of data being used because 1996 grain yields reflect above average rainfall in that year. Furthermore, abrupt reductions in lumber and wood production in 1996 and 1997 are reflected in the wood product shipment data. For these reasons, readers should probably interpret the studies results as a worst case scenario of impacts because the one-year 1996/1997 snapshot assumes an instantaneous change and adjustment from the loss of the four lower Snake facilities, with the impacts continuing each year thereafter. In reality, the Corps of Engineers estimates that it would take a number of years to implement the change, giving economic agents a chance to anticipate the drawdown with investments and innovations to lower impacts beyond the choices offered at present.

Secondary Impacts. Other direct costs conceivably could be considered in this type of an analysis. For example, changes in emission levels might occur as traffic is diverted from barges to railroads and trucks. Also, changes in safety levels could result from more truck traffic. However, given the rural character of eastern Washington, and the magnitude of traffic diversion, we would not expect emission factors to be as important as they would be in a metropolitan area. We believe the proper focus of the study is on pavement and highway infrastructure, shipper costs, and railroads. Changes in fuel consumption may occur as traffic is diverted from barges to trucks and railroads. However, relative fuel costs should be reflected in the transportation rates of the modes.

Sensitivity and Scenario Analysis. Within the LP framework, we strongly encourage the use of sensitivity and scenarios analysis. We feel this is an appropriate way to represent many complex interactions and uncertainties, such as variations in production levels or other model inputs. Several scenarios could be run describing how railroads would react, how truckers would react, etc. Sensitivity analysis could also be used to assess uncertainties over the COE lock performance system data.

DATA INPUTS AND MODELING ISSUES

Base Years for Production and Cost Data. The study uses 1996 wheat and barley production figures. The 1996 data were generated at the township level by indexing 1993 production data developed for EWITS. Because of the unique availability of township level production data in 1993, the Review Panel feels this is an appropriate approach with caveats for climate noted; i.e., it should be noted that 1996 was a significant year for grain production with above average rainfall.

With regard to wood products, 1997 is the base year. Both 1996 and 1997 were significantly lower than previous years in terms of the amount of wood products being shipped. Thus, some statements are needed regarding the base year for wood products.

Clearly, we want to use the most recent transportation cost data, even if the cost data are for a later year. Transportation *unit costs* are not likely to be significantly affected by changes in volume from 1996/1997 to 1998. Thus, we agree with the use of 1998 unit costs with 1996/1997 production and shipment data.

Cross-Checking and Verification of Data. In general, the project team should try to independently verify as many data sources as possible. For example, there is some concern about the lock performance system data. One way to check the reasonableness of tonnage estimates is to count the different types of barges and then use the physical capacities of the barges to estimate tonnages. Independent verification is important and some of that also can be accomplished through interviews.

Also, the Panel believes that in cases where COE data has *gaps*, such as missing months, it is appropriate to extrapolate from partial year to full year data, or look at prior years to estimate the missing months as best as possible. In particular, this applies to petroleum products. In general, the Review Panel feels that the data structure that has been set up is probably the best that is available.

Representation of Farmer Decision-Making. The Panel recommends that the supply nodes should be the farms (e.g., townships) rather than the local elevators. In other words, the modeling of decisions should start with the farmer. The farmer should have all options available within the LP modeling framework, including: direct truck movements to regional elevators and river ports and perhaps direct truck movements to Portland. Farmers may adjust to drawdown by purchasing tractor/semi-trailers and changing traditional delivery patterns. Farmer adjustments are critical to the accurate representation of post-drawdown decisions and flows.

A related issue discussed in the meeting was whether or not the flow of grain from farms to local elevators was realistic and should it be based on traditional throughput, storage capacity, or some other variable. One modeling approach is to flow enough grain from farms to local elevators to fill up the facility at least once. This approach would allow for some sort of a minimum flow into the facilities.

Representation of Highway Load Limits. Another issue is the potential effect of highway seasonal load limits on routes used and trucking costs. The committee feels that some of the 2,000 plausible routes that remain after the winnowing down of the EWITS routes may be subject to seasonal load limits. The project team should investigate some of the major routes to determine if they indeed are load-restricted and, if so, make some determination as to how these situations would be handled in the model. They could potentially be reflected through some type of link penalty or through increased trucking cost per ton-mile. Even if a modeling adjustment is not made, the topic should be discussed in the report.

SCENARIO ANALYSIS

One of the potential benefits of the LP framework is the capability to look at a great many different scenarios. Variations in inputs and effects could be examined by defining different scenarios or through post-optimality analysis wherein the project team looks at dual prices and objective function coefficient ranges.

In particular, three scenarios were discussed in the Review Panel meeting. The first scenario relates to the responses of the railroads to a potential drawdown and whether or not shuttle trains are a viable railroad scenario. If so, some aspects of shuttle train movements should be specified. The second scenario envisions farmers converting their farm truck fleets to combination trucks and thus would reflect the implications of farmer-owned transportation in large-capacity efficient trucks. This scenario could involve direct movements to Portland or other potential destinations, and longer hauls directly from farms to Pasco. The third scenario is a wood products scenario that would reflect trends in the wood products industry and lumber production.

Wood Products Scenario. In the 1990s, harvests of timber and wood products from publicly-owned lands have dropped dramatically. For instance, the cuts from Region 1 National Forests, which cover all of Northern Idaho and Montana, have dropped from 2.8 billion board feet in 1970 to 300 million board feet in 1997. This shortfall has been lagged several years as timber sales come to market and has been made up in part by production at unsustainable levels from privately-owned forest land. A future scenario for the wood products industry could be drawn from the preferred alternative of the Upper Columbia River Basin draft EIS, which will guide future public lands harvest in eastern Washington, eastern Oregon and Idaho. Harvest levels on public lands are projected to be higher than current harvests, but still much lower than historical levels. Harvests will likely contain a mix with increasing shares of smaller diameter trees and less desirable species. Such a wood products scenario might mean higher transportation costs and might also imply that wood products would be further processed before shipping to reduce weight. For instance, we may see an increase in lumber and secondary manufactured wood products as opposed to unfinished logs and cants.

Railroad Response Scenario. Although uncertainty exists regarding the railroads' potential reaction to drawdown, there is a consensus among the panel members that the railroads might react differently if the operating scenario is one of shuttle trains instead of sporadic single-car shipments or the 26-car grain shipments that predominate today.

Shuttle trains have been successfully deployed in the Midwest, the northern plains and other parts of the U.S. Under shuttle train operations a shipper agrees to consign a minimum number of 100 to 110-car trains during a certain time period, usually a year. The agreement could call for 5 trains or for 20 trains. In shuttle service, a dedicated car and locomotive set shuttle back and forth between the shipper's facility and a major destination such as Portland. The program usually requires shippers to load in 15 hours and unload in 15 hours at destination; thus, resulting in an expedited car cycle time.

Under this type of operational plan -- which is more economical that 26-car movements and creates greater car utilization -- railroads might have greater interest in handling the diverted traffic after drawdown. Thus, the Panel recommends that at least one scenario be run in which a limited number of large loading facilities (e.g., shuttle train elevators) are identified -- perhaps four or five facilities to which all of the rail grain would be delivered from farms or from smaller elevators, feeding into these shuttle train facilities. The outbound portion of the movement possibly would consist of 100-car trains, although the railroads may option for 52-car trains.

A question arose regarding this scenario as to whether there will be sufficient rail car capacity. A shuttle train program actually increases rail car capacity. Also, railroads have other programs, such as the Certificate of Transportation program, in which shippers can bid above or below the base freight rate for rail cars. Moreover, shippers can buy their own cars and put them into railroad pools, such as occurs with the Burlington Northern-Santa Fe's guaranteed freight program. For these reasons, the Panel feels that rail car capacity probably will not be an issue after drawdown. If railroads want the traffic, they will acquire the car capacity.

In describing the shuttle train scenario, the study team should emphasize the benefits of a collaborative approach involving railroads, shippers, the State, and economic development stakeholders. Railroads might be induced to share some of the efficiency gains from shuttle trains with producers in the region. However, this may require some re-evaluation of unit train facilities and some non-railroad investments in affiliated infrastructure along rail routes.

A related railroad trend is the use of 286,000-pound covered hopper cars. These newer cars haul 111 to 112 tons per trip. We are unsure of the rail car load factor reflected in the original EWITS model. The rail rates may have reflected 100-ton cars instead of 286,000-pound cars. Under carload rate structures, the rate per ton could be different for heavier-loading cars. The study team should ask the railroads about these service options and the prevailing future rate (which would probably be the 286,000-pound car rate).

Farmer Trucking Adjustments. The third scenario is a shift by farmers to a farm truck fleet that primarily consists of combination trucks, perhaps including the combination truck pulling a pup -- the so-called Rocky Mountain Double, which operates legally in Washington at 105,500 pounds. This truck is very economical in that it spreads fixed driver and other costs over a greater number of payload tons. The use of larger farm trucks may act as a constraint on potential rail rate increases after drawdown and could provide competition for railroads, in which case, railroad abandonment or other railroad system changes might be partially prevented.

In addition, the farmer trucking scenario offers a rich management opportunity for farm operators to productively use off-season labor. Under this particular scenario the number of truck miles will probably increase with the distance of haul. Also, the highway routes may change.

REGIONAL ECONOMIC IMPACTS

With regard to regional economic effects and commodities shipped within the region, the Review Panel does not expect major changes in land use as a result of the drawdown. We do think that there will be some marginal changes in the boundaries of the market shed for wheat transportation in Montana, but probably very few changes within the state of Washington. There may be some short run changes in employment as the sources of loads are shifted, particularly in the region between Lewiston and Pasco. The Panel recommends that the study team examine these community effects.

ADDITIONAL RESEARCH AND DATA IMPROVEMENTS

The Importance of Truck Configurations. The type of equipment used is a very important input, not only in this scenario but in all other scenarios. It will have a tremendous impact on projected pavement costs. For example, a scenario in which farmers use old single-axle farm trucks with the single rear axle loaded to 20,000 pounds may be much more damaging to pavements than the Rocky

Mountain Double. In essence, the type of truck used is important in estimating both pavement impacts and shipping costs.

Rate Structures and Changes. Rate structures and changes in rate structures after drawdown are going to be a critical aspect of the study and are critical inputs to the model. There are three facets discussed here: truck rates, shuttle train rates, and handling charges.

With respect to truck rates, the Panel feels these will vary significantly by type of truck. So, again, it is important to specify which type of truck is being used on each particular link. The project team should probably talk to a small sample of elevators to ascertain the current mix of truck types, changes that have occurred over the last several years, and additional changes which the elevators foresee in the future. It may also be useful to talk to at least one or two of the large river elevators, asking them the same types of questions.

With respect to railroad rates, if railroads go to shuttle trains after drawdown it is very possible that the rates would actually be lower. Shuttle trains have been deployed in North Dakota, Iowa and other locations. In North Dakota for example, 100-car shuttle train movements operate between select origins and Portland at a net $150.00 discount from the lowest available 52-car rate. Almost certainly, any shuttle train rates for 100-car trains would be lower than the 52-car rate or the 26-car rate. However, it doesn't necessarily follow that the minimum shuttle train size would have to be 100 cars. It could certainly be less than that; perhaps it could be 50 cars given that the prevailing railroad rate is the 26-car rate. It may make more sense for the railroads to opt for a 50-car shuttle train rate. In any respect, the railroad rate would almost certainly be lower than any rail rate in existence at this time. Also, it doesn't necessarily follow that the train would have to shuttle the entire year round. It could be 5 to 20 trains that could be concentrated during and after harvest. These are operational features that could be negotiated with the railroad.

While barge rates respond very aggressively and very rapidly to changes in export demand, changes in railroad rates tend to be much more sluggish and occur over a long period of time. The major way that railroad shipments change quickly in response to changes in demands is through programs like the Certificate of Transportation where shippers bid premiums for guaranteed car supply for a near-term delivery (e.g., 30 days). In this case, shippers are looking at changes in export demand and will bid premiums for COT cars.

Barge Rates. The project team should try to obtain time-series barge rates from USDA. These rates would probably relate to the Mississippi River system. However, the project team could develop statistical models that look at relationships between export demand and barge rates, with a lag variable in the model. The practical aspect of this analysis would, perhaps, be to look at potential changes in barge rates in the Pasco to Boardman reach as a result of the drawdown; in which case, the additional demand previously exhibited on the Snake River system would be concentrated at Pasco.

Handling Costs and Facility Investments After Drawdown. Another important input to the LP model is the handling costs at river elevators and at regional elevators with railroad access.

Handling costs may change with changes in demand. An example is the scenario where all Snake River traffic is concentrated at Pasco. It could very well be that the handling charges would increase in response to demand.

With respect to the shuttle train elevators -- the four to five elevators mentioned earlier -- some incremental investment may be needed in side track capacity or, perhaps, in additional storage. In reality, these investments would be amortized over time. Because the additional volume going through these facilities would be much greater, the unit costs may actually be lower. The project team probably should consider estimating handling charges or changes in handling charges at these facilities.

<u>Truck Rates and Rate Functions</u>. We feel that the U-shaped EWITS truck rate function does not fit our traditional expectations. Instead, we expect that after the first few miles, the truck rate function is probably fairly linear and flat, and that if one were to get more truck rate information from ADM or other grain companies, one would possibly see that type of rate structure develop from the data. Thus, with respect to truck rates, we recommend that the study team talk to some larger grain merchandising companies such as ADM or Cargill -- people that deal everyday in purchasing a lot of truck services from different origins and different destinations. These companies should have very good information on truck rate scales. We expect that their truck rate scales might be approximately linear with distance.

Many factors will affect truck rates. They may be affected by the type of equipment used, the distance and certain other factors, and also by the backhaul potential. These truck factors should be considered in the model. Hopefully, it will become apparent from the survey data what the current backhaul proportion is. However, the backhaul proportion may change after drawdown. Therefore, sensitivity analysis may be appropriate.

We have already discussed additional research needs related to input scenarios and rate changes. In summary, the Review Panel recommends that the project team talk with railroads (particularly unit train shippers), farmers, and others to verify or obtain the specific information needed by the model.

CAVEATS

We already have discussed the need for open and full disclosure of data inputs and a discussion of potential data weaknesses and assumptions early on. Sometimes, qualifications can be discussed in technical memoranda or endnotes; they do not need to be blown-out of proportion. The idea is to just get these issues out in front so that everybody knows about them, there are no surprises, and readers appreciate the study team's efforts to understand on-the-ground realities.

In particular, the report should discuss the approach of using 1996 and 1997 data and up-front impacts instead of a phased approach. Thus, readers will understand the differences between this study and the Corps of Engineers' study. Again, the Panel agrees with the "snapshot" approach. However, we recognize the creative abilities of economic agents in the region (including farmers) to adjust and adapt, and therefore we caution that snapshot studies are likely to portray impacts at a high end of the range.

The second item under this heading is sensitivity analysis. Again, we talked about the benefits of looking at a range of possible scenarios and a range of possible outcomes and conclusions.

Finally, perhaps some caveats are needed regarding assumptions about railroad reactions after drawdown. Railroad reactions may hinge upon shipper acceptance of new service levels and technologies such as shuttle trains, and may also depend upon shippers' willingness to invest in sidetrack capacity and storage capacity, or the willingness of some third party to make these investments.

In portraying the results of this study, the Review Panel recommends efforts to improve data wherever possible and to cross-check data from as many sources as possible. Also, all perspectives should be considered and discussed in the reports so that economic players at least can see their situations represented in footnotes, if not in the assumptions built into the model. In portraying the results of the model, it should be emphasized that although the project team has built as much flexibility as possible into the analysis, at times, the study is constrained by the limitations of computer models, which behave according to necessary constraints and abstractions.

Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 6

Summary of Corridor Impacts and Costs

This technical memorandum summarizes the estimated impacts and costs to Eastern Washington's highway and railroad systems if a drawdown were to occur on the Snake River prohibiting all river barge traffic. Specifically, these costs and impacts are related to the additional demand placed on highways and railroads as a result of the diversion of commodities from barge to railroads and trucks. If this shift occurs, modifications to the infrastructure of the highway and rail systems will need to be made in the form of new system connections as well as mitigation of accelerated highway pavement damage.

This technical memorandum identifies those corridors which would be most directly affected by the proposed drawdown. Included in the summary of investments and costs are considerations for capacity improvements, congestion mitigation, safety concerns, and loading and unloading facilities. The two scenarios identified in this memorandum are tools for evaluating the infrastructure needs of the truck/barge and railroad systems such that each mode would have the capacity to handle a significant portion of the traffic generated by Eastern Washington commodities. No attempt is made to determine which of the two scenarios is a more likely outcome of a drawdown.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four Lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts. Other technical memoranda being produced for the Lower Snake RiverDrawdown Study include:

TM#	Topic
1.	Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources
2.	Annotated Bibliography of Newly Acquired Data Sources
3.	Description of EWITS Model and Features
4.	Summary of Geotechnical Implications of Drawdown on Parallel Transportation Facilities
5	Summary of Assumptions and Affected Corridors
7.	Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake Rivere Reservoirs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction

The proposed removal of the four dams on the Lower Snake River could have significant impacts on the transportation infrastructure of Eastern Washington. Previous technical memoranda have addressed the data and methods used to develop a least-cost transportation model for the LTC Snake River Drawdown study. This memorandum discusses the outcomes of specific scenarios tested with the model and describes in detail the methods used to calculate impacts to the transportation system based on the model results.

In many parts of the Eastern Washington study area, the rates charged for shipment of commodities by rail and by truck/barge are quite competitive with one another; with barge currently enjoying a competitive advantage. Under the proposed drawdown scenario, the economics of commodity shipment in the region are likely to change. Market forces and decisions by carriers may make a significant difference in the modal split between truck/barge and rail.

Two scenarios were established for this analysis which represent likely responses to a drawdown. Scenario 1, discussed below, assumes that transportation costs will remain constant relative to one another and that current rail car shortages will continue. Under this scenario, the truck/barge mode would continue to carry the majority of the commodities, and thus infrastructure investments would be focused on the highway system. A second scenario models a significant movement of commodities by rail. This identifies a maximum need for investment in railroad infrastructure. By examining both scenarios, and comparing them with a model calibrated to replicate existing conditions, a range of impacts can be expressed which represent the worst-case impacts to highway and rail.

Existing Conditions

In order to verify model assumptions, the results of a model run using existing conditions (i.e., no river drawdown and no change in relative shipping costs) were compared with actual shipping data. Figure 1 presents the results of this model run. Figures 2 and 3 break down the results into their highway and rail components. Commodity movements were verified as indicated in *Technical Memorandum No. 5 - Summary of Assumptions and Affected Corridors*, demonstrating close correlation with actual reported commodity movements. In general, the patterns indicated in the model run closely resembled existing patterns of freight movement up and down the Columbia/Snake River system, the tributary highways, and the railroad systems.

Table 1 illustrates the commodities modeled and their present patterns of shipment. In order to best capture the quantities of goods affected by a drawdown of the Lower Snake River, volumes of commodities shipped are presented for barge traffic at Ice Harbor Dam, the furthest downstream of the four dams under consideration for removal in the EIS being prepared by the Army Corps of Engineers.

Table 1, Barge Commodity Movement, Existing Condition

Commodity	Volume at Ice Harbor, Tons	Direction
Wheat & Barley	3,240,618	Downstream
Petroleum	114,980	Upstream
Wood Products	590,000	Downstream
Fertilizers	33,123	Upstream
Containers	457,887	Downstream

Scenario 1, Highway Scenario Impacts With Snake River Drawdown

The model run of Scenario 1 assumed that the existing rates for commodity movements on the rail and truck/barge systems would not change relative to each other. Shipment of goods by barge on the Snake River was not permitted as a transportation option, and as a result, commodities were diverted to alternative routes and modes. Under this scenario, little change was seen in the mode or route choices of commodity shipments downstream of Umatilla. A majority of the commodities previously shipped by barge along the Snake River moved via truck to the Tri Cities area, the most upstream slack water group of ports. This movement pattern would increase traffic on three primary highway corridors, US 395, SR 124/US 12, and the Pasco-Kahlotus/SR-26 system.

Under Scenario 1, a small percentage of the commodities displaced off of the Snake River would move to railroads, in part due to the continued competitiveness of the truck/barge mode, but also because of constraints placed on elevator facilities which limit them to current throughput levels.[1] In essence, highways in these three corridors replace the Snake River as the primary route to the Tri-Cities ports for trans-shipment to barges for delivery to the Portland area.

Figure 4 shows this information, graphically displaying the change in highway truck volumes flowing from Eastern Washington to the Tri-Cities.

With the Snake River dams removed, there would be no commodity movements on the Snake River. The highways which roughly parallel the Snake River, (US 395, SR-124/US 12, and Pasco Kahlotus/SR-26) would experience an annual increase of approximately 4,512,000 tons of freight; or approximately of 169,000 one-way truck trips per year.

Significant impacts to state highways and county roads would result from this dramatic increase in freight movement into the Tri-Cities area. In order to reasonably accommodate these increased truck movements, infrastructure improvements will be necessary to maintain adequate highway performance and minimal travel delay. Improvements identified include additional highway capacity, particularly, intersection/interchange improvements that would minimize congestion. Furthermore, the additional truck traffic that would occur under this scenario will result in increased wear on the pavement surface, requiring more frequent

[1] The throughput constraint placed on facilities which ship by rail attempts to incorporate the effects of a lack of grain cars for the short haul from Eastern Washington to Portland, as well as the capacity limitations of many elevators located on railheads, which may not be able to handle a large increase in demand. This is considered to be an appropriate assumption for this scenario in which the worst-case impacts to the highway system are to be assessed. Scenario 2 which addresses the worst case scenario for rail infrastructure improvements does not incorporate these constraints.

maintenance and pavement replacement/overlay. Table 2 summarizes the estimated costs of this increased freight movement over the highways. A detailed discussion of the methodology used for calculating the highway infrastructure, maintenance and accident costs is found in Appendix A.

Table 2: Cost Summary, Scenario 1, Highway Scenario Impacts

Highway Corridor	Current Number of Trucks Per Day (Both Ways)	Increased Number of Trucks Per Peak Day (Both Ways)	One-Time Costs			Annual Increase in Accident Costs
			Intersection Improvement	Pavement Improvement	Total Transportation Infrastructure	
US 395 (Tri-Cities to Ritzville)	3,360	456	$0.0M	$20.4M to $24.4M	$20.4M to $24.4M	$0.5M
Pasco-Kahlotus/SR -26 (Tri-Cities to Colfax)	102	408	$0.0M	$18.9M to $22.7M	$18.9M to $22.7M	$0.5M
SR-124/US-12 (Tri-Cities to Clarkston/ Wilma	519	.744	$0.2M	$31.3M to $37.6M	$31.5 to $37.8	$1.3M
Tri-Cities Area (Pasco/ Kennewick)	1,015	696	$8.7M to $10.4M	$4.6M to $5.4M	$13.3M to $15.8M	$0.1M
Total			$8.9M to $10.6M	$75.2M to $90.1M	$84.1M to $100.7M	$2.4M

Scenario 2, Railroad Scenario Impacts With Snake River Drawdown

Scenario 2 incorporates the maximum infrastructure improvements that would be necessary to ensure that railroads continue to participate in the shipment of Eastern Washington commodities. Unlike the improvements identified under Scenario 1, the improvements discussed below refer to investment in private infrastructure. Scenario 2 assumed that railroad transportation costs would be reduced by ten percent relative to truck/barge transportation. This ten percent change could be realized if the railroads were to compete more aggressively for freight diverted off of the Snake River, or because of increased barging transportation costs stemming from the loss of the most profitable, longer haul, portion of the Columbia-Snake navigation route. More importantly, the model constraint which limits rail traffic to current elevator and rail car capacities, was removed. During the verification process for this study, producers and shippers agreed that rail car shortages stem from the relatively low profits that can be realized by the Class I railroads on short-haul shipments of low-value commodities. The low profit margins are, in part, a result of rates being kept low by competition from the barge industry. The constraint on rail cars can be viewed as an effect of the current set of economic relationships in Eastern Washington. The removal of the rail car limiting constraint does not imply that these cars will become available, but rather acknowledges that the underlyingcauses which led to the constraint are subject to change.

Under this scenario, the model indicates a significant increase in the traffic carried by the railroads from Eastern Washington to Portland (see Figure 5). The grain passing The Dalles dam in this scenario is split in volume with 54% traveling by barge and 46% traveling by rail. Under the existing condition the split indicated by the model is 93% barge and 7% rail. This breakdown would increase commodity tonnage on the rail system by approximately 2.2 million tons. In addition, the increase on the SR-124/US-12 highway corridor would be approximately 1,838,000 tons or 73,300 trucks. Table 3 shows the total costs for these highway and rail improvements.

Table 3: Total Costs, Scenario 2, Railroad Scenario Impacts

Railroad Improvements	$ 76.4 – 91.8 M
Highway Improvements	56 – 67.2 M
Railroad Grain Cars	50 – 55 M
Total One Time Costs	$182.4 – $214 M

As shown in Tables 4 and 5, shipping patterns under this scenario would require infrastructure improvements on both the truck/barge and railroad modes. The primary impact occurs on the shortline railroads, which would require track and bridge improvements, as well as storage track for accumulating the grain cars into unit trains. In addition, one highway corridor, SR-124/US-12 from Clarkston to the Tri-Cities, would continue to carry increased freight under this scenario. These increases are primarily due to movement of commodities other than grain (timber products) that, according to the model, and available tariff rates, would still be more economical to ship by truck. The following tables summarize the additional costs associated with Scenario 2. A detailed discussion of the methods used to calculate impacts to the rail infrastructure appears at the end of this document as Appendix B.

Table 4: Cost Summary, Scenario 2, Railroad Scenario Impacts

Railroad Infrastructure Costs

Railroad Corridor	Additional Trains (1) (originating lines)	Interchange W/Mainline Facilities	Track Upgrade	Other Costs (Inc. Bridge Upgrades)	Elevator Load/Unload Track Upgrades	Total
Blue Mountain Railroad	12	$0.0M	$0.0M	$0.0M	$0.4M to $0.5M	$0.4M to $0.5M
Palouse River Railroad (2)	69.4	$2.8M to $3.4M	$4.6M to $5.5M	$1.0M to $1.2M	$8.8M to $10.6M	$17.2M to $20.7M
Camus Prairie Railroad	45.4	$2.0M to $2.4M	$0.0M	$0.0M	$0.8M to $1.0M	$2.8M to $3.4M
BNSF/UP Mainline	27.8	$0.0M	$0.0M	$0.0M	$8.4M to $10.1M	$8.4M to $10.1M
Coulee City Palouse River	42.6	$2.0M to $2.4M	$4.0M to $4.8M	$1.0M to $1.2M	$4.0M to $4.8M	$11.0M to $13.2M
Columbia Basin	6.5	$0.0M	$0.0M	$0.0M	$1.6M to $1.9M	$1.6M to $1.9M
Columbia River Ports	-0-	$0.0M	$0.0M	$0.0M	$35.0M to $42.0M	$35.0M to $42.0M
Total	203.7	$6.8M to $8.2M	$8.6M to $10.3M	$2.0M to $2.4M	$59.0M to $70.9M	$76.4M to $91.8M

(1) Assumes 108 car unit trains
(2) Combined total with 11.5 trains interchanging at Marshall near Spokane and 57.9 trains at Hooper junction.

Table 5: Cost Summary, Scenario 2, Railroad Scenario Impacts Highway Infrastructure Costs

Highway Corridor	Current Number of Trucks Per Day (Both Ways)	Increased Number of Trucks Per Peak Day (Both Ways)	One-Time Costs			Annual Increase in Accident Costs
			Intersection Improvement	Pavement Improvement	Total Transportation Infrastructure	
US 395 (Tri-Cities to Ritzville)	3,360	0	$0.0M	$0.0M	$0.0M	$0.0M
Pasco-Kahlotus/SR -26 (Tri-Cities to Colfax)	102	200	$0.0M	$13.2M to $15.8M	$13.2M to $15.8M	$0.3M to $0.4M
SR-124/US-12 (Tri-Cities to Clarkston/ Wilma	519	580	$0.2M	$31.3M to $37.6M	$31.5M to $37.8M	$1.3M to $1.6M
Tri-Cities Area (Pasco/ Kennewick)	1,015	560	$8.7M to $10.4M	$2.6M to $3.1M	$11.3M to $13.6M	$0.1M
Total			$8.9M to $10.6M	$47.1M to $56.5M	$56.0M to $67.2M	$1.7M to $2.1M

One significant limitation to the shipment of Eastern Washington commodities by rail is the current lack of hopper cars for the shipment of grain. Because the long-haul shipment of grain from Montana, North Dakota and other more easterly states is currently more profitable than the short haul of grain out of Eastern Washington, many areas face a shortage of cars, which would limit the ability of rail to absorb the additional tonnage diverted off of the Snake River. Major rail carriers have consistently stated that this short haul route is not a primary market focus. The increased tonnage will make the short haul out of Eastern Washington more attractive to the railroads, but it is not expected to divert grain cars from the long haul routes.

Based on two round trips per month, preliminary investigations indicate that approximately 1,000 additional grain cars at an estimated cost of $50 to $55 million would need to be purchased.

Sensitivity of Commodity Shift

The discussion of these two scenarios indicates how sensitive the movement patterns of commodities are based on the relative price of the competing systems. Scenario 1 illustrates the resulting patterns of commodity movement using the current relative price differences between truck/barge and railroad system. This pattern indicates that 88% of the all commodities are carried by the truck/barge system, while railroads carry just 12%; and a very small proportion is trucked all the way to Portland. Scenario 2 presents the patterns of commodity movement based on a 10% relative change in the price differential favorable to the railroad system. Under this scenario only 53% would be carried by the truck/barge mode, while rail would account for up to 47%.[2]

As relative price changes are made, shippers are expected to take advantage of the lowest transportation costs, without much regard for shipment mode. In order to allow a competitive environment to lower costs for commodity movement, investment in both modes of transportation would be necessary.

[2] It should be noted that a significant portion of the increase in the tonnage carried by rail can be attributed to the removal of capacity restrictions. With rates held to existing levels, the addition of unlimited capacity on the rail lines shifts the proportion to 62 percent carried by truck/barge, and 38 percent carried by rail.

Appendix A: Cost Determination for Highway Infrastructure

Impacts and costs to Eastern Washington highways and railroads were estimated, with the assumption that the Snake River would become unnavigable to barges. The model developed for this project predicted commodity shifts for the two scenarios as described above. The increase in commodities diverted to highways was analyzed to identify the projected increase in truck trips needed to haul these commodities. With the increase in truck trips established, the project team estimated the following impacts and costs to Eastern Washington's highways.

- Intersection improvements and costs needed to accommodate the projected increased truck traffic;
- Pavement improvement and costs needed to accommodate the increased truck traffic; and
- Annual increase in accidents and costs resulting from the projected increased truck traffic.

Increase in Number of Trucks

The increase in the number of truck trips was estimated based on the increase in annual tonnage for all commodities diverted from river barges to trucks. This information was collected by roadway segment for the roads which experienced the greatest increases in tonnage. By dividing the annual tonnage by the average payload per truck, the increase in number of one-way trucks was calculated. Currently, when trucks are used to haul grain in Eastern Washington, they are primarily used in a feeder role to deliver grain at harvest time to an elevator within a relatively short distance of the farm.[3] These short distance hauls are performed typically utilizing 80,000 pound or less GVW trucks. Because of the increased haul distances and quantities of grain diverted to trucks in this region if shipment by barge on the Snake River is prohibited, it was assumed that 105,500 pound GVW trucks, the largest truck-size legally allowed on Washington highways, would be used to haul grain products. In contrast, standard 80,000 pound GVW trucks would be used to haul containers, petroleum, fertilizer and wood products.

Increase in trucks hauling grain products (assuming 105,500 pound GVW trucks):

Payload = 61,400 pounds = 30.70 tons
Average load = 93% of payload

$$\text{Annual increase in grain trucks (one-way)} = \frac{\text{Annual increase in grain tonnage}}{(30.70 \times 0.93)}$$

Increase in trucks hauling products other than grain (assuming 80,000 pound GVW trucks):

Payload = 50,680 pounds = 25.34 tons
Average load = 93% of payload

$$\text{Annual increase in non-grain trucks (one-way)} = \frac{\text{Annual increase in non-grain tonnage}}{(25.34 \times 0.93)}$$

Total increase in trucks (hauling commodities diverted from river barges) per roadway segment:

Total annual increase in trucks

= Total annual increase in trucks (grain + non-grain trucks) x (2 trips / round trip)

[3] EWITS Report #5

Intersection Improvements and Costs

Intersections were analyzed along Eastern Washington roadway corridors where significant increases in truck traffic were identified. These intersections were analyzed to identify any increases in delay at the intersections. Where significant increases in delay were identified, the need for and extent of intersection improvements to alleviate these delays was assessed. The study team then prepared estimates for implementing these identified improvements.

In analyzing intersections to identify whether improvements were required, the total annual increase in trucks was converted to increase in trucks during peak hours. This value was determined using the following assumptions:

1. *10% of all the grain currently transported by barge is hauled during the peak month.*[4]
2. *The majority of the grain is transported during weekdays. (There are 21 weekdays during the average month.)*
3. *The majority of the grain transported on a weekday is hauled during a 12-hour period.*
4. *The increase in number of truck trips during peak hours is calculated as follows:*

$$\text{Total increase per hour} = \frac{\text{Total annual increase in trucks}}{10 \times 21 \times 12} \quad \text{or} \quad \frac{\text{Total annual increase}}{2520}$$

Costs for intersection improvements were estimated using typical Eastern Washington prices. Costs for each improvement within each corridor/study areas were added together to determine an intersection improvement cost for each of the four corridor/study areas.

Pavement Improvements and Costs

To determine the extent of the pavement improvements that would be required under a drawdown scenario, the study team completed a conceptual analysis of the pavement to determine the percent reduction in pavement life which could be expected if truck traffic were to increase. Utilizing a simplification of the basic concepts for pavement rehabilitation, described in the WSDOT Pavement Guide, general design traffic values[5] for four basic roadway classifications (major arterial, minor arterial, collector, and other county roads) were developed. These design traffic values are indications of the number of trucks the "average" highway is expected to withstand during the design period for each of the roadway classifications.

In addition, a traffic value was determined for each of the roadway sections, based on the estimated annual increase in truck trips resulting from a loss of river barge traffic on the Snake River. This projected increase in truck traffic was estimated based on the increase in annual tonnage for commodities diverted from river barges to trucks, as discussed in an earlier section of this Appendix A. This value was then converted to ESALs using 2.63 ESALs per round trip (2.57 ESALs for load truck plus 0.06 ESAL for the unloaded truck return trip. The percent reduction in pavement life was then estimated as the ratio of the traffic values for the roadway section divided by the design for the designated roadway classification of the section being analyzed.

[4] EWITS Report #5

[5] Using ESALs (or Equivalent 18,000-lb Single Axle Loads), a design value used in evaluating a pavement system.

Roadway Classification	Assumed ESAL for Roadway Classification	Decrease in Pavement Life With Increase of 1 Truck/Hour (or 2520 1-Way Trips per Year)	Increase in Trucks/Hour for 5% Annual Decrease in Pavement Life
Prin. Arterial	3,000,000	0.2%	25
Minor Arterial	1,000,000	0.7%	7.1
Collector	500,000	1.3%	3.8
Minor Collector	200,000	3.3%	1.5

In order to determine whether or not pavement improvements would be required, the study team assumed that any reduction in the pavement life of 5 percent or more per year was significant enough to warrant upgrading the pavement structure. Again, using a methodology provided in the WSDOT Pavement Guide, it was established that an average asphalt pavement overlay depth of 0.3-feet would provide the structure integrity necessary to accommodate the projected increased truck trips.

The study team estimated the costs for improving the pavement using typical Eastern Washington prices. An average cost to provide a 0.3-feet asphalt overlay per lane-mile was estimated. The study team obtained a cost per segment by multiplying this estimated cost per lane mile times the length of the roadway section, and multiplying this number by the number of travel lanes. The costs for each roadway segment within a corridor were added together to determine a pavement improvement cost for each corridor/study area for each of the four most critically affected areas.

Costs for damage to county roads are not included at this time, as this is a separate area identified for possible future study. This study does indicate changes in truck traffic volumes will occur on county roads if shipment by barge on the Snake River is prohibited. Some local roads will see increases, while others will decrease. Even the slightest change in trucking patterns has the potential to significantly impact the wear on county roads, since typically the pavement structure for these roads is not constructed to withstand heavy truck loads. As indicated by the above table, only minor increases of 1 to 2 trucks per hour over a one-year period may result in substantial increases in wear to pavement of these lower classified roadways, and decreases in the pavement life approaching 5% annually.

Annual Increase in Accidents and Costs

An increase in accidents which could result from an increase in the number of truck trips was calculated based on average rates of accident occurrence per truck-mile.[6] The cost per occurrence was based on WSDOT cost factors for use in performing safety-related analysis.[7] The rates and costs used are as follows:

Accident Type	Roadway Classification	Occurrence Rate (per 100 million combination truck miles)	Cost per Occurrence
Fatality	Rural Highway Rural Other Road	7.12 5.37	$800,000
Injury	Rural Highway Rural Other Road	41.12 31.04	$62,000
Property Damage	Rural Highway Rural Other Road	107.55 81.18	$5,800

From these calculations the study team estimated annual increases in accident costs. A cost per segment was obtained by multiplying the projected increase in truck trips, divided by 100 million, times the length of the roadway section (in miles), and then multiplying by the occurrence rate for the roadway segment classification:

$$\textit{Cost/Segment} = \frac{\textit{Truck trips}}{100{,}000{,}000} \times \textit{Length of segment} \times \textit{Occurrence}$$

The costs for each roadway segment within a corridor were added together to determine an annual increase in accident cost per corridor/study area for each of the four most critically affected areas. The methodology employed to develop the highway cost impacts under Scenario 1 was also used to determine highway costs in Scenario 2.

6 Transportation Research Board (TRB) Special Report 246: Paying Our Way: Estimating Marginal Social Costs of Freight Transportation National Academy Press, 1996

7 These cost factors are not actual costs but instead are values used to identify deficiencies (based on past collision history) and to calculate future benefits of proposed improvements.

Appendix B: Cost Determination for Railroad Infrastructure

Rail drawdown impacts are based on a fundamentally different set of assumptions than those utilized for truck/barge movements. An understanding of railroad operations, revenue streams and power, crew, and car availability must be factored into any methodology that attempts to assign capital costs to commodity shifts between modes.

The study team developed railroad train counts by converting the annual increase in net tons which the model indicated would travel on a section of rail into annual carloadings. Grain cars were assumed to hold 100 tons (263,000 lbs. Gross) of wheat or barley with all other commodities being shipped in cars averaging 88 tons. A monthly peak volume was determined utilizing Snake River barge movements obtained for the USACE lock records.[8] The peak monthly volume was estimated at 10 percent of the annual shipments. Grain trains are generally 108 cars long, and since the majority of the rail freight increases supported by the model were from grain movements, all trains were assumed to be 108 cars long.

Light density railroads and logical line segments within the railroads were identified to geographically locate potential capital costs associated with the increased trains. Light density rail lines with specific line segments that experienced a significant increase in car loading were analyzed to identify improvements to bring them up to a minimum level of maintenance as follows:

- Greater than 3,810 cars annually required minimum of FRA Class 3 track (maximum allowable operating speed for freight trains of 40 m.p.h.)
- Less than 3,880 cars annually required minimum of FRA Class 2 track (maximum allowable operating speed for freight trains of 25 m.p.h.)

Main lines segments that experienced and increase of 38,000 cars (5 million gross tons) annually were analyzed for potential capacity improvements or upgrading to a minimum FRA Class 4 track (maximum allowable operating speed for freight trains of 60 m.p.h.).

Light Density Rail Lines Infrastructure Needs

The study team performed an analysis of maintenance data to determine the current level of maintenance on the various line segments. These findings were then verified through interviews with people familiar with railroad operations and maintenance. Order of magnitude cost estimates were developed on a per mile basis for improving the line segment to the desired level of maintenance to allow for reliable operations for the projected traffic volumes. Costs included tie renewals, ballast, surfacing, timber bridge repairs and rail relays for 85 lb. rail or lighter. One time capital costs for the replacement of major structures were investigated. Based on the limited information available at this level of investigations no major bridges were identified as requiring rehabilitation to handle standard 269,000 lbs. grain cars. If the use of the newer and heavier grain cars (289,000 lb. to 315,000 lb. Gross) is considered, most of the timber trestles will require replacement, and most steel trestles will require retrofitting to handle the heavier axial loads.

For light density lines experiencing car loadings of more than 3,810 cars new interchange yards were investigated and order of magnitude costs developed to allow for the efficient interchange of unit trains with the main line railroads. See discussion on rail car fleet requirements for additional sizing assumptions.

[8] EWITS Report #5

Main Line Capacity Improvements

The increased annual tonnage over the Burlington Northern and Santa Fe Railway Company and the Union Pacific Railroad mainlines was investigated for capacity impacts. A net increase of 3.8 million net tons (or 5 million gross tons) was assumed as the threshold before more detailed investigations of potential capacity improvements were justified. Based on discussions with the railroads and previous capacity analysis by Washington State Department of Transportation, the predicted increases in main line traffic (3 million gross tons for both UPRR and BNSF main lines) from a drawdown could be absorbed by the current infrastructure. Given ongoing capacity improvements such as reopening Stampede Pass and double tracking projects between Spokane and Portland this appears reasonable.

Rail Car Fleet Requirements

A critical assumption in the diversion of grain to rail is that an adequate supply of rail cars will be available for loading by the elevators. The average cycle time for grain shipments from the identified interchange yards to the major export terminals was developed based on the following assumptions:

- Main transit time is 3 days round trip
- Dwell time at the export terminals is limited to 2 to 3 days
- Time for light density lines to distribute empties, collect loads, and assemble unit trains in blocks of 28 to make up a full train of 112 cars is 5 to 10 days.

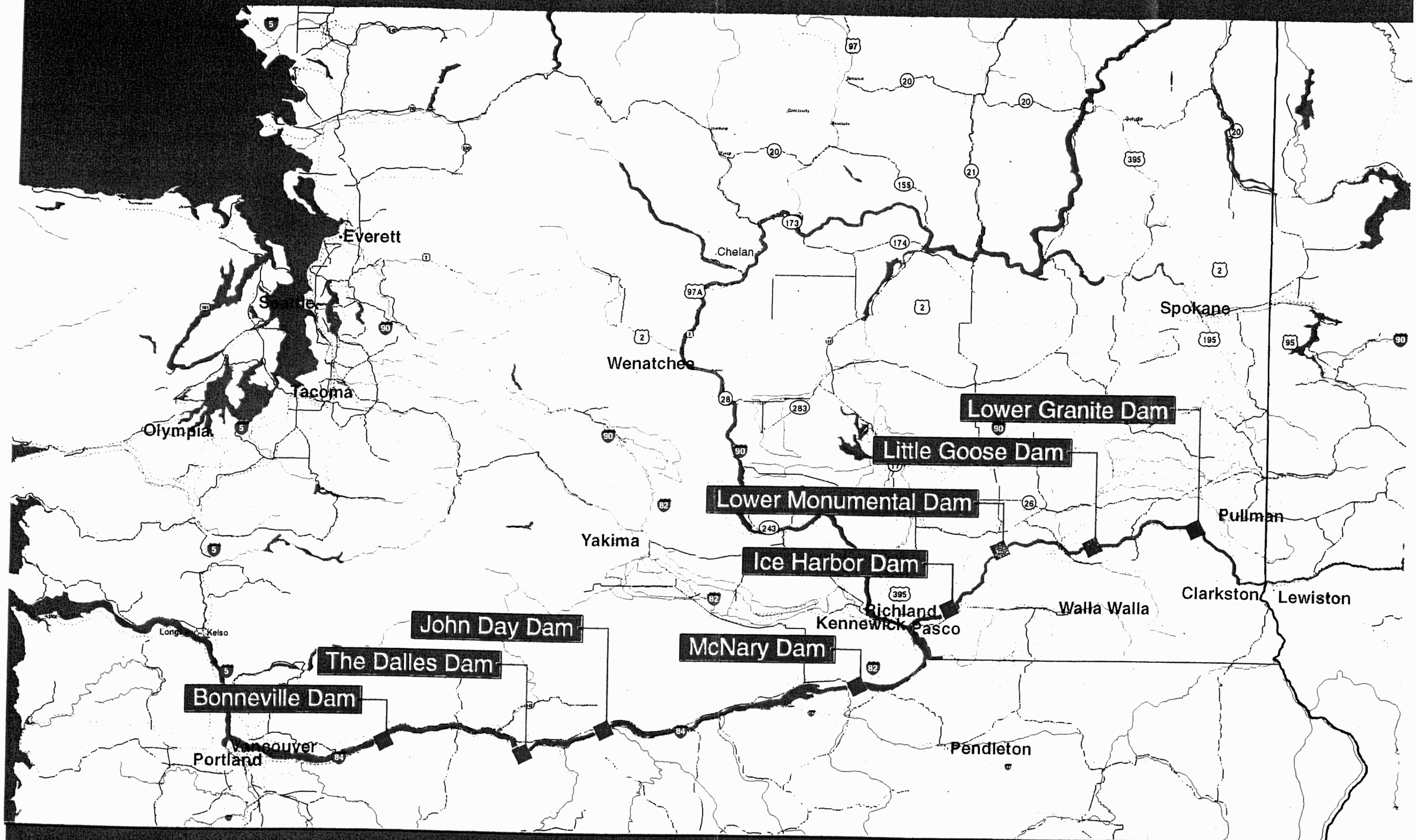
Interchange yards would need to be sized to hold approximately 2/3 of the car fleet predicted to use the identified interchange points. For example Hooper Junction is predicted to interchange 626 cars (5.6 trains) monthly will require a fleet of 345 cars and an interchange yard capacity of 230 cars.

Loading/Unloading Facilities Improvements

A total of 129 grain elevators currently located on active rail lines were identified as potential loading points for the shipment of grain. Order of magnitude costs were developed based on a typical rehabilitation scenario, which included new turnouts as well as limited tie, ballast and rail replacement for a 1000-foot typical siding. It was assumed that a number of elevators would not resume rail shipments, others would expand their rail capacity to handle the increase in business and still others would build new spurs to convert from barge shipments. The resulting order of magnitude cost represents an averaged impact and is not based on specific improvements at each potential loading point.

Export terminals currently unload much greater volumes of grain from the mid-west by rail than the projected increase from the drawdown. Congestion at the terminals however continues to be a problem due to a lack of car storage near the export elevators. Based on the rail car fleet assumptions it was assumed that the major export terminals would need to be able to storean additional two-unit trains per day within the four major export terminals along the lower Columbia River. Since the shipment of grain is not divided equally on a daily basis between terminals two additional unit trains of storage was assumed for each terminal. These improvements are the most difficult to make considering the limited property near the ports, potential environmental impacts, potential modifications to existing facilities and limited access to the main lines.

Snake River Drawdown Study



Dam Locations along the Columbia and Snake Rivers

Snake River Drawdown Study

Existing Conditions - Rail & Highway Total Commodity Movement

LEGEND

- Ports

Road Tonnages
- 0 - 250,000
- 250,000 - 600,000
- 600,000 -900,000
- 900,000 - 1,200,000

Rail Tonnages
- 0 - 381,000
- 381,000 - 710,000

- Columbia and Snake Rivers
- Region Border

SNAKE RIVER BARGE TONNAGE at Ice Harbor Dam

Commodity	Tonnage
Wheat & Barley	3,240,000
Petroleum	115,000
Wood Products	590,000
Fertilizer	33,000
Containers	458,000

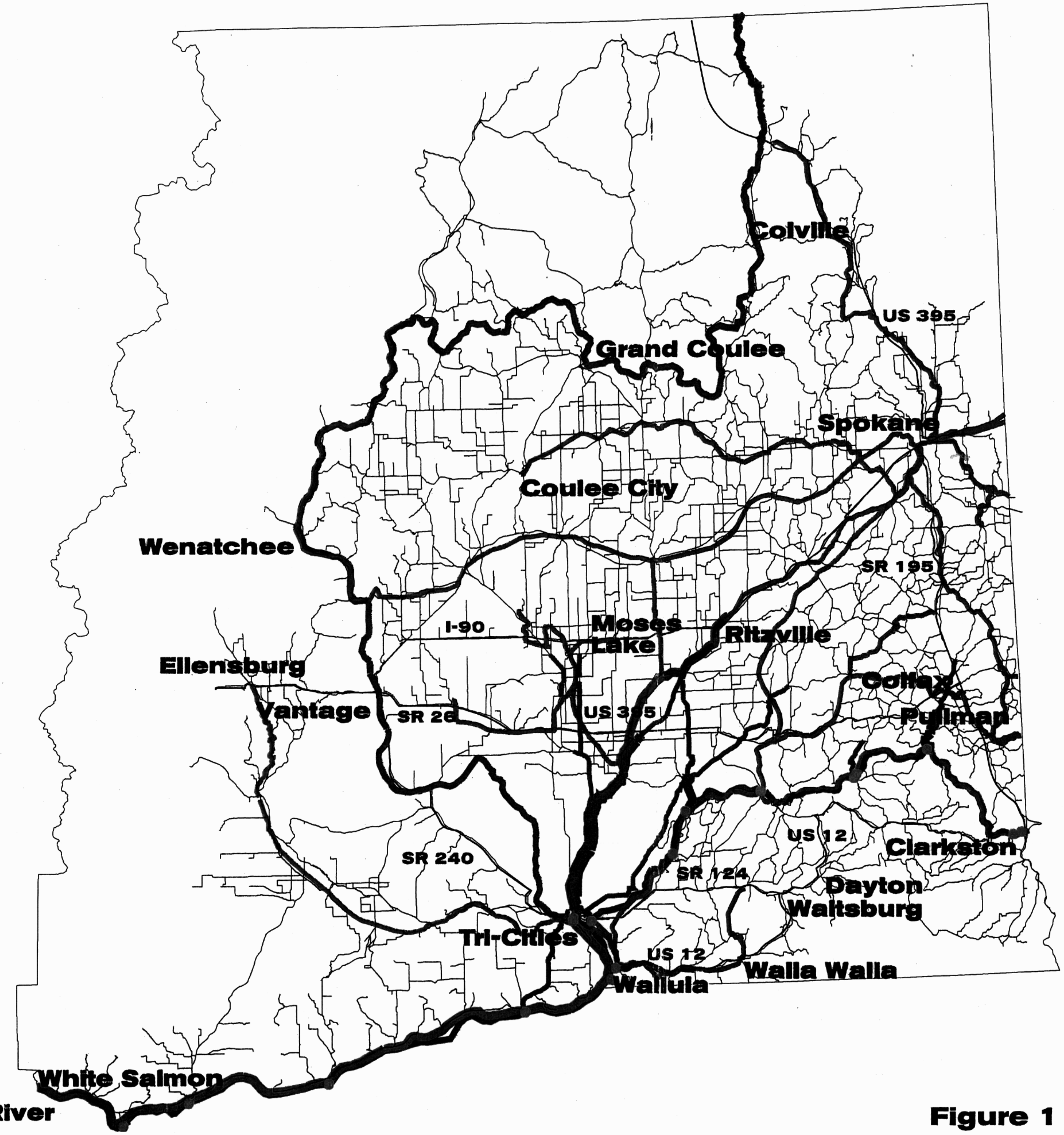


Figure 1

Snake River Drawdown Study

Existing Conditions - Highways Only
Total Commodity Movement

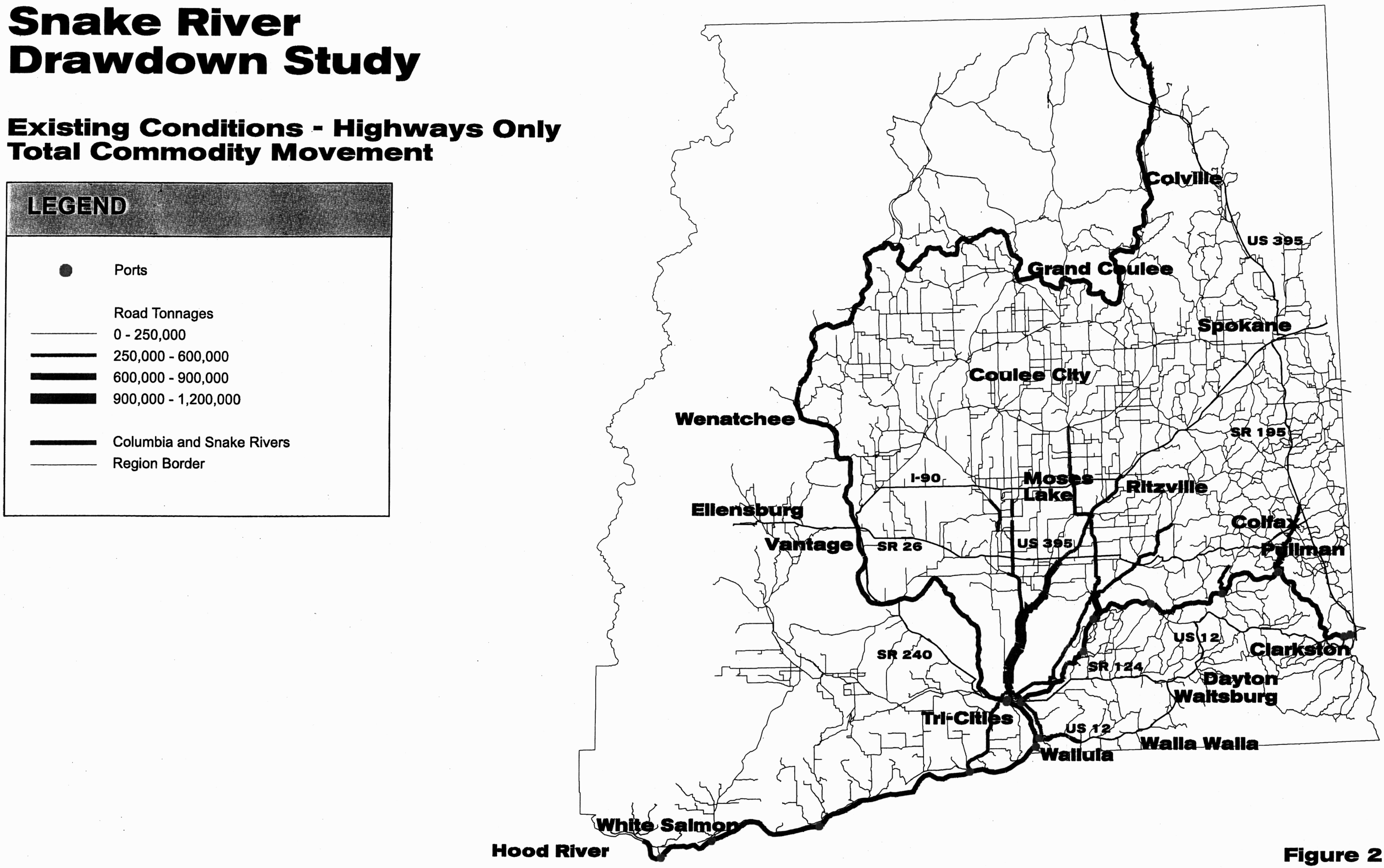


Figure 2

Snake River Drawdown Study

Existing Conditions - Rail Only Total Commodity Movement

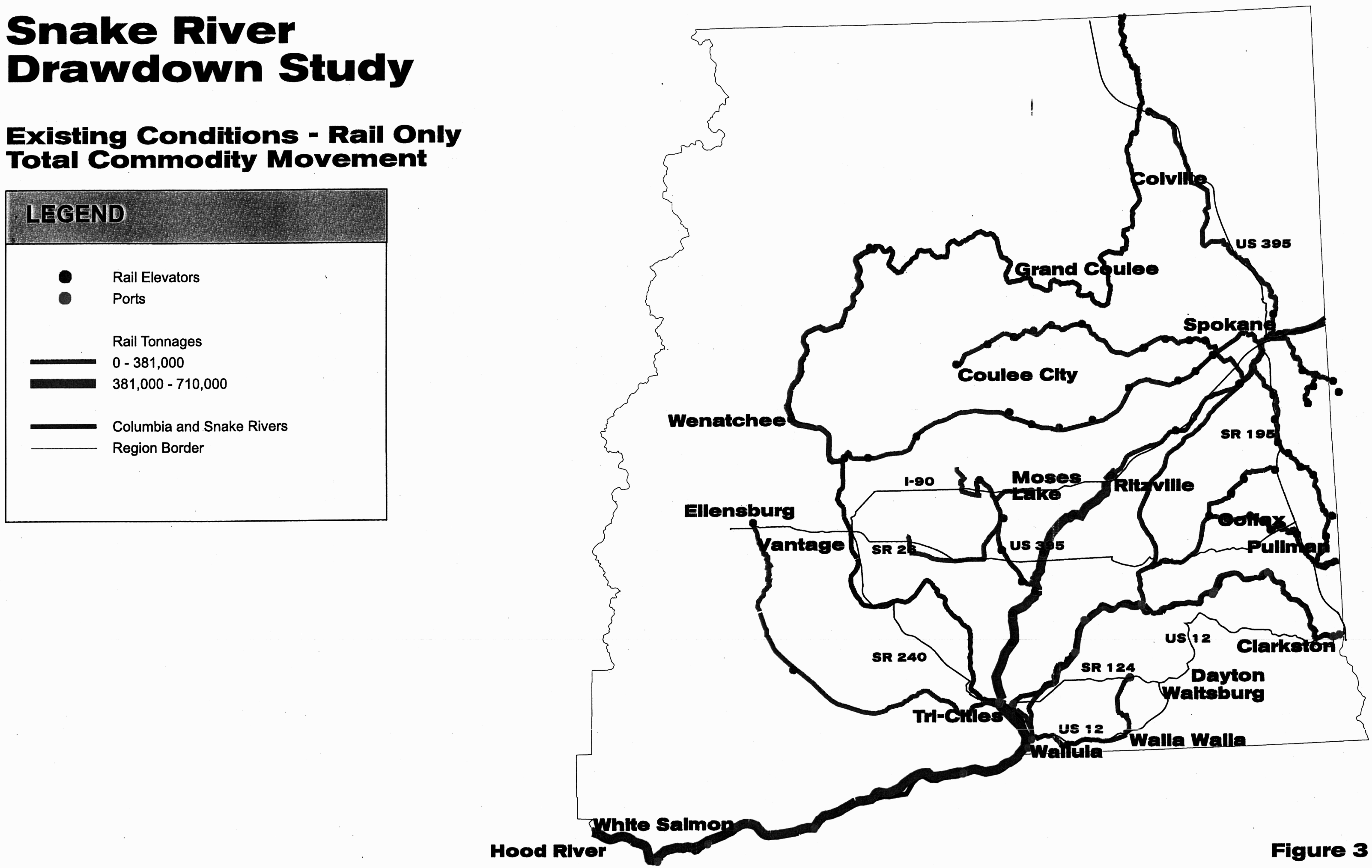


Figure 3

Snake River Drawdown Study

Highway Senario Impacts - Highways Only
Increase in Tonnage Is Shown

LEGEND

- Ports
- Highway Tonnage Increase
  - 0 - 600,000
  - 600,000 - 1,200,000
  - 1,200,000 - 1,800,000
  - 1,800,000 - 2,930,000
- Columbia and Snake Rivers
- Region Border

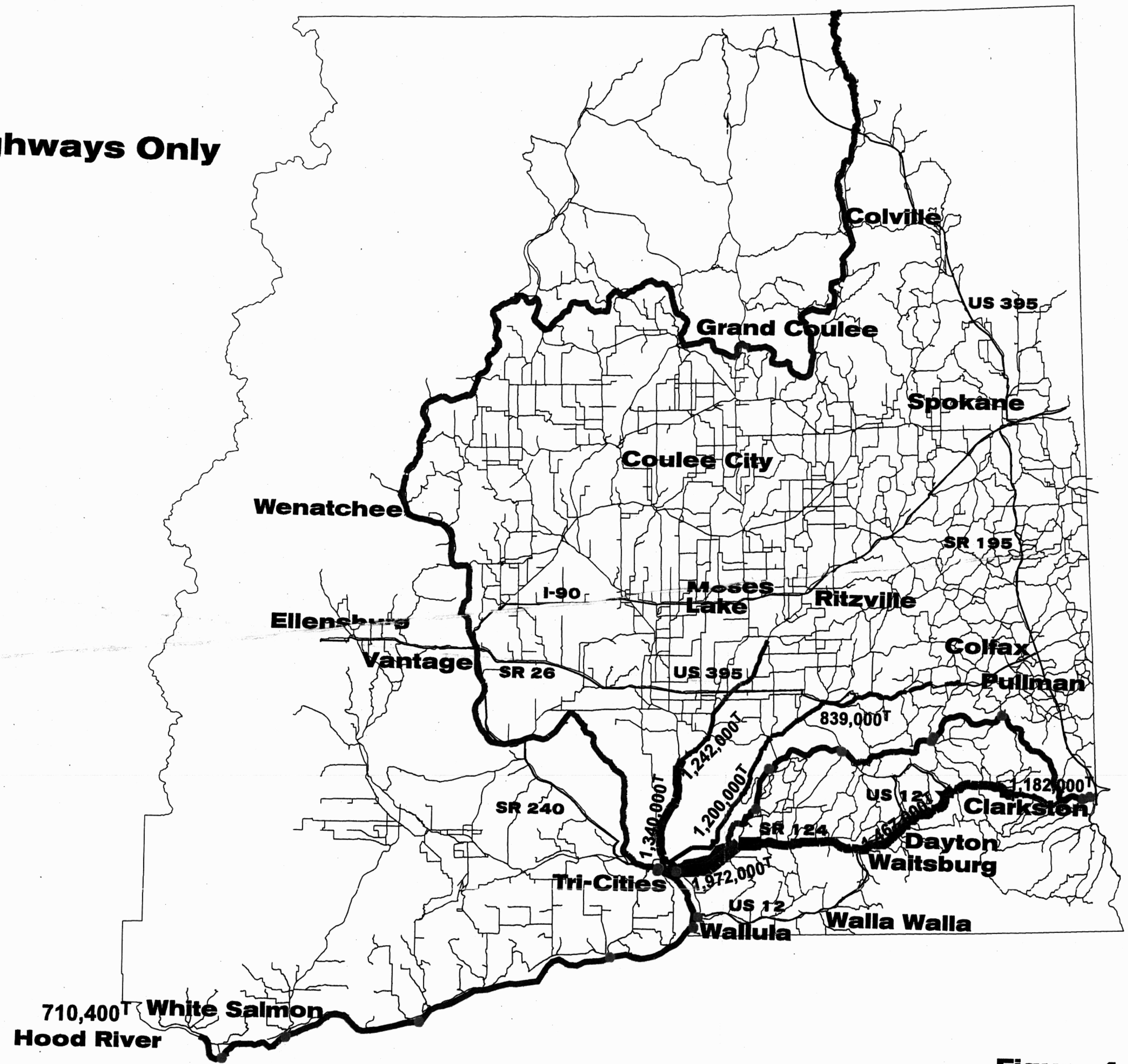


Figure 4

Snake River Drawdown Study

Railroad Senario Impacts - Rail Only Increase in Tonnages Is Shown

LEGEND

- ● Rail Elevators
- ● Ports

Rail Tonnages
- 8000 - 381,000
- 381,000 - 1,620,000
- 1,620,000 - 2,194,000

- Columbia and Snake Rivers
- Region Border

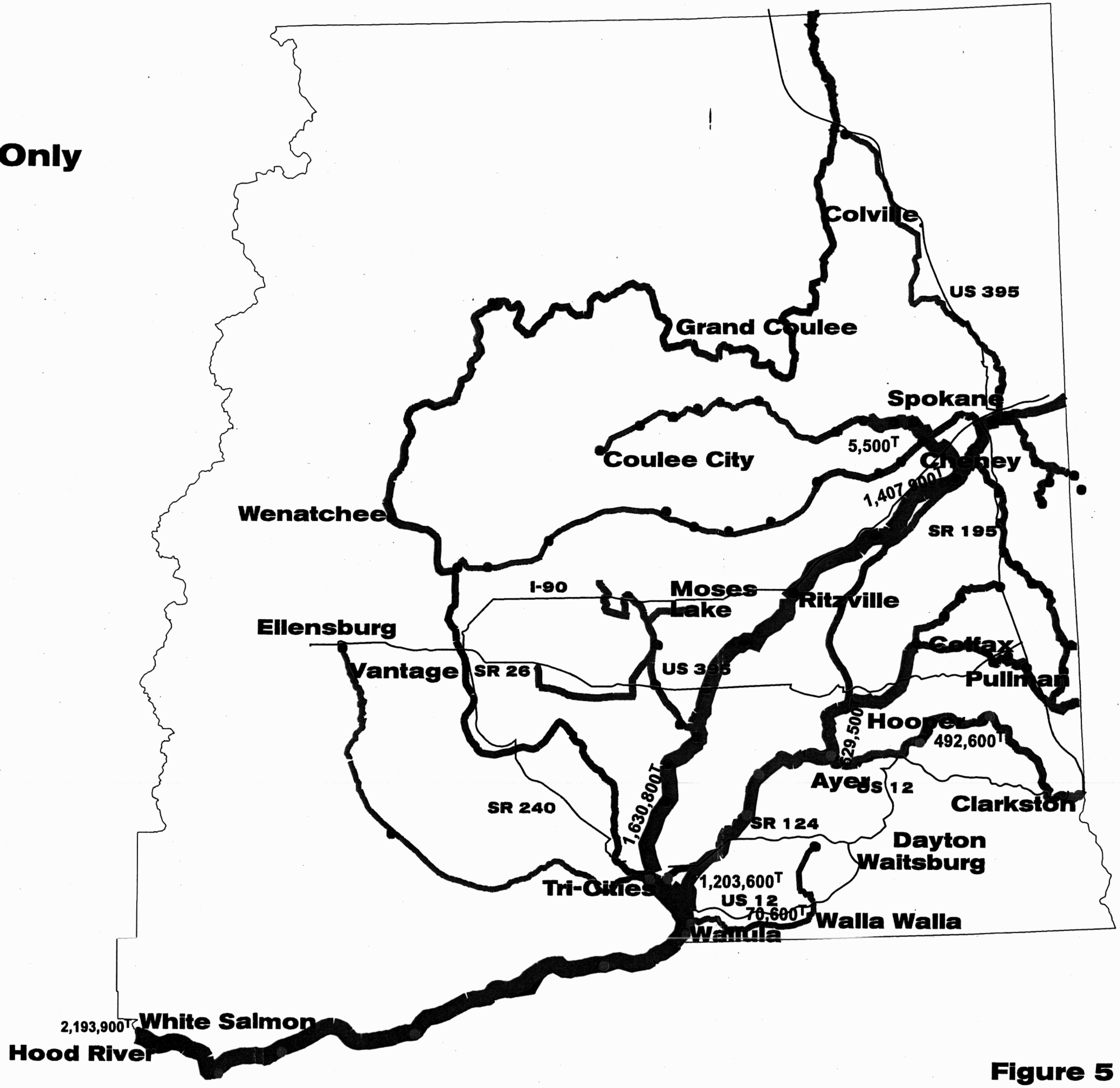


Figure 5

Snake River Drawdown Study

No Barge Scenario - Highways Only Increase in Tonnage Is Shown

Highway Infrastructure Costs

Highway Corridor	Current Number of Trucks Per Day (Both Ways)	Increased Number of Trucks Per Day (Both Ways)	One-Time Costs: Intersection Improvement in Millions of $	One-Time Costs: Pavement Improvement in Millions of $	One-Time Costs: Total Transportation Infrastructure in Millions of $
US-395 (Tri-Cities to Ritzville)	3,360	380	0	20.4-24.4	20.4-24.4
Pasco-Kahlotus/ SR-26 (Tri-Cities to Colfax)	102	340	0	18.9-22.7	18.9-22.7
SR-124/US 12 (Tri-Cities to Clarkston/Wilma)	519	620	0.2	31.3-37.6	31.5-37.8
Tri-Cities Area (Pasco/Kennewick)	1,015	580	8.7-10.4	4.6-5.4	13.3-15.8
Total			**8.9-10.6**	**75.2-90.1**	**84.1-100.7**

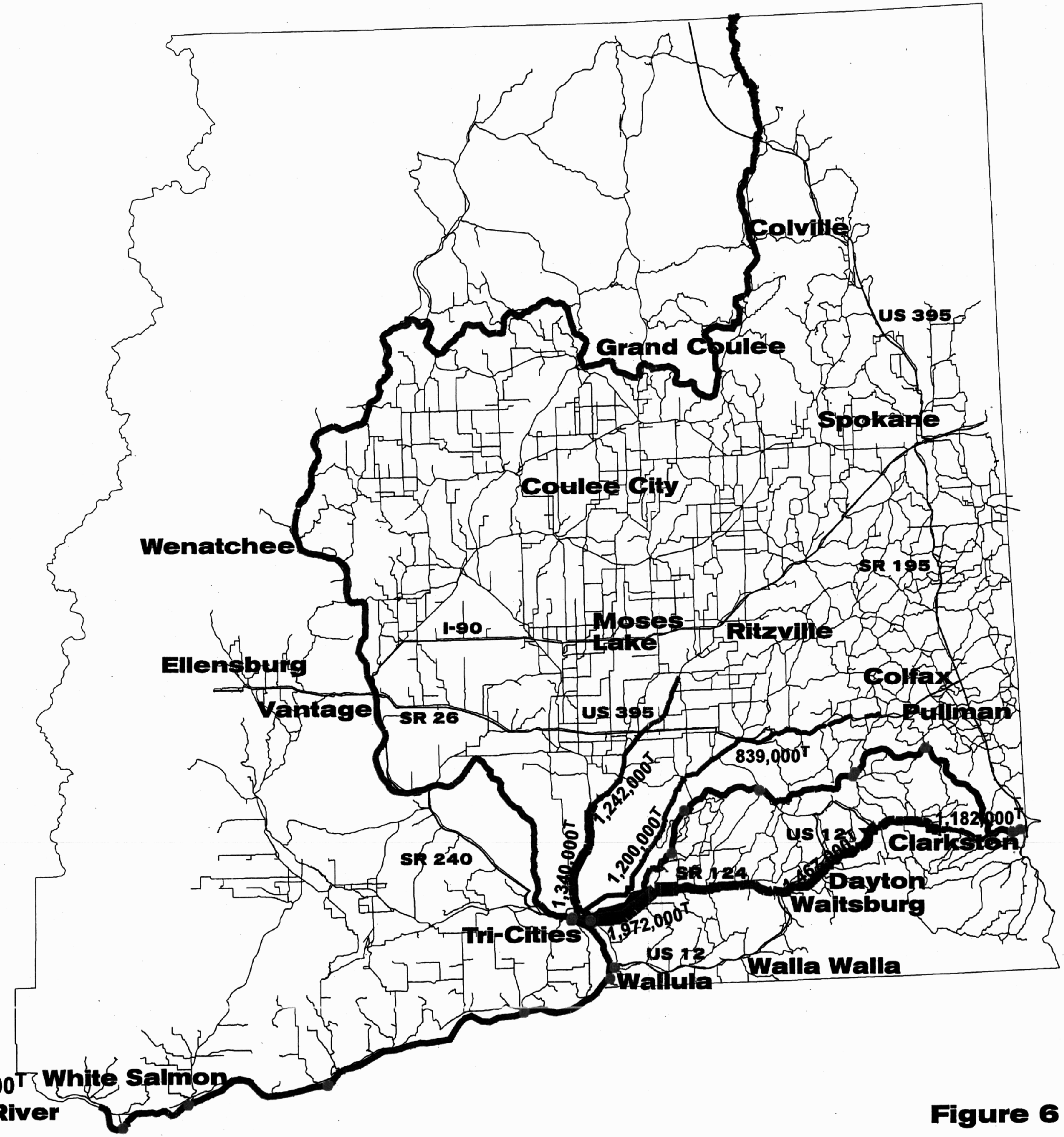


Figure 6

HDR
Technical Memorandum

Lower Snake River Drawdown Study

Technical Memorandum No. 7

Summary of Commodity Shifts Out of Eastern Washington as a Result of a Drawdown of the Lower Snake River Reservoirs

This technical memorandum summarizes the economic impacts that could result from a drawdown of the Lower Snake River reservoirs as predicted from a commodity flow/ transportation diversion model constructed for this study, as well as research conducted on the subject in other regions of the United States. The analysis focuses on the generalized direct and indirect economic impacts associated with a probable increase in shipping costs as a result of the elimination of barge traffic east of the Tri-Cities on the Snake River. More specifically, this analysis assesses the impact due to reduced traffic and handling activities at Lower Snake River ports, to producers of goods, and to the employees and industries that rely on the success of these commodity movements.

In summary, the analysis finds that commodities would likely not shift out of the region as a result of increased shipping costs or lack of barge traffic on the Snake River. There will certainly be direct and indirect impacts to certain ports, communities, and producers that are currently operating without ample resources to survive any increased expenses. It is expected, however, that the proximity of strategic facilities found at the Port of Portland for Eastern Washington products, as well as the relatively costly and problematic alternative destinations of the Gulf ports via the Missouri and Mississippi river systems, will keep products flowing in their current patterns. It is possible that commodities could shift to Puget Sound and Canadian ports, however, facilities at those ports are not presently equipped to handle the massive quantities of product being shipped to and from Eastern Washington.

This analysis is being completed as part of a study of the impacts of a permanent drawdown of four Lower Snake River dams on transportation systems and the general economy of Washington State for the Legislative Transportation Committee. The intent of the analysis is to provide an assessment of both statewide and localized impacts, and to have a clear understanding of the impact analysis being completed by the U.S. Army Corps of Engineers in their Snake River System Operation Plan EIS.

Other technical memoranda being produced for the Lower Snake River Drawdown Study include:

TM#	Topic
1.	Annotated Bibliography of Existing EWITS and Eastern Washington Freight Mobility Study Data Sources
2.	Annotated Bibliography of Newly Acquired Data Sources
3.	Description of EWITS Model and Features
4.	Summary of Geotechnical Implications of Drawdown on Parallel Transportation Facilities
5.	Summary of Assumptions and Affected Corridors
6.	Summary of Corridor Impacts and Costs

In addition, an Executive Summary report, which incorporates the above memoranda as well as documentation of the Salmon Decision Process, will be prepared under this Study.

Introduction
The purpose of this technical memorandum is to identify the potential economic impacts that could occur in Eastern Washington as a result of a drawdown of Lower Snake River reservoirs . More specifically, this discussion focuses on the regional economic adjustments that could be expected from a drawdown, including the potential for commodities which have traditionally flowed through Eastern Washington to find new routes or locations outside of the State for their marketing and distribution centers. The following issues are addressed:

- The economic impacts that are related to the diversion of commodities from the river to highways and railroads.
- Analysis of the direct and indirect economic impacts of a drawdown scenario with respect to local commodity production and regional economic parameters.
- Discussion of the economic incentive for commodities passing through the Eastern Washington transportation system, such as Montana and Idaho grain, to "shift" to other markets and ports, such as the Gulf ports or the Puget Sound.

The following analysis and discussion relies upon the results of the commodity flow/ transportation diversion model built by HDR Engineering, Inc. for the Lower Snake River Drawdown Study, as well expertise drawn from this project's Peer Review Panel, and other published sources.

Estimated Impacts of a Drawdown Scenario on the Eastern Washington Transportation System
Eliminating river navigation at the Snake River ports above the Tri-Cities would force commodities that were formerly trucked to a Lower Snake River port to be trucked to the next nearest port, primarily near the Tri-Cities area. According to the diversion analysis discussed in technical memoranda no. 5 and 6, without allowances for significant capacity increases in the rail system, a relatively small portion of these commodities shift to rail, while most commodities continue to use the truck/barge system loading at ports further downstream.

Grains, primarily wheat and barley, comprise 75 percent of all waterborne commerce along the Lower Snake River *(National Waterborne Commerce Data Center Lock Performance Monitoring System, 1996)*. In addition, transportation costs comprise a substantial percentage of grain producers' and grain shippers' overall investment in these commodities. Therefore, impacts to grain producers will account for a similarly large percentage of the overall economic impact of a drawdown scenario. As a consequence, relatively more effort was focused upon assessing the impacts to the grain production and grain transportation industry. It is recognized that transportation costs account for similarly high percentages of investments in other lower-valued commodities (on a dollars per ton basis) such as wood products and wood chips, however, these latter commodities account for a smaller percentage of waterborne traffic on the Lower Snake system (about 16 to 17 percent).

Wheat and Barley
With no allowance for capacity and rail car supply improvements, about 20 million bushels of grain (about 10% of the total) would shift from the current truck/barge system to rail (for more details refer to the discussion of "Scenario 1" in *Technical Memorandum No 6- Summary of Corridor Impacts and Costs*). The impact of this modal shift at individual ports is substantial,

especially in the Tri-Cities area. Given sufficient handling capacities, annual grain shipments from the Tri-Cities ports to Portland would be anticipated to increase by over 100 million bushels, or by a factor of 3.0 to 4.0 times the present levels. The 20 million bushels of grain that would move by rail would represent a small increase over present levels. The additional truck traffic necessary to get commodities to more distant ports would be more concentrated on routes leading to the Tri-Cities and to a lesser degree at certain railheads.

In addition, in areas where the grain transportation mode shifts from barge to trucks, there will be significant impacts to the operations of local grain handlers. With only a fraction of the loading capacity of a barge, trucks will require much more frequent loading and traffic management around the facilities.

Containers
Approximately 458,000 tons of containerized commodities move down the river from Lewiston/Clarkston area each year. Under a drawdown scenario, the least-cost transportation mode and route for these goods would be trucking to the Tri-Cities for subsequent loading onto barges.

Petroleum
Approximately 115,000 tons of petroleum products are annually barged from Portland to Wilma. Under the drawdown scenario, the least cost alternative route would involve barging from Portland to Pasco, with subsequent loading to truck for shipment to Wilma.

Fertilizer
Approximately 33,000 tons of liquid fertilizer are barged annually from Pasco and Portland to tank farms at Central Ferry and Wilma. With a drawdown in effect, these quantities would most likely be trucked from Pasco to Central Ferry and Wilma.

Forest Products
Approximately 300,000 tons and 290,000 tons of wood products are annually barged to Portland from Clarkston and Wilma, respectively. Under a drawdown, these products will most likely be trucked to Pasco for loading to barges.

Direct and Indirect Economic Impacts of a Drawdown
The primary direct economic impact of a drawdown scenario is an increase in the commodity shipping costs borne by producers. Producers of raw products, such as grain, lumber, and other unfinished commodities, have little influence on the output price of their products. Therefore, the increased transportation cost reduces their "bottom line" profit.

Indirectly, the drawdown will likely cause a change in regional earnings and employment, though from a regional perspective, the adverse and beneficial changes may offset one another. That is, while some regions of Eastern Washington may suffer economically as a result of increased transportation costs, other areas such as the Tri-Cities area, may enjoy the economic benefits of increased transportation options and the corresponding rate competition that would potentially occur. In addition, there may be impacts to local governments associated with decreased land values associated with more tightly squeezed profit margins.

Direct Impacts

The commodity flow/transportation diversion model estimates that the overall cost of shipping grain to its final destinations will increase by about $0.05 per bushel, or about $1.50 to $2.00 per ton depending on the specific grain. However, the use of such an aggregated average masks significant impacts in specific areas.

The impacts to the shipping costs of Eastern Washington grain can be expressed in the proportions of the total annual crop:

- About 35 to 40 percent of the grain crop (wheat and barley) will not be directly impacted by a drawdown because these producers are not in areas dependent upon Lower Snake River ports.
- About 33 percent of the grain crop will experience increased shipping costs of approximately $0.11 per bushel. This represents about a 15 percent increase in these producers' transportation costs.
- The remainder of the crop (about 30 percent) will experience increased shipping costs of $0.20 per bushel or more, resulting in an increase in transportation cost approaching 40 percent for these producers.

Figure 1 illustrates the range of impacts to grain shipping costs per bushel by region.

Although the annual variability in the price of grain can frequently exceed this range of transportation cost impacts, these cost increases represent a permanent reduction in the expected value of the grain crop. For those producers impacted by the drawdown, this reduction in expected value will create significant impacts to farm profits (and eventually agricultural land values), influence agricultural lenders, and, in some cases, cause marginal producers with lesser financial resources to go out of business.

The impact of a drawdown scenario on "typical" farm profits is very difficult to estimate because production costs for individual farmers vary significantly. Even the farm-level expenditures on apparently homogeneous products, such as seed, fertilizers, pesticides, and hired labor vary across farms due to variations in local climate, soil types, and the presence of pests. Annual expenditures on fixed costs, such as land and machinery, are heavily dependent on when they were purchased by the farmer and whether he or she is carrying a mortgage on these assets. As a result, fixed costs also vary widely across individual farmers. Therefore, for about any given level of crop prices and farm production costs, there are some farmers who make a significant profit and some who do not[1].

An alternative to examining farm profit is the potential impact to cropland values. Long-term cropland values are based on the profitability of crop production and should serve as a proxy to profitability. The impact to land values is discussed below under Indirect Impacts. A second alternative is to examine some governmental guidelines for crop production expenditures. The

[1] It should be noted that under extremely low crop prices, such as those being experienced during 1998 and 1999, very few farmers make a profit because the output price may not allow for recovery of annual operating costs. If these low prices are sustained for a long period of time, then large-scale reductions in crop production, with many farmers going out of business, might be expected. However, there is no historical precedent for this since the Great Depression and the advent of USDA crop programs.

Bureau of Reclamation, for instance, assumes a 10 percent return to management on farm production costs. This return to management could alternatively be viewed as a proxy to profit.

For an operator whose production costs are $150 per acre, a return to management might be $15 (10 percent times $150). If his yield is 50 bushels per acre and transportation costs increase by $0.15 per bushel, his costs increase by $7.50 and his "profit" decreases by 50 percent. If transportation costs increase by $0.20 per bushel, net returns are reduced by $10 per acre, or 67 percent. This significant reduction in net returns may have few impacts in the short-term because it is within the range of the annual variability of crop prices. However, since it is a permanent reduction in net returns, a corresponding reduction in cropland values would be expected. The Peer Review Panel pointed out the possibility that, in the long-term, the increases in transportation costs may be partially mitigated as railroads and grain handlers have the opportunity to increase efficiencies. For example, the "shuttle train" concept was discussed, in which the grain handlers assure the railroads of high utilization and quick loading/unloading of grain hoppers. In return, the increased efficiencies, and reduced costs, are shared by the railroads and grain handlers. It should be noted, however, that these mitigating measures to reduce transportation costs, such as shuttle trains, require an increased level of management at the local elevator and farm levels. Therefore, some of the efficiency gains in transportation may be offset by increased management effort.

Although the above discussion acknowledges that some farm operators will likely go out of business due to increased transportation costs, , the Peer Review Panel discounted the hypothesis that there will be a significant change in wheat and barley production in Eastern Washington as a result of the drawdown. Though acknowledging that the drawdown may cause some individual operators to cease farming, they cited examples in other parts of the country where cropland has remained in production despite periods of low crop prices and/or significant increases in transportation costs. The highly-leveraged operators and operations will sometimes be replaced with those operators with lower overall costs and higher efficiencies.

However, it should be noted that events such as low crop prices tend to impact grain producers equally and are most often temporary. In addition, there are marketing tools, such as futures market hedging and forward contracting which can partially protect producers from output price risk. With transportation costs, the increase in costs (or decrease in profitability) is most likely permanent and has disproportionate impacts across Eastern Washington.

The impacts to the producers of the other commodities in Eastern Washington were also examined in this study, however only those producers who currently ship on the river were examined, and the changes in cost expressed below represent shipments which continue to go to riverside facilities on the Snake, but shift modes from barge to truck. In the long term, these shipping behaviors would likely change to minimize transportation costs under the altered transportation regime. Because of these potential shifts the costs expressed below can not be used to estimate long-term, industry wide shifts, but rather an immediate affect to shippers who currently benefit from the comparative advantage of river transportation.

Containers:	increase in shipping cost of about $4.50 per ton;
Petroleum:	increase in shipping cost of about $14.00 per ton;
Fertilizer:	increase in shipping cost of about $6.00 per ton; and
Forest products:	increasing in shipping costs of $3.00 to $5.00 per ton.

Indirect Impacts

The main indirect impacts to the Eastern Washington economy resulting from the drawdown is anticipated to be a decrease in the value of cropland used for grain production, and employment changes resulting from the closure of the Lower Snake River ports.

The reduction in the profit margins for Eastern Washington grain farmers will eventually be capitalized into agricultural land values, lowering them in a manner proportionate to the reduction in profit. For example, assuming a 50 bushel per acre yield and a $0.10 per bushel impact, the profit for an acre of wheat is reduced by about $5.00. Capitalizing this reduction using a competitive discount rate for agricultural land yields a reduction in land value of about $60-$70 per acre, or about an 8 percent to 10 percent in its overall value. A $0.20 reduction in the profitability of grain production could decrease local land values by as much as $125 per acre. This reduction in land value reduces the wealth of Eastern Washington operators and reduces local tax collections. Though on a per acre basis this is not a large sum, its aggregate impacts can be quite substantial, and clearly will impact some farmers more than others.

Closure of the Lower Snake River ports will result in the loss of jobs for those employed at those facilities. Since the amount of grain to be marketed is not anticipated to change, these employment losses should at least be partially offset by employment increases at theTri-Cities ports, and by increased employment for grain handling for rail shipments. However, these offsetting impacts may be little consolation for communities between Lewiston and Pasco, as some well-paid workers would exit the area. In addition, economic models of regional employment indicate that for every port job lost in this area, about 0.3 jobs are lost in supporting industries.

Another indirect impact of a drawdown scenario is the impact on the competitiveness of Eastern Washington's commodities in the national and world markets. Though not the focus of this study, it is apparent that the increased transportation costs will raise the long-term price of exported commodities, possibly giving foreign producers an opportunity to gain market share relative to U.S. exports. For developing countries whose governments are investing in transportation infrastructure, such as Brazil, this could be considered an opportunity to become an alternative supplier to the world markets for raw materials such as grain and wood products.

Commodity Shifts Out of Region

A major concern at the onset of this study was the possibility that major shifts might occur in commodity shipping patterns, resulting in goods that were previously shipped within (or through) Eastern Washington to seek more cost effective routes or market destinations. The commodity flow/transportation diversion model used to estimate the impact of the drawdown has shown many important shifts in transportation modes and routes within the region. However, the analysis does not indicate that commodities would travel out of the region as a result of the drawdown. That is, transportation cost increases alone would not cause commodities to divert to the Puget Sound or Gulf ports because of the proximity of, and the strategic location and facilities contained within, the Port of Portland. This conclusion was confirmed by the Peer Review Panel.

The analysis indicates that about 15.8 million bushels of grain loaded at Lewiston/Clarkston is shipped across Eastern Washington and barged directly to Portland. Under a drawdown, this grain would probably be trucked to the Tri-Cities area for loading onto barges, or to Spokane for rail shipment to Portland. In either case, the increase in shipping cost is about $0.07 per bushel for this out-of-region grain. It should be noted that this volume of grain, 15.8 million bushels, is within the year-to-year variation cycles that occur in Eastern Washington grain production. Therefore, the impact of a commodity shift would have to be disaggregated from the annual variation in local grain production.

A question posed to the Peer Review Panel was whether this impact would be sufficient to shift some of this grain towards a different port. The Panel did not believe such a shift would occur, citing that Gulf ports are further away from these production areas than they are from Portland. In addition, barge navigation will soon be significantly reduced on the Missouri River (to dedicate more flow for peak periods), and the Mississippi system is already severely congested and barge-short. Upbound steel imports are currently occupying many of the Mississippi barges, with the unusual result of railroads becoming a more economical mode for Midwestern grain handlers rather than barges.

Overall, the Peer Review Panel does not anticipate a major change in grain shipping patterns by western Montana and Idaho grain handlers. The Panel qualified this response by acknowledging some uncertainty regarding the shipping of this grain by rail to the Puget Sound area, or north into Canada for export from the Vancouver area. Though there is not currently a large capacity for handling wheat and barley at these ports, the appropriate facilities could be provided over time.

With respect to non-grain commodities, the following points are essential to the analysis of commodity shifts:

- Our analysis indicates that fertilizer currently being barged upriver, past Pasco, may change to rail or truck at Pasco to reach its pre-drawdown destinations of Central Ferry and Wilma. Discussions with fertilizer suppliers indicate that while this could happen, it is more likely that rail shipments of fertilizer from the east (delivered to the Spokane area) and the west (delivered to Ritzville) as well as an increase in distribution directly from Pasco and Kennewick will cover the area previously served by the Snake River ports.

- Any transportation shifts with respect to forest products would be very difficult to assess because of the major transitions occurring in these industries. The project team's discussion with industry experts indicates that there is no close communication among producers with respect to transportation.

- Though this analysis estimates that upbound fuel would transfer to trucks at the Tri-Cities, there is some future uncertainty with respect to a new petroleum pipeline into Eastern Washington from Puget Sound, proposed to begin operation within the next three years. If the pipeline is constructed, it is probable that regional shipping patterns of petroleum would shift with or without a drawdown.

- Changes in the shipping patterns of containerized goods are assumed not to change because of the non-homogeneous nature of the products shipped in containers. Containers account for a wide variety of commodities flowing through Eastern Washington, ranging from peas and lentils to finished products to empty containers. Each product has its individual marketing characteristics. As a result, anticipating major commodity shifts of containerized products would be a major task with uncertain results.

Snake River Drawdown Study

No Barge Scenario - Rail Only Increase in Tonnages Is Shown

Railroad Infrastructure Costs

Railroad Corridor	Additional Trains (originating lines)	Interchange w/Mainline Facilities in Millions of $	Track Upgrade in Millions of $	Other Costs (incl. Bridge Upgrades) in Millions of $	Elevator Load/Unload Track Upgrades in Millions of $	Total
Blue Mountain Railroad	12	0	0	0	0.4-0.5	0.4-0.5
Palouse River Railroad	69.4	2.8-3.4	4.6-5.5	1.0-1.2	8.8-10.6	17.2-20.7
Camus Prairie Railroad	45.4	2.0-2.4	0	0	0.8-1.0	2.8-3.4
BNSF/UP Mainline	27.8	0	0	0	8.4-10.1	8.4-10.1
Coulee City Palouse River	42.6	2.0-2.4	4.0-4.8	1.0-1.2	4.0-4.8	11.0-13.2
Columbia Basin	6.5	0	0	0	1.6-1.9	1.6-1.9
Columbia River Ports	0	0	0	0	35.0-42.0	35.0-42.0
Total	**203.7**	**6.8-8.2**	**8.6-10.3**	**2.0-2.4**	**59.0-70.9**	**76.4-91.8**

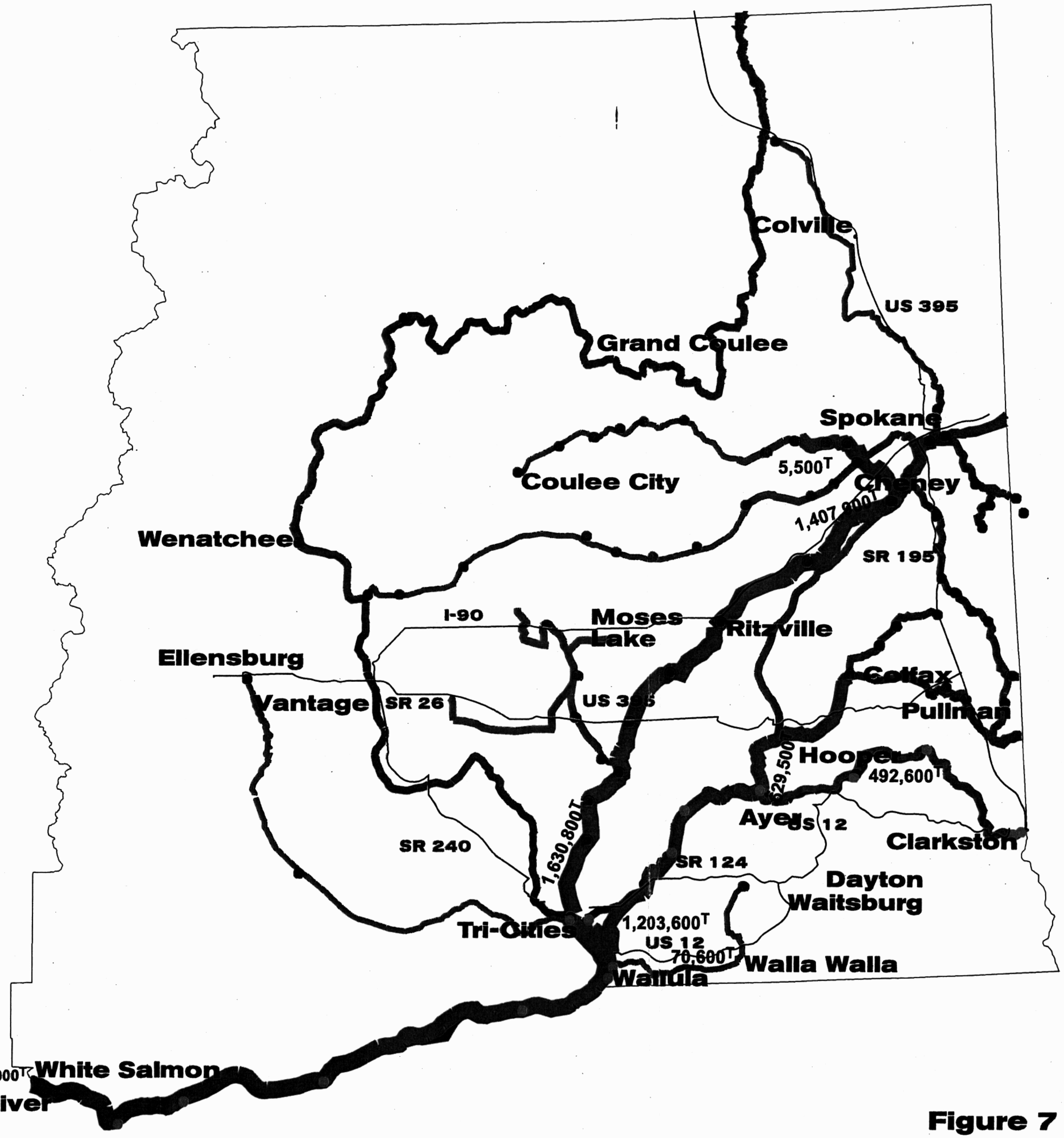
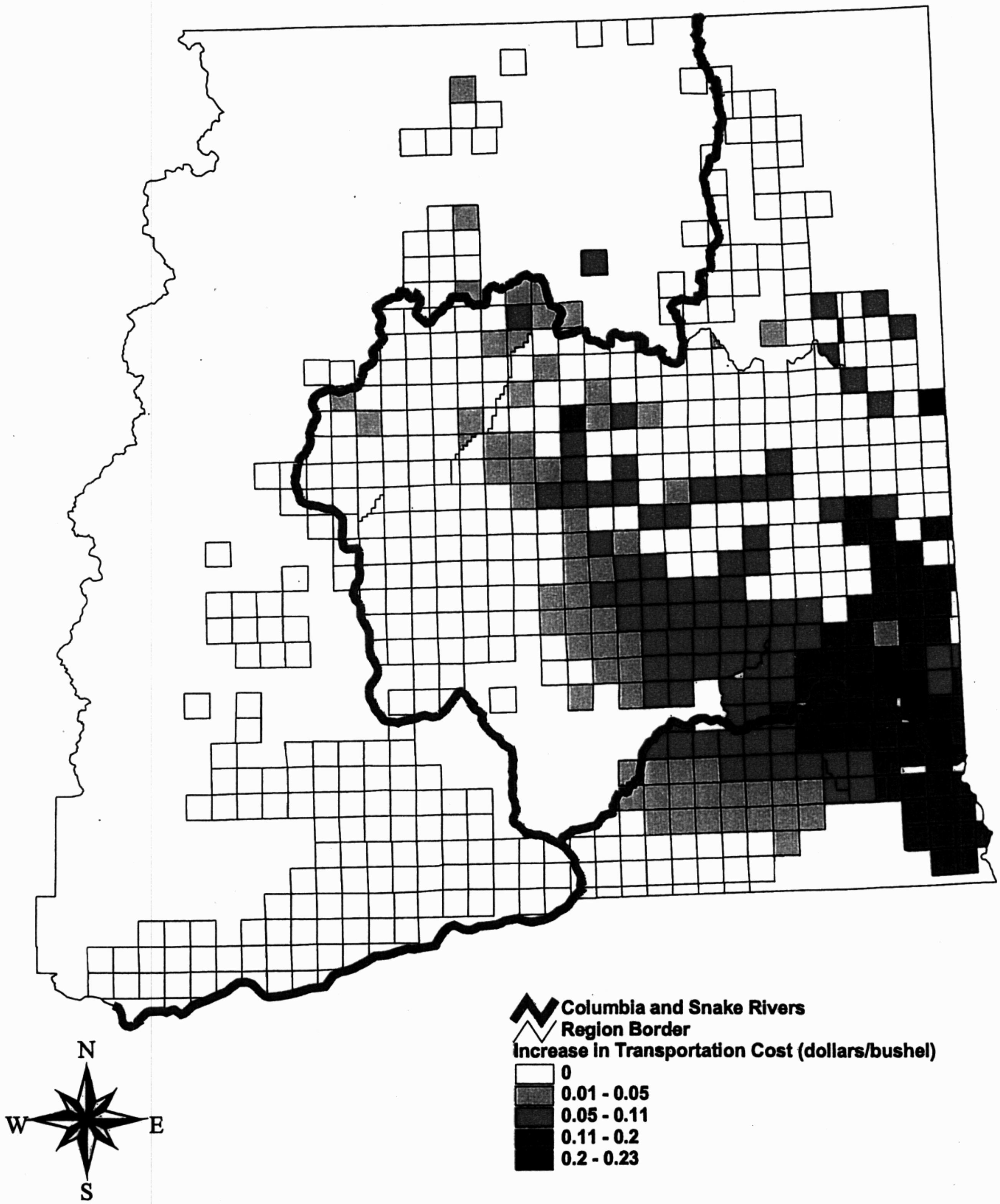


Figure 7

Figure 1
Approximate Changes in Transportation Costs for Wheat between Existing and Drawdown Scenarios



Townships shown on map are those reporting wheat production in 1993 (Casavant et. al. EWITS Research Report #18)