EXECUTIVE SUMMARY

This report presents an analysis of the energy, emission, and safety implications of potential investments in the Upper Mississippi River and Illinois Waterway (UMR-IW) System. The U.S. Army Corps of Engineers (USACE) has identified 10 alternative improvements to the UMR-IW System. The most comprehensive improvement scenario (Alternative J) would result in: the construction of adjacent mooring cells at Locks 12, 18, 20, 22, and 24 on the Upper Mississippi River; the extension of guidewalls to 1,200 feet (with powered kevels) at Locks 14-18 on the Upper Mississippi River; the extension of Locks 20-25 on the Upper Mississippi River to 1200 feet; and the construction of new 1200-foot locks at Peoria and LaGrange on the Illinois Waterway. The other 9 alternatives encompass one or more of the above improvements.

The energy, emission, and safety effects of each alternative are estimated for 2015, 2030, and 2050 based on traffic forecasts developed by the USACE. For each alternative, USACE has projected waterway traffic levels in the "with-project" and "without-project" futures. The difference between the two estimates is the incremental or affected tons, which are the focus of this analysis. In 2015, USACE estimates that over 10 million tons of traffic will be affected under 6 of the improvement scenarios. By 2050, between 15.8 and 23.7 million tons will be affected under the same 6 scenarios. Although 17 commodity groups are affected by the improvements, agricultural products comprise over 85 percent of the affected traffic. In 2050, approximately 20 million tons of agricultural products will be affected by some of the proposed projects. This tonnage is equivalent to roughly 200,000 annual rail carloads.

STUDY APPROACH AND KEY ASSUMPTIONS

For purposes of consistency, this study uses the same traffic forecasts that were used in earlier phases of the UMR-IW study.[1] These forecasts are based on: Waterway Traffic Forecasts for the Upper Mississippi River Basin, by Jack Faucett Associates (April, 1997) and a detailed economic model described in: A Spatial Price Equilibrium-Based Navigation System NED Model For the UMR-IW Navigation System Feasibility Study (USACE, 1998).

Because of the commodities and distances involved, railroad transportation is the only feasible alternative to river movements. In this report, a comparison is made of the line-haul fuel efficiencies of rail and barge modes. Gathering or distribution movements by truck are not reflected in this comparison. If truck trip distances into rail and barge stations differ substantially, then combined truck-rail and truck-barge fuel efficiencies may differ from the direct modal estimates shown in this study.

Barge and rail energy comparisons are made on the basis of revenue ton-miles per gallon (RTMG). It is expected that both barge and railroad fuel efficiencies will be greater in 2015 than today, but the relationship will stay approximately the same. Manufacturers of marine diesel engines typically start with a partial or fully completed land-based engine and adapt it for use in a marine environment. Because of similarities in engine manufacturing and the uncertainties involved in technological forecasting, it seems reasonable to assume that the relative fuel efficiencies of the modes will be the same in 2015 as today.

Barge Fuel Use Factors. Barge RTMG factors have been obtained from Tennessee Valley Authority

1 A new traffic forecast was not included in the scope of work for this project. Using the same traffic forecast that was used in earlier phases of the UMR-IW study provides a consistent basis for evaluating the results.

(TVA) and the Corps. TVA data for 1995, 1996, and 1997 indicate that revenue ton-miles per gallon ranged from 306 to 320 on the Upper Mississippi River and from 259 to 312 on the Illinois River. In comparison, a USACE report projects that efficient 15-barge grain movements on the UMR-IW System could achieve 450-700 revenue ton-miles per gallon. Clearly, upper river fuel efficiencies are expected to be higher than historic values in the with-project scenarios because of lock and guidewall extensions and mooring cells. Thus, a value of 375 RTMG is used for barge movements on the upper river system. This value represents a compromise between the USACE:s lowest efficient movement estimate of 450 RTMG and the midpoint value of the TVA data set (about 300 RTMG). A value of 644 RTMG is used for the lower river system, which corresponds to the middle year of the TVA data range.

Railroad Fuel Efficiency Factors. A detailed literature review was conducted of railroad energy studies, including recent train performance simulations. In 1999, Gervais and Baumel published the results of several simulations of corn unit-train movements in 100- and 110-ton cars from Iowa to New Orleans and Tacoma, Washington. The reported RTMG estimates range from 554 to 664 for the Tacoma movements and from 688 to 802 for movements to New Orleans. Although the Gervais and Baumel simulations are referenced in this report, an extensive empirical analysis is presented based on 1989-1998 Class I railroad data obtained from the Surface Transportation Board (STB). Two statistical models of railroad fuel use are estimated from the data. Both models exhibit excellent statistical properties and predict RTMG values that are very close to actual values. The models are used to predict RTMG for each origin-destination movement, considering the railroads involved, the commodities, train service characteristics, and car weight factors.

Air Quality Impact Assessment. In the future, air quality regulations are expected to uniformly limit emissions per gallon of fuel from nonroad freight sources. The approach used in this study is to multiply the estimated difference in gallons of fuel consumed in the with-project and without-project scenarios by the emission rates per gallon. The cost or valuation of incremental emissions is a complicated issue that can be approached in several ways. In the first approach used in this study, the difference in emissions is multiplied by a unit cost of pollution compliance or abatement computed from an Environmental Protection Agency (EPA) report. The assumption is that railroads will keep emissions at the same level in the with-project and without-project scenarios, and in doing so will incur a compliance or abatement cost. If the incremental emissions are not abated or offset by reductions elsewhere, then overall emissions from nonroad sources will increase and there will be a cost to society that is not internalized by the transportation modes. In this case, incremental emissions of nitrogen oxides, particulate matter, and other pollutants will adversely impact human health, property, vegetation, and crops. The potential societal costs are estimated by multiplying the incremental emissions by a set of air pollution damage factors used by Federal Highway Administration in the Highway Economic Requirements System. In this approach, the health and property damage costs associated with increased levels of specific pollutants are accounted for. The estimates from the two approaches are not additive. Either railroads will keep nonroad emissions at the same level and incur a compliance cost, or the incremental emissions will result in air pollution damage costs.

Safety Data and Analysis Methods. Three categories of accident costs are analyzed: property damage, injuries, and fatalities. Without-project costs are based on railroad accident factors, while with-project costs reflect waterway accident data. The railroad accident data are derived from Federal Railroad Administration (FRA) reports and bulletins. Waterway accident rates and costs are derived from a previous study by University of Memphis. For each mode, a two-step analysis process is followed: (1) estimate the annual accidents, fatalities and injuries for the incremental traffic and (2) multiply the annual events by the applicable unit cost per property damage, fatality or injury. The fatality and injury unit costs reflect economic cost factors as well as the value of Alost quality of life.@ They reflect estimates of what people are willing to pay for improved safety. According to the National Safety Council, these Acomprehensive costs@

can be interpreted as Athe maximum amount society should spend to prevent a statistical death or injury.@

SUMMARY OF RESULTS

Estimated Railroad Revenue Ton-Miles per Gallon. As noted earlier, two statistical models were estimated from Class I railroad data. Model 1 estimates railroad fuel consumption as a function of way train, through train, and unit train gross ton-miles. It is used to illustrate how RTMG vary with type of train service. For 1998, the model predicts Class I railroad fuel consumption rates of 446, 352, and 193 RTMG for unit, through, and way trains, respectively. When these values are multiplied by the percentages of gross ton-miles in each train category, the predicted value of 379 RTMG is within 1 percent of the reported industry mean of 384 RTMG. Model 2 directly predicts revenue ton-miles per gallon as a function of the revenue tons per train, the tare tons per train, and the loaded trip miles. The model was tested by comparing predicted RTMG values to actual (reported) values for each railroad, for each year of the analysis period. The prediction error exceeded 10% in only 8 of the 90 cases. The 1998 prediction errors were less than 5 percent for the UP, BNSF, and IC (the primary railroads of interest in this study). The model was used to estimate values for a series of hypothetical movements. It predicted RTMG ranges of 309 to 605 for mixed freight trains and 349 to 682 for 75-car grain through/unit trains moving distances of 400 to 800 miles. The largest estimated value that does not violate the data range of the model is 735 RTMG for a unit train movement of approximately 1000 miles on the Illinois Central Railroad. In general, the high-end grain through/unit train estimates generated from the model overlap the lower end of the Gervais-Baumel RTMG range.

Estimation of Railroad Fuel Use for Incremental Movements. The origins and destinations and incremental tons were provided by the USACE. However, important railroad shipment information was derived from the 1998 public-use waybill sample, which was used to develop movement profiles for traffic originating in Business Economic Analysis (BEA) areas adjacent to the upper river system. The waybill sample was not used to forecast railroad traffic. Its was only used to describe current railroad shipment characteristics in the Upper Mississippi region. The primary characteristics of interests were: the percentage of tons moving in each level of train service, the number of cars in the shipment, the average load per car, and the average tare or light weight per car. The last three variables determine the revenue and tare weight inputs to Model 2. The percentages of railroad traffic moving in various waybill strata were used to partition affected river traffic into train service levels. In essence, the approach used in this study allocates the incremental tons in each commodity group to railroad shipment strata, then estimates the fuel consumption within each strata and sums or weights the results. The underlying calculations also reflect the railroads involved in the movements. In most cases, the sample waybill data reflect efficient railroad movement patterns. For example, approximately 80% of the farm products tons shipped from Iowa BEA areas to the Pacific Northwest moved in100-110 car blocks. Similarly, the observed farm products shipments from Iowa to California, the Gulf Coast, and Lower Mississippi Valley regions consist predominantly of unit train and large multiple car movements.

Estimated 2015 Fuel Effects. In the with-project scenarios, the affected traffic would move on the river, thus resulting in reduced fuel consumption, emissions, and a lower occurrence of accidents for the incremental traffic. In general, Alternatives E, F, G, H, and J exhibit the greatest estimated reductions or cost savings because of the greater amounts of affected traffic. As noted earlier, fuel cost reductions are estimated by multiplying an average fuel cost by the estimated reduction in fuel consumption. In 2015, the estimated annual reduction in fuel costs resulting from various waterway improvements ranges between $59 thousand and $4.7 million in 1998 prices, depending on the extent of improvements made. Because fuel expenses are reflected in the cost of each mode, the fuel cost reductions presented in this report are captured already in the transportation cost savings estimated in the UMR-IW National Economic Development (NED) analysis.

Estimated 2015 Emission Effects As noted earlier, emission cost savings are estimated in two alternative ways. The first way is to assume that any incremental pollution resulting from rail transportation in the without-project scenarios will be abated by the railroads. The annual emission cost savings estimated in this way are small, ranging from $3,500 to $278,000 in 1998 prices, depending on the extent of waterway improvements. The second way to estimate the reduction in emissions costs is to assume that any incremental pollution resulting from a shift of waterway traffic to rail in the without-project scenarios will not be abated, and will therefore cause health and property damage. The annual emission cost savings estimated in this way range between $105 thousand and $8.36 million in 1998 prices, depending on the extent of waterway improvements. To the extent that emission costs are internalized by each of the modes, the emissions costs savings may already be reflected in NED benefits. However, if incremental emissions resulting from a shift in traffic from waterway to rail in the without-project scenarios are not abated, then the costs imposed on society will not be reflected in the NED estimates.

Estimated 2015 Accident Effects. Accident cost savings are estimated using accident, injury, and death rates by mode, expected modal traffic shifts, and cost estimates for property damage, injuries, and deaths. This analysis, it should be noted, is not an attempt to place blame. The preponderance of rail-related fatalities and injuries result from highway-rail grade crossing collisions and from trespassers making illegal and ill-advised track crossings. Nevertheless, each injury or fatality entails a social cost. Using 1998 prices, the estimated accident cost savings range from $411,000 to $31.9 million, depending on the extent of waterway improvements. A portion of these costs is probably accounted for in the NED analysis, through the effects of accidents on insurance and casualty costs. However, to the extent that accidents occur where the transportation mode is not liable, the comprehensive costs of accidents are not captured by the NED benefits. Highway grade-crossing accidents may result in lawsuits against state, county or local governments instead of against the railroad. Moreover, there may be many instances in which the railroad is not held liable trespasser accidents. The extent of future railroad liability is uncertain and may be affected by the outcome of pending court cases. Clearly, a more detailed analysis is needed before definitive conclusions can be drawn regarding the portion of accident cost savings that is included in the NED benefit estimates.

Summary of 2030 and 2050 Benefits. In 1998 prices, the estimated total fuel, emission, and accident cost reductions resulting from the proposed improvements range between $507 thousand and $40 million in 2015, between $386 thousand and $47 million in 2030, and between $323 thousand and $64 million in 2050 under the assumption that incremental emissions are not abated. In these scenarios, additional health and property damage costs from air pollutants are imposed upon society. Under the scenarios where emissions are abated, the cost reductions from various alternatives range between $406 thousand and $32 million in 2015, $311 thousand and $37.5 million in 2030, and $262 thousand and $51 million in 2050. These estimates are subject to the same questions and limitations as the 2015 estimates and therefore should not be added to the NED benefits without further study.

POTENTIAL NOISE AND OTHER IMPACTS

A detailed review of transportation noise impacts was also undertaken. Most noise studies address highway, aircraft, or high-speed rail noise. It was not possible within the time frame of the study to estimate railway noise costs, and the literature review did not discover factors that could be used with confidence. Nevertheless, a qualitative background analysis is presented in the report.

Measurement of Noise. As described in the report, loudness is defined by sound pressure level (SPL) which is measured in decibels (dB). Because the decibel is a logarithmic unit, a doubling of source noise results in only a 3 dB increase in the existing sound pressure level. On the logarithmic scale, a 10-dB change in SPL is perceived by humans as a doubling or halving of loudness. The A-scale on a sound-level meter is used most often in noise analysis because it best approximates the frequency response of the human ear. In a 24-hour period, A-weighted decibel (dBA) sound levels may range from 30 (very quiet) to 90 (very loud) or greater. Background or residual sound level is about 45 dBA.

Maximum Train Noise Levels. Although railroad noise levels were not measured in this study, the maximum allowable railroad noise levels were obtained from 40CFR201. Under these regulations, a locomotive manufactured after December 31, 1979 cannot produce sound levels in excess of 90 dBA when in motion, although the maximum noise emission of older locomotives is somewhat higher (96 dBA). Moreover, a rail carrier cannot operate rail cars that produce sound levels (while in motion) in excess of 88 dBA at speeds up to and including 45 mph, or 93 dBA at car speeds greater than 45 mph, when measured at 100 feet from the centerline of the track. It should be noted that these noise regulations do not apply to train horns. Given the regulatory maximums, it is likely that a freight train in motion produces noise levels of 88 to 96 dBA at distances of 100 feet from the track along a line source of several minutes duration. Moreover, it appears that a substantial increase in trains per day through a community has the potential for increasing existing noise levels in relation to community impact thresholds which are in the 55-65 dBA range.

Horn Noise. The locomotive horn or whistle is a very controversial community issue that has implications for both safety and noise levels. The FRA noise impact model is based on an sound equivalent level of 107 dBA at 100 feet from the tracks for locations not closer than one-eighth mile from a grade crossing. Many community complaints arise in regard to nighttime soundings of the horn when ambient noise levels are much lower than during the day. In calculating an equivalent 24-hour noise level (L_{dn}), a 10-dBA correction factor is added to nighttime noises to account for increased annoyance from loss of sleep. A number of communities across the nation have regulated or attempted to regulate the use of locomotive horns in their jurisdictions. Federal Railroad Administration currently is involved in a rule-making proceeding to address the use of locomotive horns at public grade crossings. The elimination of community whistle bans would improve safety but would have a substantial noise impact in the study region. Nearly half of all persons potentially impacted by the elimination of whistle bans reside in the state of Illinois. Wisconsin and Minnesota rank third and fifth respectively in terms of potentially impacted populations.

Noise Cost Estimates. In the 1997 Highway Cost Allocation Study, Federal Highway Administration (FHWA) quantified the impacts of highway noise on residential property values. Using a middle-range estimate from a widely-quoted study, FHWA concluded that a dBA increase in noise above the community impact threshold of 55 dBA would result in a .4 percent decrease in property values. Using the median housing value from the 1993 Census survey, annualized at a 10 percent discount rate and multiplied by the 0.4 percent, FHWA estimated a highway noise cost of about $35 per decibel per housing unit. Although housing residents may not react in exactly the same way to railroad noises, highway noise factors provide some insights as to potential changes in market valuations that might result from increased railroad noise.

STB Environmental Analysis Thresholds. The Surface Transportation Board has established thresholds for evaluating whether potential changes in railroad traffic and operations might result in significant environmental impacts. If a proposed action affects a class I or nonattainment area under the Clean Air Act, and will result in either: (a) an increase in rail traffic of at least 50 percent or an increase of at least three trains a day on any segment of rail line, or (b) an increase in rail yard activity of at least 20 percent, then the railroad's environmental report must state whether any expected increased emissions are within the parameters established by the State Implementation Plan. If a proposed action affecting any area would result in: (a) an increase in rail traffic of at least 100 percent or an increase of at least eight trains a day on any segment of rail line affected by the proposal, or (b) an increase in rail yard activity of at least 100 percent, the railroad's environmental report must quantify the anticipated effect on air emissions and noise. If the proposed action will cause an incremental increase in noise levels of at least three decibels L_{dn} or an increase to a noise level of 65 decibels L_{dn} or greater, the report must identify and quantify the noise increase for sensitive receptors (e.g., schools, libraries, hospitals, residences, retirement communities, and nursing homes) in the project area. The STB thresholds are related to potential rail system changes such as construction, abandonment, and mergers. However, they describe incremental railroad traffic levels that might trigger an environmental analysis during a regulatory proceeding.

CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDY

Because of the high level of data aggregation and short time frame[2], the results should be viewed as general findings. As noted previously, a separate traffic forecast was not prepared for this study. Therefore, the findings are linked to the traffic forecasts provided by USACE for the "with project" and "without project" scenarios.

As the report suggests, railroads have become much more fuel efficient over time and the relative energy benefits of waterway transportation have become smaller. However, the analysis shows that there is a relatively small fuel advantage to barge transportation in this instance. This fuel efficiency advantage translates into lower emissions for the incremental traffic in the with-project scenario. However, the dollar benefits are not large assuming that railroads internalize the cost — in which case, the emission cost is equivalent to a compliance cost. However, if railroads don't internalize the emission cost, a larger cost to society will result from pollution damage to health, property, and vegetation. Without further analysis and comparison, the proportion or percentage of emission cost reflected in the NED calculations cannot be ascertained.

The study did not address potential impacts on non-attainment areas, where even a relatively modest increase in emissions could have significant impacts. Many of the alternatives would result in at least three incremental trains per day, and depending upon the routes involved, could meet the STB threshold for an environmental impact assessment. Although the STB thresholds would not apply to traffic diverted from waterways to railroads, such a finding would suggest that a detailed analysis of potential impacts is warranted.

In general, more research is needed to firm-up the emission, safety, and noise impacts. The accident approach used in this study could be improved by: (1) estimating a statistical model of railroad accidents instead of using average accident rates; (2) estimating accident probabilities for grade crossings, based on both rail and highway traffic exposure and crossing characteristics; (3) looking at hazmat issues such as risk assessment and the broader implications of a hazmat grade crossing accident; and (4) analyzing the relationship between comprehensive accident cost and railroad casualty and insurance cost. In the report, BNSF's 1998 casualty and insurance costs are compared to estimated comprehensive accidents costs for accidents on that railroad. In this comparison, the estimated comprehensive accident cost is much greater than the reported casualty and insurance cost, suggesting that all aspects of comprehensive accident costs may not be internalized by railroads. This example is for one railroad and year only, but it does indicate that a more detailed multi-year comparison is warranted.

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2 The draft report was prepared during January and February of 2000.

As noted earlier, changes in noise levels may result from increased rail traffic. However the impacts will depend on the routes traveled, the population exposed to noise on the routes, and existing noise levels. Many communities in Illinois, Wisconsin, and Minnesota would be impacted heavily by the proposed elimination of train whistle bans. In general, train noise is an important issue in the study region and warrants more study. With more specific traffic and route data, it may be possible to forecast instances when the STB threshold criteria are reached.

Note. *The USACE contracted with Tennessee Valley Authority to review this report. The comments of the reviewers are attached as Appendix D to the main report, along with my responses to their comments.*