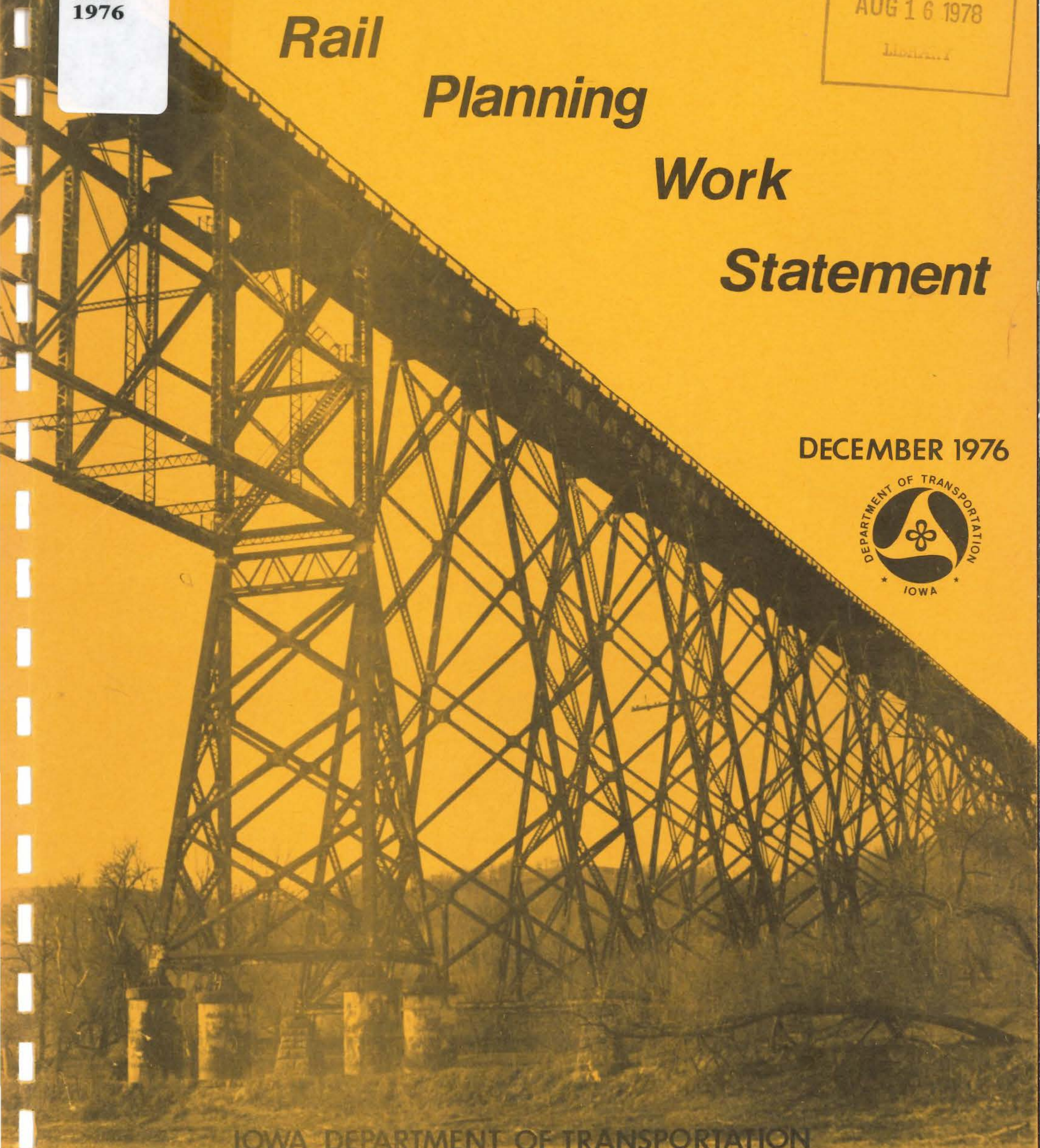
STATE OF IOWA

Rail Planning Work Statement



DECEMBER 1976

IOWA DEPARTMENT OF TRANSPORTATION

Department of Transportation

STATE CAPITOL DES MOINES, IOWA 50319

November 29, 1976

REF. NO. 700.010

Mr. Asaph H. Hall
Administrator
Federal Railroad Administration
Nassif Building
400 7th St. S.W.
Washington, D.C. 20590

Dear Mr. Hall:

The Iowa Department of Transportation is submitting this work plan to complete the planning of a state rail system for Iowa. This work program will resolve the question of the amber lines that are in our present TransPlan '76. Upon the completion of this plan, we will have identified those lines which should remain in service and receive subsidies. We will also have identified those lines which serve no such economic need and should be abandoned. We will also have identified those areas of the state which should receive subsidies for alternate needs of transportation with the abandonment of rail lines.

We ask your approval of this work plan to develop a comprehensive rail plan that is compatible with the other transportation plan in the State of Iowa.

Les Holland
Director
Railroad Transportation Division

Raymond L. Kassel
Director
Planning and Research Division

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INTRODUCTION

This Rail Planning Work Statement presents the basic planning process and philosophy to be used in the development of a state rail plan for the State of Iowa. The Rail Planning Work Statement was prepared within the guidelines presented in 49 CFR Part 266.9, published in the August 9, 1976 Federal Register.

The Iowa Department of Transportation does not endorse the basic philosophy of the Branch Line Continuation Assistance Program (Section 803 of the Railroad Revitilization and Regulatory Reform Act of 1976-4 R Act) for which this planning work statement was developed. The Rail Continuation Assistance Program was enacted by Congress in 1973 as a means to reduce the impact of the mass abandonment of over 8000 miles of Branch Lines in the Northeast Region which were not included in the new Conrail System. This same program concept, which was a reaction to a crisis situation, was applied to the remaining 33 states with the passage of the 4 R Act in 1976.

The situation outside the Northeast is not a crisis situation. The 33 states outside the Northeast Region have only 4300 miles presently pending abandonment. Unlike the 8000 miles of branch lines in the Northeast Region, each rail line outside the Northeast Region must undergo a comprehensive ICC hearing process involving both the railroads and the shippers before it can be abandoned.

Rather than spending the limited funds available on slowly "phasing out" those lines which have been abandoned through the rigorous ICC abandonment process, the Iowa DOT feels that the funds should be spent on improving those branch lines which have potential to become self-supporting. This positive approach would contribute to the rebuilding of the nation's rail system, and again make the railroads a viable part of an integrated transportation system.

IOWA'S RAIL SYSTEM

Present System

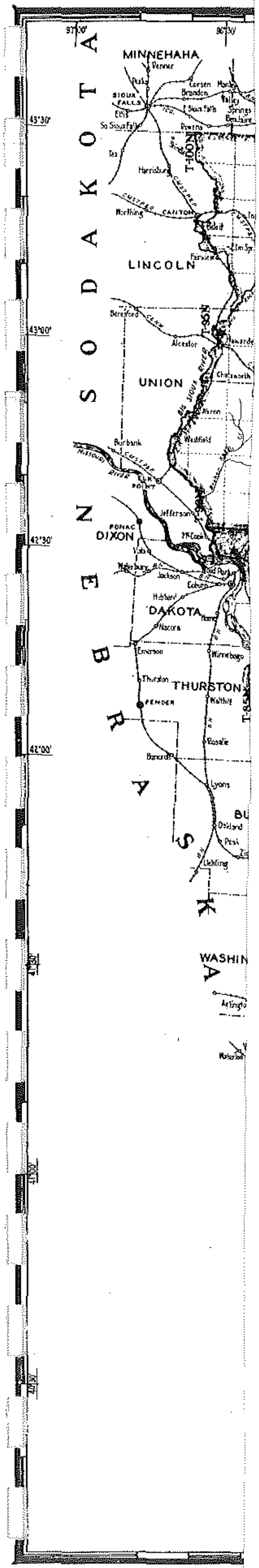
Iowa ranks 6th in the nation in rail mileage and 25th in land area and population. The present rail system (shown in Figure 1) is comprised of approximately 7,400 roadway miles, the majority of which is owned and operated by 5 major rail companies.

TABLE 1
IOWA RAILROAD MILEAGE

	Iowa Mileage	% of Iowa Mileage
Chicago & Milwaukee, St. Paul & Pacific	2254	30%
Chicago, Rock Island & Pacific	1605	22%
Chicago & North Western	1579	21%
Burlington Northern	838	11%
Illinois Gulf Central	685	9%
Norfolk & Western	168	3%
Atchinson, topeka & Santa Fe	20	-
Union Pacific	2	-
Class II Railroads	283	4%
TOTAL	7436	100%

The Rock Island Railroad filed bankruptcy in March, 1975, and is presently operating under a trustee. The Milwaukee and the North Western are also in marginal financial condition. These three railroads comprise 73% of Iowa's present rail system.

Most of Iowa's branchlines were built before 1900. These lines were the first lines to be affected by deferred maintenance practices



SOUTH DAKOTA
NEBRASKA
MINNEHAHA
SIOUX FALLS
Brandon
Valley Springs
Harrisburg
CANTON
Worthing
LINCOLN
Beresford
Alcester
UNION
Chatsworth
Akron
Westfield
Burbank
MISSOURI RIVER
ELK POINT
Jefferson
PONCA
DIXON
Jackson
Hubbard
DAKOTA
Nacora
Emerson
Winnebago
Thurston
THURSTON
PENDER
Walthill
Rosalie
Bancroft
Lyons
Oakland
Pender
WASHIN
43°30'
43°00'
42°30'
42°00'

which has left Iowa's branchline system in generally poor condition.

Eligible Mileage

The only lines presently eligible for rail continuation assistance, under Section 803 of the Railroad Revitilization and Regulatory Reform Act of 1976 (4 R Act) are lines for which the Interstate Commerce Commission have issued a final certificate permitting the abandonment or discontinuance of service after February 5, 1976.

Iowa has 161 miles of rail line which have had a final certificate of abandonment issued by the ICC between February 5, 1976 and August 1, 1976. There are an additional 189 miles, of Iowa rail line for which the ICC has entered an initial decision to abandon or discontinue service subject to finalization. Also, there are an additional 191 miles of rail line in Iowa which have abandonment applications pending before the ICC. This results in a total 541 miles potentially eligible for the rail continuation assistance (see Figure 2 and Table 2).

Initial Iowa Transportation Plan

When the Iowa Department of Transportation became operational on July 1, 1975, it was required by law to develop an intermodal transportation plan for the State of Iowa. This plan, entitled "TransPlan '76, Initial Iowa Transportation Plan," was released in March 1976.

Figure 2

IOWA PAST AND PENDING ABANDONMENTS

NOVEMBER 1, 1976

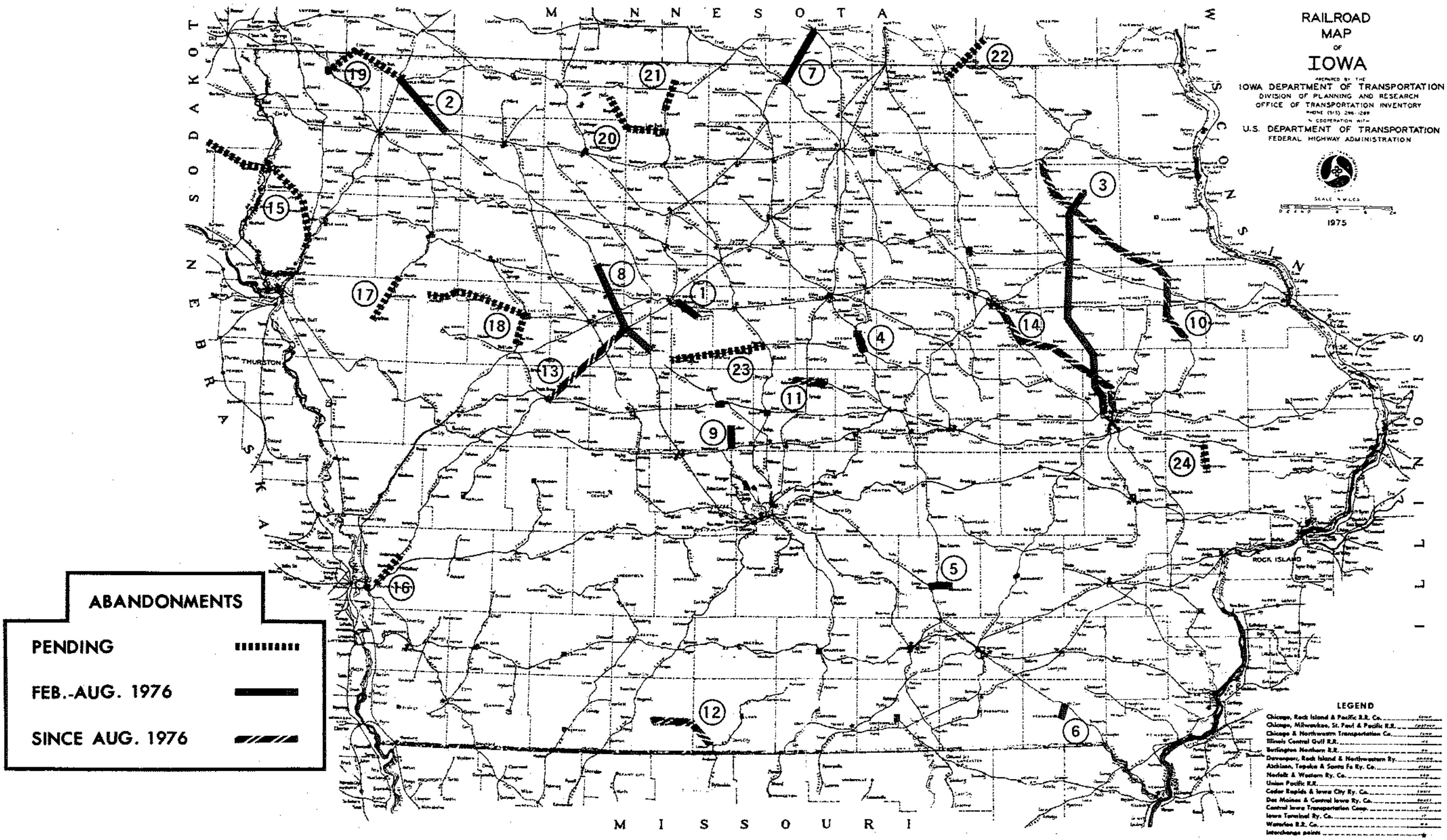


TABLE 2

Lines Abandoned - Eligible Mileage
Feb. 5, 1976 - Aug., 1976

1.	C&NW	Fort Dodge to Kalo	5.60
2.	CRI&P	Hartley to Sibley	18.49
3.	CRI&P	West Union to Linn Jct.	70.48
4.	C&NW	Conrad to Eldora	16.30
5.	CRI&P	Oskaloosa to Mich Spur	3.32
6.	CRI&P	Mt. Zion to Keosauqua	4.50
7.	C&NW	Albert Lea to Lake Mills	6.70
8.	CRI&P	Palmer to Gowrie	29.10
9.	Milw.	Madrid to Luther	7.00
			161 Miles

Lines With Initial Abandonment Decision Since August 1976

10.	Milw.	Jackson Jct-Hopkinton	79.0
11.	C&NW	Roland-Zearing	10.0
12.	BN	Mt. Ayr-Lamoni	19.7
13.	C&NW	Carroll-Somers	30.9
14.	WRC	Gilbertville-Cedar Rapids	49.1
			188.7 Miles

Lines Pending Abandonment

15.	C&NW	Wren-Hawarden	31.0
16.	C&NW	Council Bluffs-McClelland	11.7
17.	ICG	Anthon-Washta	15.6
18.	C&NW	Holstein-Saction	44.4
19.	CRI&P	Rock Rapids-Little Rock	15.2
20.	C&NW	Burt-Halfa	21.4
21.	C&NW	Bancroft-Ledyard	9.5
22.	C&NW	McIntire-Stewartville	5.6
23.	C&NW	Harcourt-Jewell	28.6
24.	C&NW	Standwood-Tipton	8.2
			191 Miles

The rail section of this plan identifies 55% of Iowa's present rail system as essential to the states economic and social well-being. The plan shown in Figure 3 is based on the following factors:

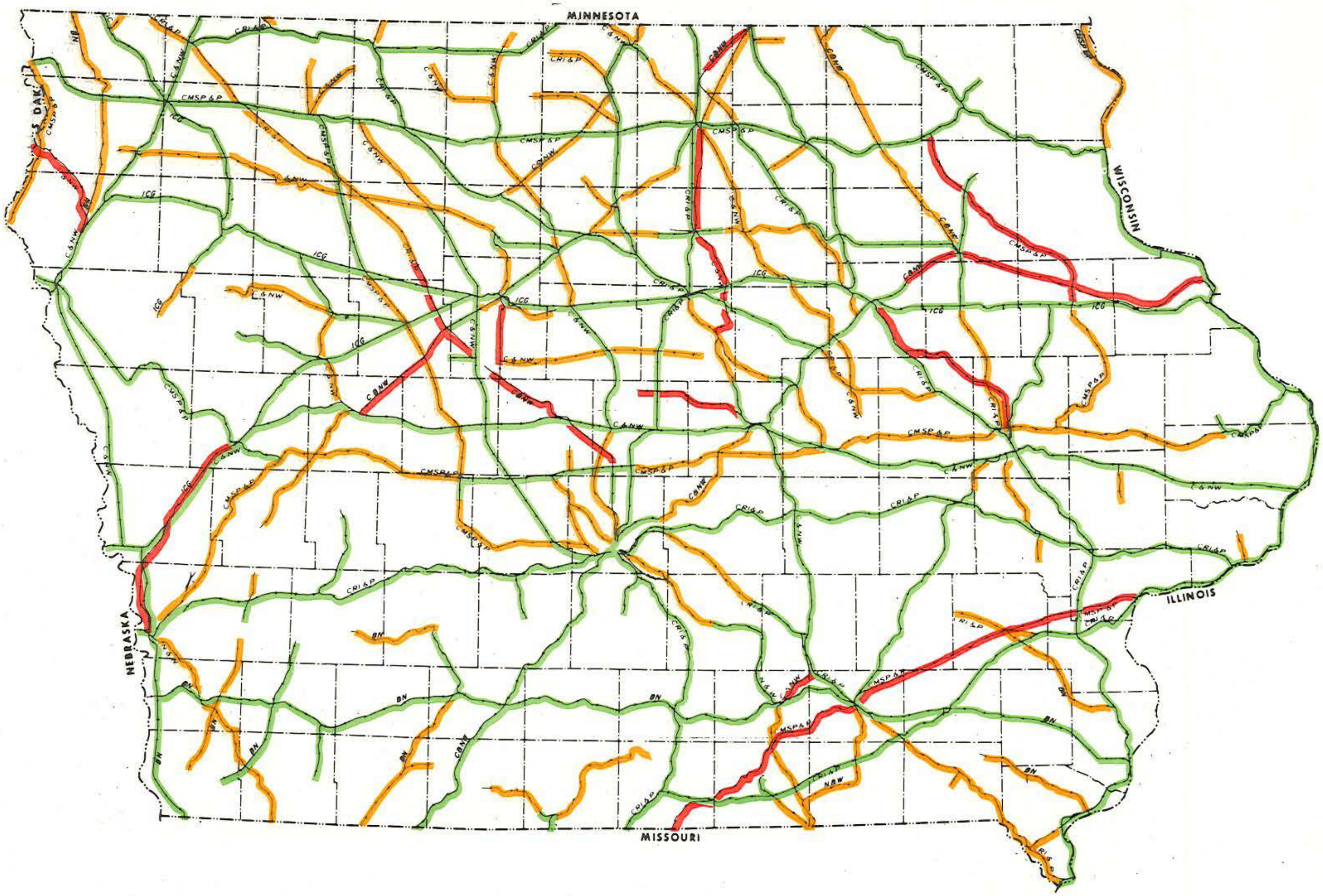
- Providing service to Iowa's 16 Regional Economic Centers
- Providing service to existing unit grain train terminals
- Providing service to major population centers
- Linking the Iowa rail network to the primary national rail system
- Retaining some minimal rail service in geographical areas

The Iowa transportation plan does not meet the many specific requirements for the state rail plans set forth in Part 266.9 - Title 49 of the Code of Federal Regulations published in the Federal Register on August 9, 1976. It is anticipated that the detailed branchline analysis as proposed in this work statement will verify the necessity for most of the lines identified as essential in the initial State Rail Plan.

Figure 3

IOWA RAIL SYSTEM PLAN

November 21, 1975



	Roadway Mileage	%	Number Cities Served	%	Population Cities Served	%
Necessary Lines	4240	55%	475	65%	1,797,000	90%
Not Sure	2770	36%	223	30%	180,000	9%
Not necessary	720	9%	34	5%	14,000	1%
Total	7730	100%	732	100%	1,991,000	100%

Iowa Branch Line Assistance Program

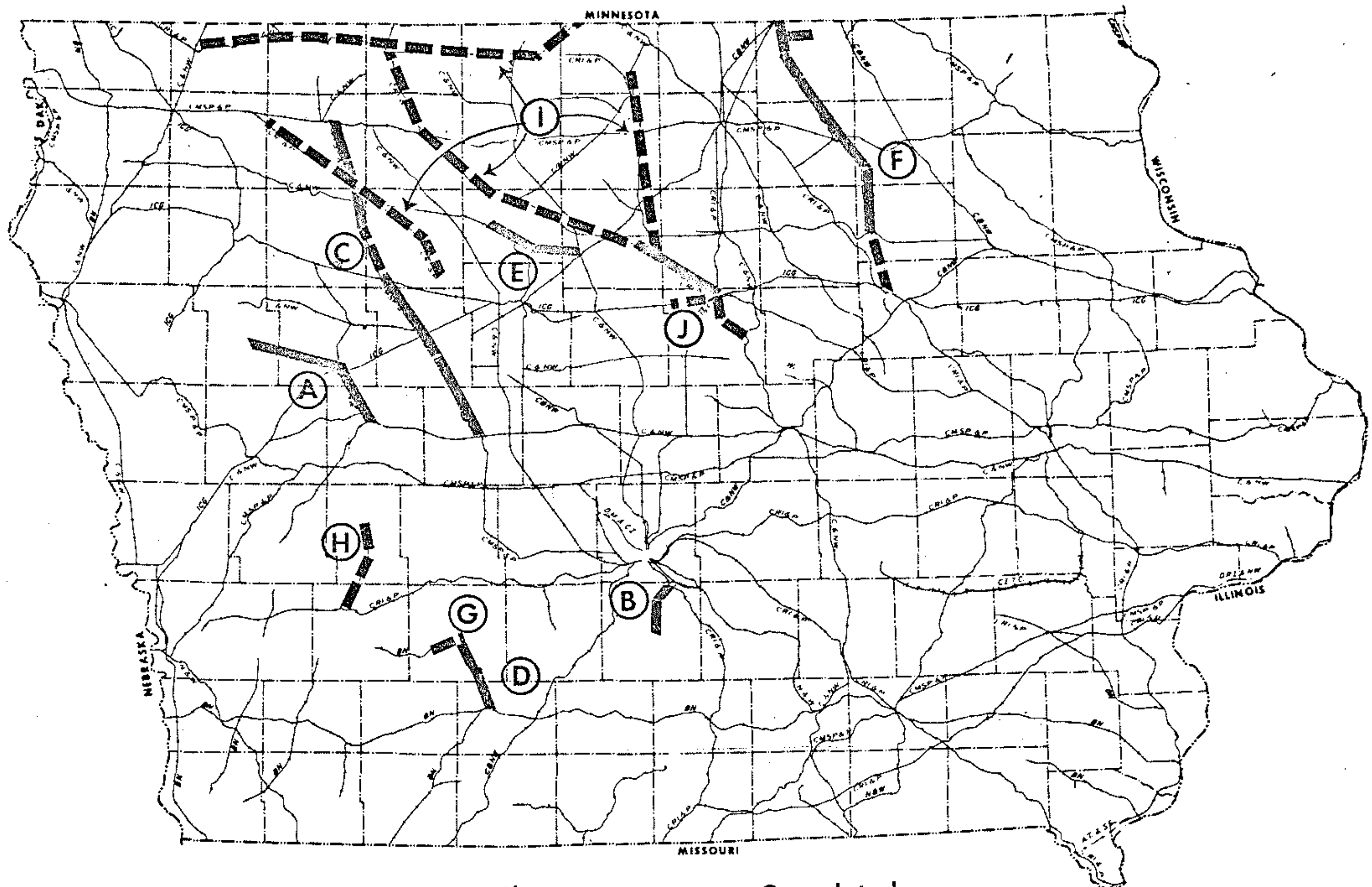
The railroad's deferred maintenance practices resulted in a reduction of service and a subsequent loss of business, which in turn, weakened the financial condition of the railroad causing a further reduction of maintenance levels. In an attempt to break this vicious cycle, the Iowa legislature appropriated an initial $3 million in 1974 to assist Iowa's branchlines. This program has resulted in $14.2 million of branchline improvements (640 miles) with $7.5 million of state expenditures. The objective of this program has been to provide timely solutions to Iowa's rail freight service needs.

Figure 4 identifies the rail segments which have been improved under this program to date. The concept has been to involve Iowa's branchline by providing capital to upgrade the lives through a 3-party formula. The capital provided by the user is repaid to them (by the railroad company) according to formulas based upon the number of cars shipped and revenues produced. A portion of the funds advanced by the State is also repaid to the State (by the railroad) on similar formula guidelines. These funds are recycled and used to improve other branch lines within the state. The amount to be recycled varies and is dependent upon the amount of additional traffic generated on a line.

Figure 4

IOWA BRANCH LINE ASSISTANCE PROGRAM

December, 1976



285 Miles		Completed
354 Miles		Work in Progress
639 Miles		Total

Table 3

IOWA BRANCH LINE ASSISTANCE PROGRAM
DECEMBER 1, 1976
($000)

MAP REFERENCE	BRANCH LINE LOCATION	RAIL-ROAD	MILE-AGE	VOLUME (CARS/MILE) 1972	1973	1974	PROGRAM QUALITY INDEX	TYPE OF WORK (RAIL, TIES, BALLEST, BRIDGE, CROSSINGS, DRAINAGE)	TOTAL PROJECT COST	SHIPPER PARTICIPATION	SHIPPER PAYBACK	STATE PARTICIPATION	STATE PAYBACK	STATE CREDIT ACCOUNT	RAILROAD PARTICIPATION	PROJECT STATUS COMPLETE (MILES)	PROJECT STATUS WORK IN PROGRESS (MILES)
A	Ida Grove-Maple River	C&NW	38	36	59	67	42	o x x x x x	$ 176	$ 80	$ 80	$ 80	$ 0	$ 0	$ 16	38	0
B	Indianola-Carlisle	RI	11	43	56	62	27	o x x x x x	600	200	10	400	0	0	0	11	0
C	Spencer-Herndon	Milw.	101	87	108	106	41	o x x o x x	2,083	385	0	1,598	0	154	100	87	14
D	Creston-Orient	BN	12	27	33	46	46	o x x o x x	441	0	0	291	0	0	150	12	0
E	Humboldt-Eagle Grove	C&NW	25	41	70	90	25	x x x x x x	1,800	500	0	800	0	0	500	25	0
F	Mona Jct.-Mn. Border	ICG	83	51	56	64	47	o x x o x x	557	178	88	191	0	4	188	74	9
G	Orient-Fontanelle	BN	20	20	31	30	16	o x x o x x	750	250	0	250	0	0	250	13	7
H	Audubon-Atlantic	RI	26	69	55	34	45	o x x o x o	1,008	380	0	356	0	0	272	0	26
I	Ia. Falls Gateway																
	Phase I	RI	302	74	82	72	46	x x x o o o	2,924	1,200	1,000	1,000	0	0	724 *	0	302
	Phase II	RI	302	74	82	72	46	o x o o x x	2,600	1,000	0	1,600	0	0	0	25	277
J	Alden to Eldora	C&NW	20	124	214	114	26		1,239	413	0	826	0	0	0	0	20
	TOTALS		639	------	------	------	------	------	$14,178	$4,586	$1,178	$7,392	0	$158	$2,200	285	354

* In kind contribution of rail, estimated cost is $724,000.

STATE RAIL PLAN DESIGN (§266.9(C))

The state rail plan will be developed in two stages. The first stage will be the analysis of Iowa branch lines which is necessary to become eligible for Federal rail continuation assistance. This stage is scheduled for completion in mid-March. The second stage will be comprised of a number of associated rail transportation studies, such as: an Iowa terminal inventory and analysis, a port of Iowa analysis, a mainline analysis, and a study of regulation and rates. The second stage is scheduled to be completed and submitted to the FRA by August 1, 1977, as part of the required state rail plan annual update.

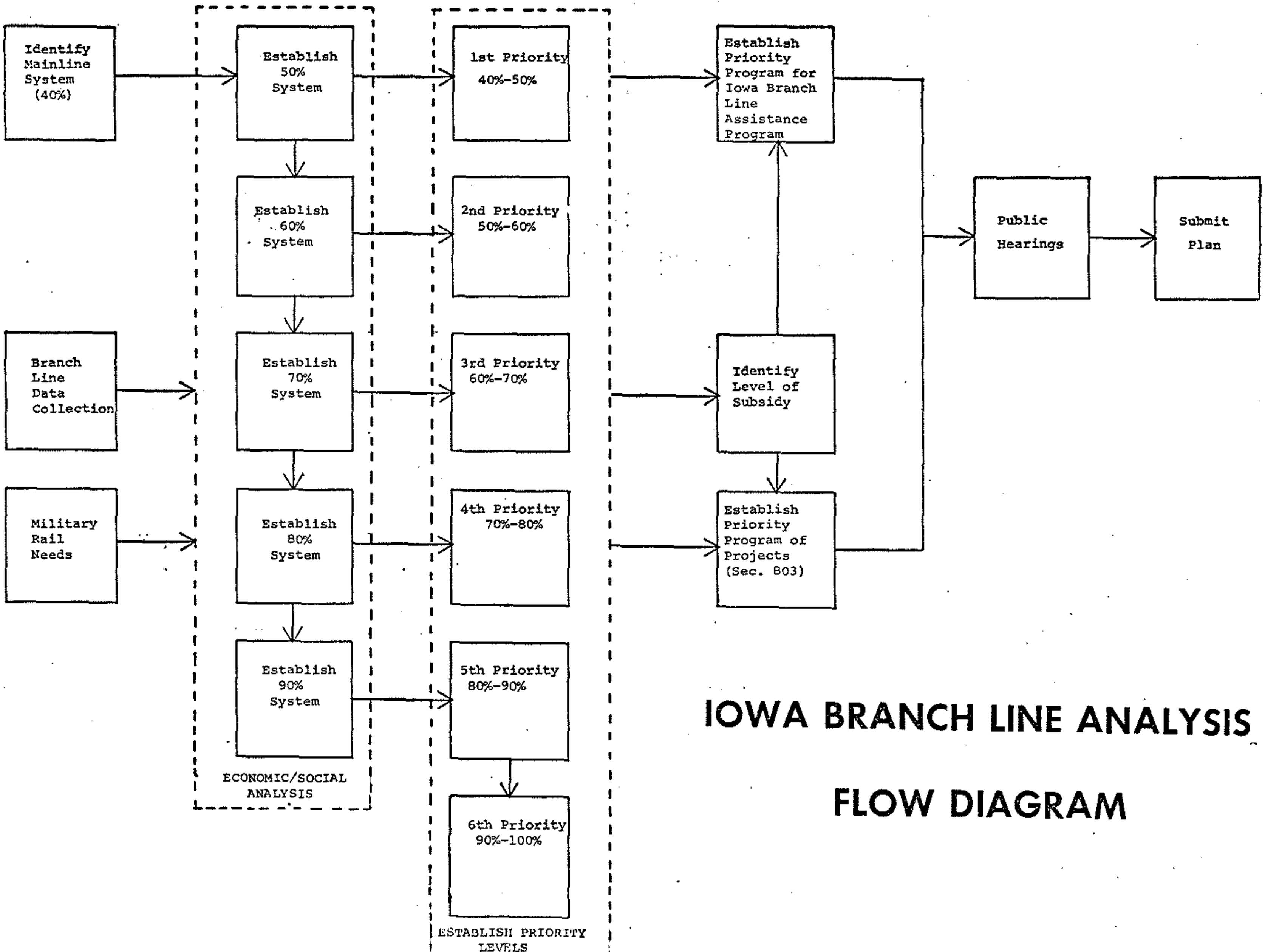
This planning work statement describes the planning procedure to be used to develop the branch line analysis and necessary priority program of projects. A summary of the associated studies are presented; the specific details and proposals for each study will be submitted at a later date as part of a revised planning work statement.

The Branch Line Analysis Process

As previously mentioned, Iowa has 541 miles of branch line which are considered potentially eligible for the Federal rail continuation program. The FRA regulations governing this program require that only these lines be analyzed. It is felt that analyzing and prioritying these lines without considering the other rail lines and transportation systems in the state is shortsighted, and not consistent with intent of the 4 R Act. Therefore, Iowa will analyze and prioritize all branch lines (4,500 miles) presently operating in the state. This analysis will be an intermodal analysis which compares the economic efficiencies of the operation of a branch line with that of a truck or barge transportation. The results of the analysis will provide a basis for developing a program of projects for the ongoing Iowa Branch Line Assistance Program and the Title V rail program in addition to the Title VIII rail continuation assistance program.

The branch line planning schematic is shown in Figure 5. The basis of the analysis is the identification of six separate rail system levels comprised of different mileages. First, the base rail system will be identified. This system will include the principle interstate mainlines in Iowa and consist of approximately 40% of Iowa's present rail mileage of 7436 miles. Once this 40% base system is identified, a 50% system will be established which consists of the 40% base system and 10% (740 miles) of branch lines that would best serve Iowa's economic and social needs if the Iowa rail mileage was reduced to 50% of present mileage. Subsequently, a 60%, 70%, 80% and 90% system would be established.

Figure 5



IOWA BRANCH LINE ANALYSIS

FLOW DIAGRAM

The establishment of the different level rail systems results in the identification of six priority categories comprised of approximately 740 miles each. The first priority category would include those branch lines added to the 40% base system to establish the 50% system. The second priority category would include those lines added to the 50% system to establish the 60% system, etc.

1st priority	40% base system	- 50% system
2nd priority	50% system	- 60% system
3rd priority	60% system	- 70% system
4th priority	70% system	- 80% system
5th priority	80% system	- 90% system
6th priority	90% system	-100% system

In addition to establishing the six priority levels, the actual costs of alternate transportation for each level system can be determined. This provides a means of determining the benefit/cost ratio associated with the continuation and upgrading of each priority category. For example, the B/C ratio for the 3rd priority category (60% system - 70% system) can be calculated as follows:

$$\frac{\text{Benefit}}{\text{Cost}} = \frac{\text{Difference in alternate transportation costs between 70\% system and 60\% system}}{\text{Cost to upgrade and maintain lines in 3rd priority category}}$$

It is anticipated that the analysis will result in a curve similiar to Figure 6.

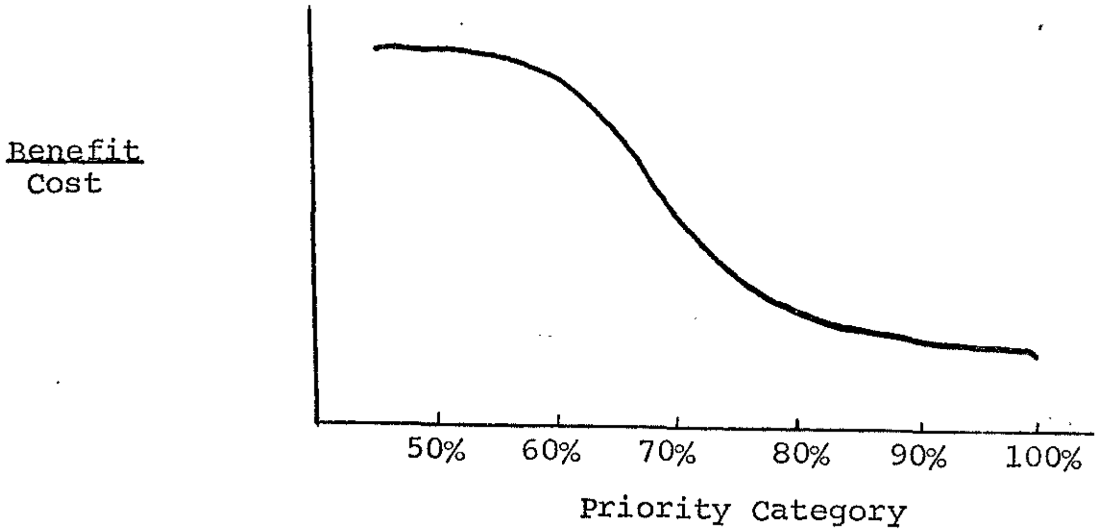


Figure 6

This information will be invaluable in determining the optimum rail system mileage for the State of Iowa.

Iowa's Rail Continuation Philosophy

The Iowa Department of Transportation has adopted the transportation policy shown in Figure 7. As can be seen from the policy statement, the Iowa DOT goal is:

> "to assure adequate, safe and efficient transportation facilities and services to the public".

It is felt that the establishment of a viable rail network in the state of Iowa can best meet this goal.

A viable and economically sound rail transportation system can best be attained by:

1) Improving economically marginal branch lines,
2) Abandoning lines with no major social importance or potential for economic viability, and
3) Encouraging the development of an integrated transportation system utilizing the inherent advantages of each mode.

An economic study recently completed by Iowa State University entitled "An Economic Analysis of Upgrading Rail Branch Lines: A Study of 71 Lines In Iowa" found that only 8 of the 71 lines studied would provide benefits greater than the cost of upgrading. These

Figure 7

IOWA TRANSPORTATION POLICY

GOAL — The transportation goal for the State of Iowa is to assure adequate, safe, and efficient transportation facilities and services to the public.

POLICY — It is the Policy of the Iowa Department of Transportation to:

A. General

1. Encourage development of a transportation system to satisfy user needs and maximize economic and social benefits for Iowa citizens.

2. Provide for a participatory transportation planning process which involves public, private, and citizen interests and encourages complementary transportation and land development patterns.

3. Encourage and support programs to provide for movement of goods and mobility for all citizens.

4. Consolidate and simplify procedures for registration and regulation of common-carriers and motor vehicles.

B. Plan

1. Develop a total transportation system plan, subject to annual review, which
   - considers all transportation modes as interacting elements,
   - considers facilities and services necessary for person and commodity movements from origin to destination,
   - contributes to the development and implementation of a state comprehensive plan,
   - provides a positive influence on social, economic, and aesthetic values,
   - provides safe and convenient travel opportunities,
   - minimizes economic, energy, and environmental costs,
   - coordinates with the plans of surrounding states and national programs,
   - coordinates available Federal, State, and local resources, and
   - recommends funding procedures for implementation.

2. Encourage and assist development of general aviation, airport facilities, and air-carrier services.

3. Encourage and assist the general development and efficient use of highway transportation through improvement programs to equalize functional adequacy of roads and streets throughout all of Iowa.

4. Encourage and assist development of public passenger transportation systems.

5. Encourage and assist a viable railroad system consistent with the needs of Iowa and the United States.

6. Encourage and assist the development of programs for proper use of river transportation.

C. Program

1. Prepare annually a coordinated current and long-range program of capital investment, services, and regulatory practice.

2. Propose and promote legislative programs to implement an integrated transportation system.

results, in conjunction with the fact that over 70% of Iowa's rail mileage is owned and operated by railroad companies in financial difficulty, indicates that Iowa can not support its present rail system indefinitely.

Rather than subsidizing the operation of branch lines which have proven to be uneconomical and have been approved for abandonment, the Iowa DOT has chosen to upgrade the marginal lines which potentially could become self-supporting while promoting the rationalization of the system by supporting abandonments.

It is anticipated that after the 5 year rail subsidy program marginal lines which were upgraded will have become economically viable and self-sustaining while lines which are uneconomical and have no social importance will have been abandoned. The result is a sound rail system for the State of Iowa which is consistent with Iowa's general transportation goal.

Public Participation (266.9(C)(2)

Participation of affected interest groups and communities is particularly crucial to railroad planning in order for the plan to be accepted and implemented when it is completed. The railroad companies, local communities and affected rail users must be aware of the philosophy and purpose of the plan from its inception through implementation. The interest groups and local citizens will be given the opportunity and encouraged to participate throughout the planning process.

In 1975, the Iowa DOT organized citizen advisory councils to assist in identification of the current transportation issues and increase citizen participation in the transportation planning process. The three councils, one composed of 29 representatives from the private sector, a second with 9 government sector members, and a third with 18 special interest members were established. The councils selected a 15 member steering committee to work closely and serve as liason with Iowa DOT staff members. The councils held meetings during the summer and fall of 1975.

The original Citizen Advisory Councils have been consolidated into one group consisting of 56 members and also continues to meet monthly. In 1976, 8 additional Regional Citizen Advisory Councils were established. These councils meet on a monthly basis to discuss transportation plans and programs. The 8 regional meetings are held in Atlantic, Ames, Calmar, Chariton, Clear Lake, Manchester, Storm Lake, and Washington as shown on the attached map. Councils are voluntary and are open to the public. Regional planning agencies, local governments, and chambers of commerce are amoung those who participating in the Council dialogues. A complete list of Council members and their affiliations is shown in Appendix A.

A State Railroad Advisory Committee has also been established to provide a liason between the Iowa DOT and the railroad industry. This committee is composed of representatives of the Class I and II railroads operating in Iowa, the Iowa DOT, the Iowa Association of Railroads, and the United Transportation Union and meets on an as-needed basis. Committee representatives are listed in Appendix A.

- Criteria for Rail Service Continuation Assistance (266.9(C)(3)

Section 803 of the 4-R Act and the governing regulations provides financial assistance to States for rail freight assistance programs that are designed to cover:

"(1) the cost of rail service continuation payments;

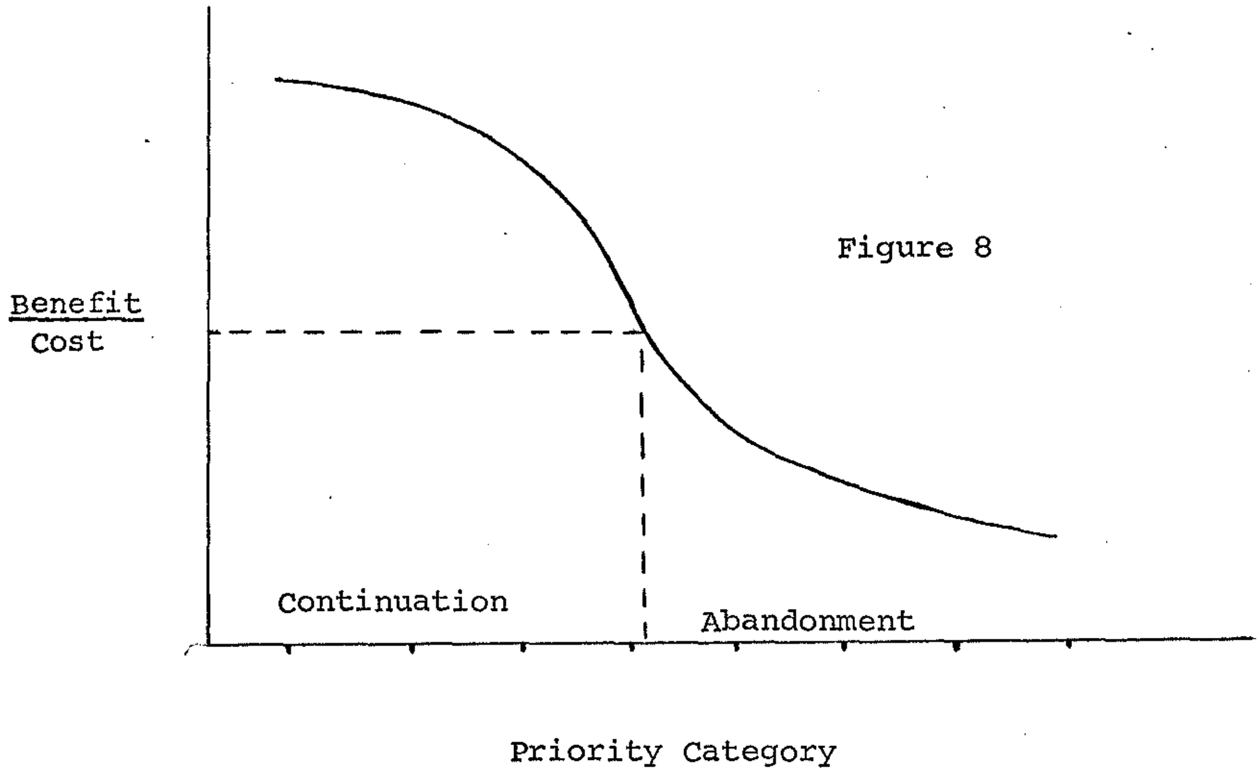
"(2) the cost of purchasing a line of railroad or other rail properties to maintain existing or provide for future rail service;

"(3) the cost of rehabilitating and improving rail properties on a line of railroad to the extent necessary to permit adequate and efficient rail freight service on such line; and

"(4) the cost of reducing the costs of lost rail service in a manner less expensive than continuing rail service.

The economic and social analysis will result in the prioritizing of all Iowa branch lines into six priority categories and establishing a benefit/cost ratio for each priority category.

The branch line mileage which the State of Iowa is capable of supporting must be established. This point will be determined by comparing the upgrading funds available from the railroads, rail users, State and Federal governments with the benefit and costs associated with upgrading each priority level.



The Iowa DOT will support the continuation of eligible branch lines, whether through subsidy, purchase, lease or upgrading, if the line falls into the "continuation" category, as shown in Figure 8. If a line falls into the "Abandon" category, the Iowa DOT may consider subsidizing the cost of alternate transportation if less than the cost of continued rail service.

Projects which fall into the "continuation" category will have priority over those projects in the "Abandon" category.

Projects for the ongoing Iowa Branch Line Assistance Program will be selected from those lines in the continuation category which are not eligible for the Federal branch line continuation funds. Both programs will be coordinated whenever possible.

In order for a branch line to be considered for Federal rail continuation assistance, a portion of the state share of the continuation cost must be born by the local community or shippers. Iowa has found that this philosophy, which is the backbone of the Iowa Branch Line Assistance Program, is a true test of the real importance of a rail line to a community.

If a branch line is included in the "continuation" category and no local group or individual is willing to accept a portion of the state share of the continuation costs, the line will be evaluated as a potential candidate for rail banking.

- Rail Planning Data (266.9(C)(4)

The Iowa DOT accumulated general planning data about the rail lines operated in the state as part of the initial rail planning effort for TransPlan '76. This data includes such items as FRA track class, train frequencies, rail service characteristics, and the location of unit-grain terminals. In addition, the Iowa track geometry car has tested all the rail lines in the state within the past year. This information provides an indication of the general track condition.

The railroads in conjunction with the Association of American Railroads have developed a specific data package for lines eligible for rail continuation assistance and a more general data package for lines not eligible. This information shown in Table 4 will be purchased from the railroads when available.

TABLE 4

General Data PACKAGE Includes:

- System map
- Track chart
- Signal chart
- Density chart
- Freight train schedule
- Operating timetable

Specific Data PACKAGE Includes:

- Physical condition data
- Rehabilitation costs data
- Operations data
- Traffic data

The economic computer model to be used in this analysis requires an abundance of specific operational data. This data was compiled for all the branch lines in Iowa as part of the original analysis conducted by Iowa State University. It is anticipated that this information will be available to the ISU staff who will conduct the computer analysis under contract with the Iowa DOT. The use of this data will be subject to all the restrictions agreed upon in the original contract (FRA-OPPD-76-3). Therefore, it will not be necessary for the Iowa DOT to request this data from the railroads, but rather, that ISU be given the authority to use the data in this analysis.

Table 5 identifies the specific data necessary for the economic computer analysis and the anticipated source of each item.

TABLE 5

Economic (Benefit - Cost Ratio) Analysis

type	source
- supply of grain at each origin for each quarterly time period	ISU CARD REPORT 51 "projected quantities of grain and fertilizer requiring transportation services in Iowa
- the demand price at each final di distincition for each time period	ISU Report No. FRA-OPPD-76-3 an econ. analysis of upgrading Rail Branch Lines in Iowa
- the estimated 1980 annual supply requirements for Iowa grain of each Iowa corn and soybean processor.	ISU Report No. FRA-OPPD-76-3

type	source
- no. of cars originating and terminating by commodity and by station	available to ISU only provided by RR and FRA - Iowa DOT can obtain only aggregated station data
- elevator coapacities, locations, and grain handling costs for receiving, storage, and loading out the grain	ISU Report No. FRA-OPPD-76-3 Iowa Grain and Feed Assoc.
- the percent of total grain receipts and shipments at country elevators and subterminals by time period	available to ISU only provided by the Railroads and FRA - Iowa DOT can obtain only aggregated station data
- grain transportation rates and costs from each origin to each destination by transportation mode	Interstate Commerce Commission statement No. ICI-72
- the sources of supply of each type of fertilizer	ISU CARD REPORT 51 "projected quantities of grain and fertilizer requiring transportation services in Iowa
- the locations of retail and wholesale fertilizer facilities	Railroad data package - ISU Report No. FRA-OPPD-76-3
- fertilizer handling costs	ISU Report No. FRA-OPPD-76-3
- fertilizer transportation rates and costs from each source of supply to each retail location	Interstate Commerce Commission statement no. LCL-72
- the quantities of each type of fertilizer expected to be sold by each retail fertilizer location	ISU Report no. FRA-OPPD-76-3 available to ISU only provided by the Railroads and FRA - Iowa DOT can obtain only aggregated station data
- quantites of each type of other products requiring transportation	ISU Report No. FRA-OPPD-76-3

type	source
- handling and trucking costs of transferring the products between rail car and industry site	ISU Report No. FRA-OPPD-76-3
- track condition	Rail data package from Railroads
- price of upgrading materials and amount	Rail data package from Railroads
- rail line maintenance cost	Rail data package from Railroads
- salvage value	Rail data package from Railroads

In addition to the operational data necessary for the economic analysis, specific information is necessary to evaluate the social impact of an abandonment. When the economic analysis identifies an unusally high cost of alternate transportation, the affected rail users will be interviewed and detailed information collected.

Opinions will be solicited regarding:

1) present usage and cost of rail and alternate modes of transportation
2) the number of employees of the business
3) the extent of dependency on rail
4) the dependency of other local businesses on the affected business

5) the impact on expansion plans

6) the impact on property taxes paid

7) willingness to contribute toward keeping local rail service e.g., railroad loans for upgrading or paying higher freight rates

- Analytical Methodology (266.9(C)(5)

The methodology that will be used in selecting essential rail lines in Iowa will be based on an economic (benefit-cost ratio) and social evaluation.

The economic methodology was developed by Iowa State University under a previous contract with FRA and Iowa DOT (Report FRA-OPPD-76-3). The major factors of this analysis include: cost relationships of alternate modes, comparison of intermodal relationships, future commodity flow patterns instead of historical trends, and evaluation of different rate structures.

The benefit/cost analysis uses a series of computer programs to analyze the benefits from upgrading each rail line. The benefits from upgrading a line are defined as: the total annual transportation and handling cost savings to grain shippers, fertilizer receivers, and shippers and receivers of other products if the line is upgraded rather than abandoned. The benefits of upgrading are estimated in two steps. First, the flow of products from origin to destination is optimized over all markets, all rail lines, and all modes of transportation to obtain the maximum net revenue to shippers in the area, under the assumption that a given rail line is upgraded. Secondly, the flow of products was reoptimized to obtain the maximum net revenue to shippers under the assumption that the rail line is abondoned. The difference between the maximum net revenue with the rail line upgraded and the maximum net revenue with the rail line abandoned is the savings to the shippers from upgrading a line.

These transportation and handling cost savings from upgrading a given line are then divided by the annualized costs of upgrading, the annual subsidy cost and the annual fixed maintenance cost to obtain a benefit cost ratio. If a branch line is eligible for rail continuation subsidies, this subsidy cost will also be included in the cost as developed by the advisory criteria published by the Office under Section 205(d)(3) of the 4 R Act of 1973, as amended.

If the benefit-cost ratio is greater than 1.00, then the annual benefits exceed the annual costs of upgrading. If the ratio is exactly 1.00, then benefits equal the costs of upgrading. If the ratio is less than 1.00 and greater than or equal to 0.75, the costs of upgrading are slightly in excess of the benefits of upgrading. For lines with a benefit-cost ratio of less than 0.75, the costs of upgrading greatly exceed the benefits. With this approach the analysis will evaluate each line or combination of lines from an objective economic stand point.

However the economic analysis is not the only concern in rail line abandonment. If the rail system was based solely on a benefit/cost analysis some areas of the State might have all of their lines assisted, leaving another area virtually without service.

The following criteria will also be used to establish the six different rail system alternatives:

- Provide rail service to all major population centers
- Provide minimal rail service to all economic and geographical regions of the state.

Therefore, those lines included in the highest priority categories will not always be those lines with the highest benefit/cost ratio's.

Associated Studies

The Iowa DOT feels a responsibility to pursue various non-branch line rail service improvement studies which will result in improved freight transportation service. Areas to be a part of the Iowa State Rail Plan studies include: yard terminal improvements, year round rail-barge interchange facilities or a Port of Iowa, interstate mainline requirements for Iowa rail users and railroad regulation and rates as they affect Iowa's transportation system. The Iowa DOT will study these improvement alternatives and promote programs which will bring railroads and other transportation modes together where operating differences make improvements difficult.

- Terminal Inventory and Analysis

In Iowa, there is a need to improve operations at rail yards and terminals. Preliminary studies conducted by the Iowa Department of Transportation have indicated that rail cars do not move through the yards efficiently and there is evidence to suggest that there may well be a surplus of yards and terminals in the state.

The shortcoming associated with inefficient use of terminals contribute to such problems as: high per diem rental for cars, underutilization of car fleets, inadequate service to shippers, excessive conflicts with road traffic (i.e., street and highway traffic) and economic growth constraints in their service areas.

There is a need to identify and evaluate the procedures that inhibit efficient operations of existing facilities and to develop alternatives designed to provide more efficient operations. The benefits from such an analysis include: greater efficiency of operations, improved competiveness in industrial traffic for railroads, reduced adverse community impact from rail facilities, less conflict with other modes, and improved economic growth potential for communities served by rail. As an example of future study directions, the Iowa DOT is currently working with Cedar Rapids and the five rail companies that operate within the Cedar Rapids area.

Port of Iowa Analysis

Access from central Iowa to year round barge facilities has been discussed frequently. Various concepts have been presented. For example, it has been proposed that the State of Iowa establish a public port facility at Keokuk and purchase and upgrade a rail line from Keokuk to Des Moines to provide access from central Iowa.

As demonstrated in the previous example, an analysis of the Port of Iowa concept is closely related to the Iowa rail system. Rail-barge needs analysis will be made a part of the state rail planning process.

It is anticipated that any feasibility analysis of the Port of Iowa concept include the following factors:

- USE PROJECTIONS
  - Need?
  - Size and type of development
  - Location altervatives
  - Twelve month operation feasibility
  - Transportation needs (other modes)
- COSTS
  - Capital investment
  - Operating costs
  - Maintenance costs
- BENEFITS
  - Lower shipping costs
  - Expansion of market area
  - Employment and tax base
  - Rail/water tariffs
- EFFECTS ON COMPETITOR
  - Private terminal operators
  - Other freight modes
- ORGANIZATION AND FINANCING
  - Local/State/Federal funds
  - Bonds
  - Needed legislation
  - Port authority

- ENVIRONMENTAL IMPACT
  - Effect on recreation
  - Coast Guard and Army Corps of Engineers Requirements
- EVALUATION OF PRESENT PROPOSALS
  - Ownership or lease of Des Moines to Keokuk rail line and state port development at Keokuk

- Mainline Analysis

The Preliminary Rail Standards, Classification, and Designation Report (Section 503 - 4 R Act of 1976) categorized the rail lines of the nation so that investment in track could be directed where it would do the most good. Figure 9 depicts the Iowa Preliminary Rail Classification System. Iowa was one of 2 states which had no "A Mainlines" designated. Instead 27.8% of the Iowa rail miles are designated as "A Potential Mainline" because they were determined to lie in "Corridors of Excess Capacity".

The Final Classification Report will be published before January 30, 1977. This report and the Capital Needs Study will be used by the U.S. Department of Transportation to determine funding priorities. Guarantee of obligations for improvement loans of $1 billion and $600 million of redeemable preference shares will be made available for approved rail upgrading projects. While the final funding philosophy has not been disclosed - lines in the highest mainline category will probably receive the highest funding priority.

PRELIMINARY RAIL CLASSIFICATION - IOWA

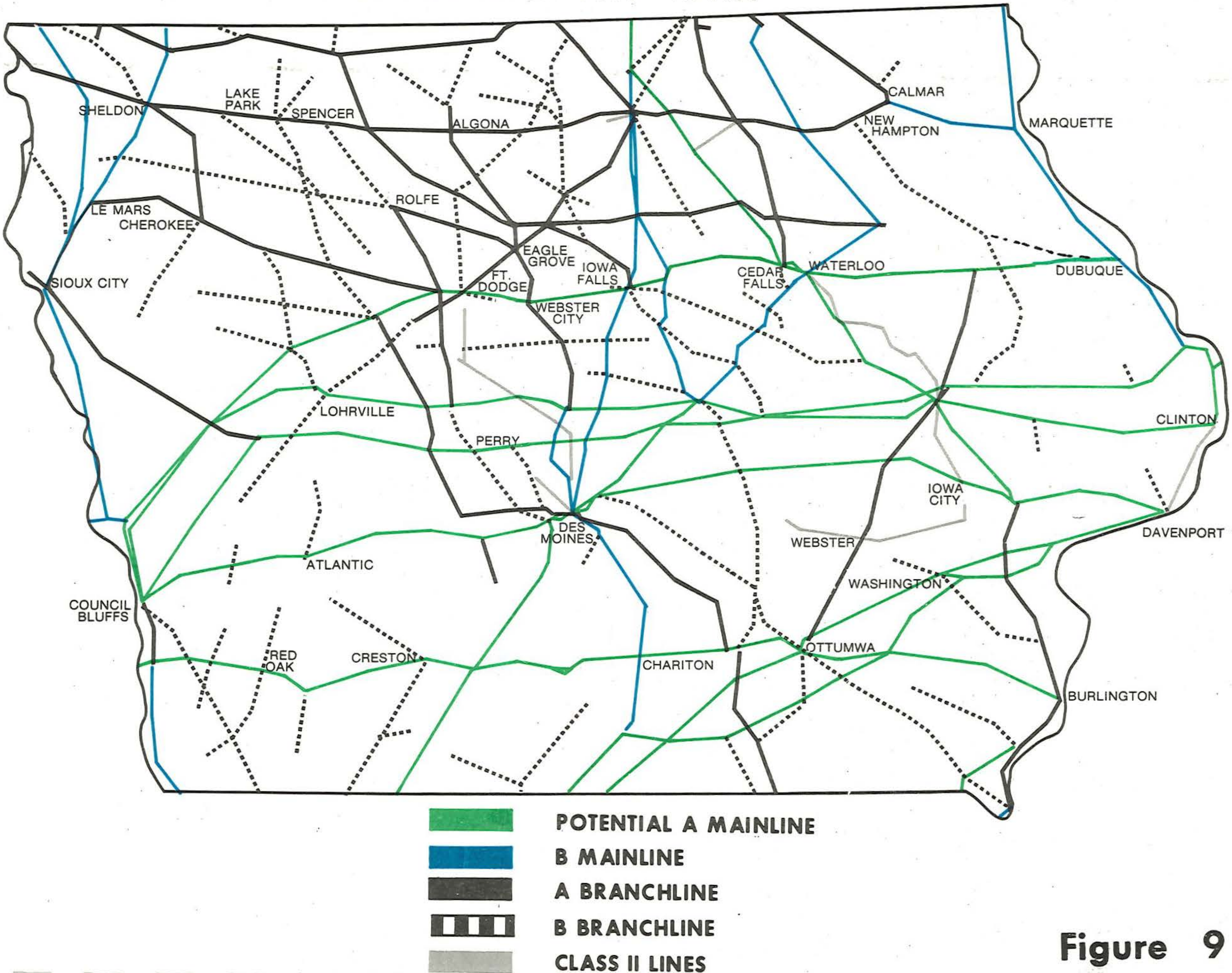


Figure 9

The Iowa DOT will develop a detailed study of the Iowa "Corridors of Excess Capacity" in order to promote the reclassification of lines from "A Potential Mainline" to "A Mainline" and therefore, increase their chances of being included among the funded projects. Iowa will study the mainlines in the state and the possible mergers, joint trackage agreements and consolidations which might take place. The Iowa DOT staff will act as a catalyst and will encourage parties to meet and discuss rail consolidation methods. The Iowa DOT has formed a Rail Merger Committee as the prime instigator of mergers and consolidations studies.

- Regulation and Rate Analysis

Similarly to virtually all forms of transportation, rail services are provided in a mixed public-private market. There is no a priori reason to believe that a purely private and unregulated market would provide the best performance, any more than there is reason to believe that pure public operations are the most desirable. Regulations need to be carefully tailored to the specific characteristics of the industry and its operating environment.

A study of regulation as it affects motor carriers is underway by the Iowa DOT. The efficiencies of regulated motor carriers are being compared with unregulated carriers for level of service provided, internal stability of the carrier, etc. From this study it is hoped some generalized statements about the merits of regulation may be gleaned.

The Iowa DOT feels a better understanding of regulation and its complexities is needed. The efficiency of increased utilization of our transportation equipment should be encourage with the benefits of that efficiency accuring to the public. An appropriate policy must consider both the producer and the consumer, and the political and economic sectors. Some non-economic regulation is needed to improve our political, industrial and commercial institutions. Areas which the Iowa DOT is considering studying are rules of rate-making, especially as they relate to seasonal rates, the role of rate bureaus, financial control of rail resources and the effects of these regulations. The study may include consideration of: 1) price flexibility and its effect on transportation equipment utilization, 2) rate bureau practices and their role in joint hauls, and 3) functional accounting as it is used to recognize for example the trade offs between investment in plant and the costs of derailments and slow orders. An evaluation of the present rail regulatory climate and its impacts on Iowa will be included in the State Rail Plan.

MANAGEMENT PLAN (266.9(C)(6)

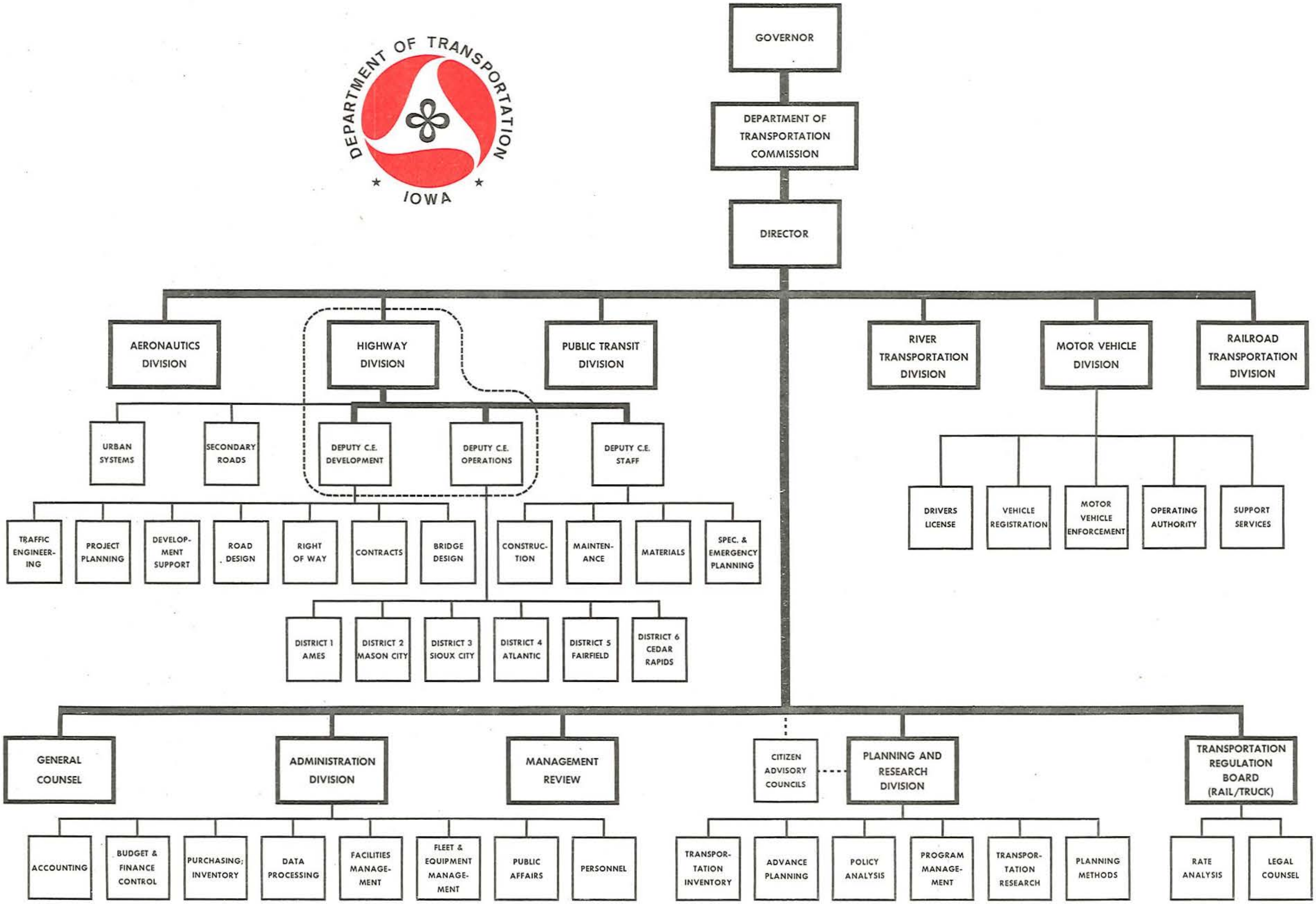
Organization

The two year old Iowa Department of Transportation is the designated state agency charged with the responsibility to develop a State Rail Plan. Within the Iowa DOT Planning and Research Division the "Office of Advance Planning" will have the primary responsibility for developing the State Rail Plan. (See Figure 10).

The Office of Advance Planning is staffed by 53 people and is responsible for such tasks as urban transportation planning, transportation needs analysis, traffic and commodity flow projections, and long-range intermodal transportation planning. The State Rail Plan development will take place in the intermodal planning area and will be coordinated with the development of other modal plans. The various modal plans will be consolidated and presented in Iowa's Annual Intermodal transportation plan as part of the continuous planning process for the Iowa DOT. (See Figure 11).

Jerry Hare, State Rail Planner, will be the State Rail Plan project manager. Glenn Miller, Intermodal Planner, and Donald Ward, Director of the Office of Advance Planning will also be involved in the plan's development.

Figure 10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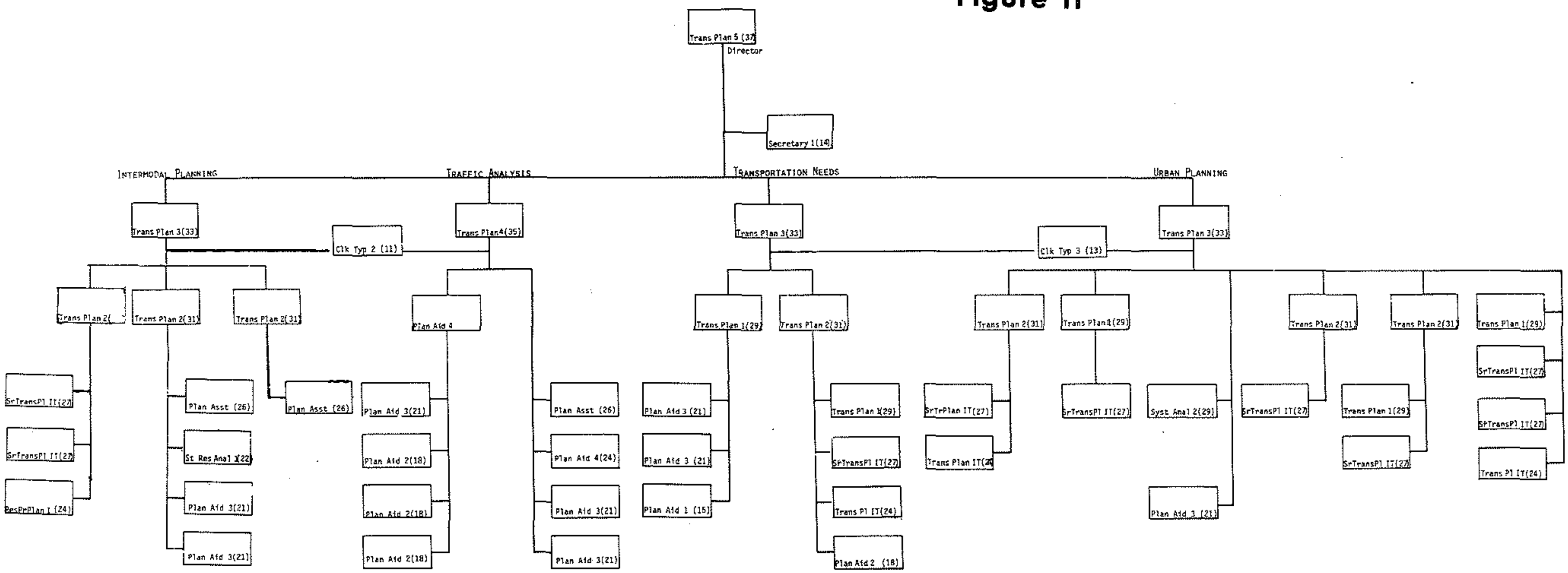
ADVANCE PLANNING
POLICY ANALYSIS
PROGRAM MANAGE-MENT
TRANSPOR-TATION RESEARCH
PLANNING METHODS
RATE ANALYSIS
LEGAL COUNSEL

OFFICE OF ADVANCE PLANNING

Figure 11



In addition to the planning division involvement in the State Rail Plan, other DOT divisions will be important contributors to the State Rail Planning process. The Railroad Division which is the operating division in charge of railroads will assist in the collection of rail data and in the solicitation of rail users' input. The Transportation Regulation Board (TRB) performs the transportation related regulatory functions for the State. Its past experiences with abandonments, its close association with rail shippers and its expertise in regulatory matters, will make it an important contributor in the planning process.

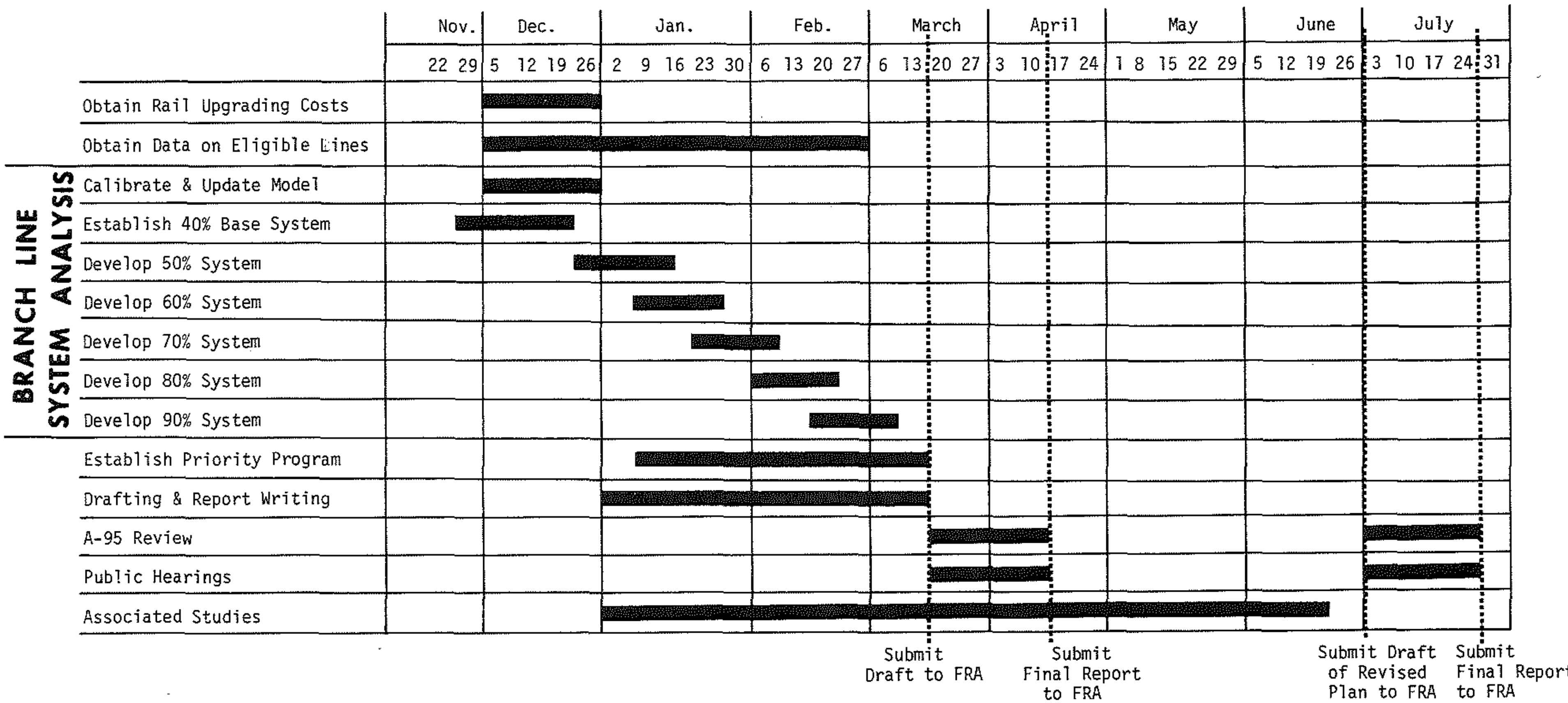
A contract has been developed with Iowa State University to perform the economic computer analysis (see Appendix C). Dr. C. Phillip Baumel, David Reinders and John Miller, who were involved in the development of the original economic methodology and computer programs, will be responsible to perform the economic computer analysis. Dr. Baumel will be the project manager.

Additional consulting contracts may develop for work to be performed on associated studies as part of the State Rail Plan.

Timetable

Figure 12 shows the Iowa rail planning timetable. The branch line analysis is scheduled to be completed in mid-April. A draft of

Figure 12 IOWA DOT RAIL PLANNING TIMETABLE



the plan and program of projects will be submitted to the FRA in mid-March. It is anticipated that this draft in conjunction with an offer of financial assistance under section 1a(6)(a) of the ICA will be adequate justification for the FRA to consider Iowa FY 77 project entitlement funds committed.

If at any time during the development of the 50% through 90% rail system, it is determined that the results of the economic analysis do not justify the expenditure, the analysis will be terminated.

The A-95 Review of the State Rail Planning Work Statement was initiated November 15, 1976. Any comments received from the A-95 review process will be forwarded to the FRA for its immediate use.

Budget

Tables 6 and 7 show the proposed project budget and Iowa State University contract budget, respectively. The total project budget is estimated to be $358,000. Iowa will return $500,000 in planning funds to the FRA so other states who did not receive their realistic share of planning funds under the entitlement formula can use these funds in a timely manner.

Table 6

ESTIMATED PROJECT BUDGET

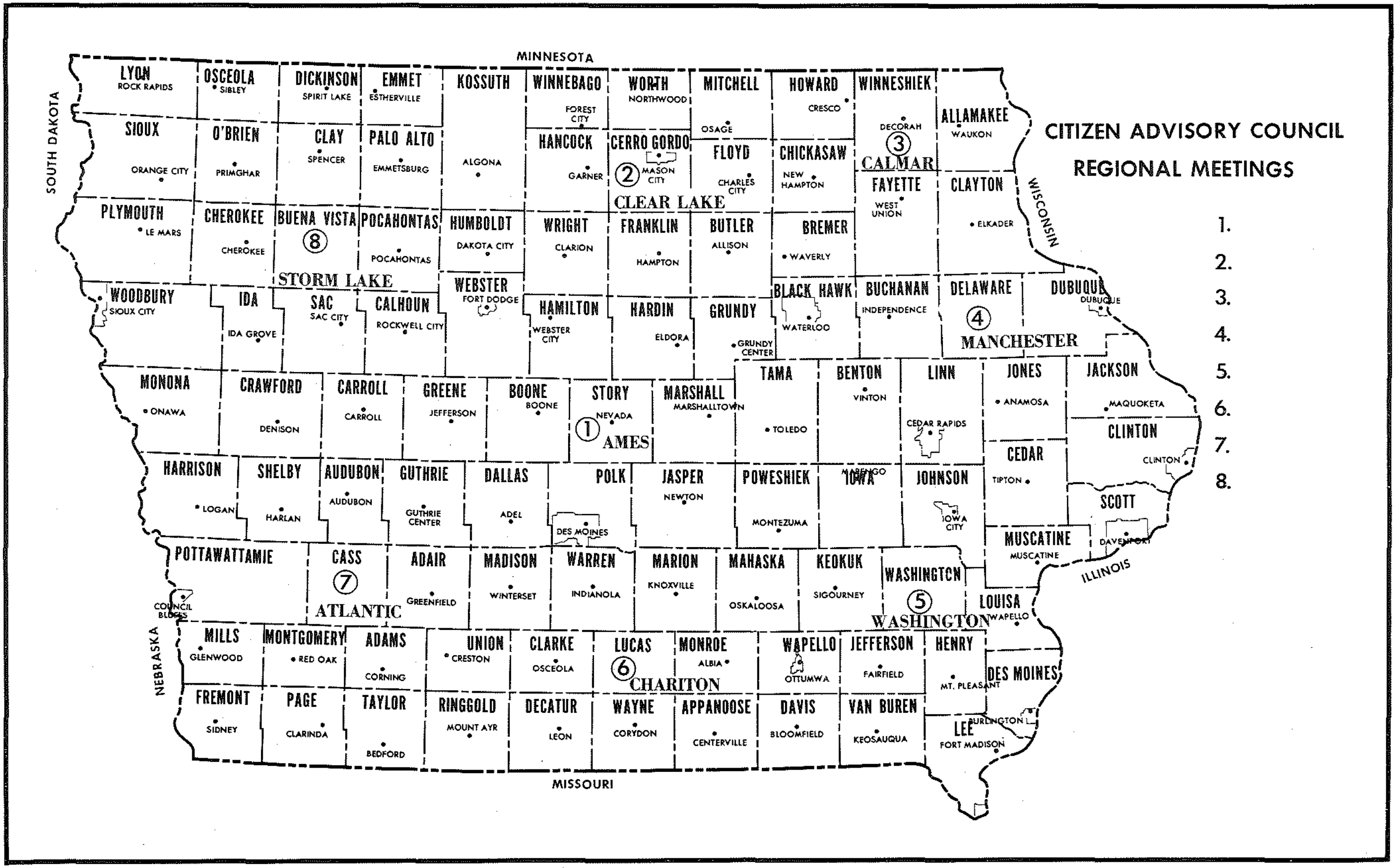
Branch Line Analysis	$150,000
Upgrading Cost Estimates	$ 10,000
Terminal Inventory & Analysis	$ 25,000
Port of Iowa Analysis	$ 25,000
Mainline Analysis	$ 25,000
Regulation & Rate Analysis	$ 30,000
Drafting & Misc.	$ 13,000
Iowa DOT Staff	$ 30,000
	$308,000
Contingency	$ 50,000
	$358,000
Return to FRA	$500,000

Table 7

IOWA STATE UNIVERSITY CONTRACT BUDGET

ITEM	RATE	AMOUNT
SALARIES		
Baumel (principal investigator)	5 mo. @ 40% of Time $1,016.67/mo.	$5,083.33
Miller, John J. (Pre. Doc. research assoc.)	5 mo. ½ time @ $645.83/mo.	$3,229.17
Reinders, David L. (Grad. Assistant)	5 mo. @ $700/mo.	$3,500.00
Research Tech 2 @ 100 hr/mo as needed	1000 hr. @ $4.00/hr.	$4,000.00
		$15,812.50
Other Direct Costs		$ 964.50
Employee Benefits		2,373.00
Computer Time		125,000.00
Indirect Costs		5,850.00
		$150,000.00

Appendix A



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Appendix B

Grain Model

One major objective of this study is to estimate the net income effect on grain shippers of branch rail line abandonment. The nature and scope of the grain distribution system in Iowa where economies of large-size grain shipments exist suggests a method of analysis based on a transshipment plant-location model. Transshipment plant-location models are used to determine the optimal structure of an industry when transportation costs are incurred from origin to plant and from plant to destination.

Stollsteimer developed a plant-location model to determine the optimal number, size, and location of plants when either transport costs from origins to plants or transport costs from plants to destinations are relevant. An extension of the Stollsteimer model incorporating both the transport cost from origins to plants and plants to destinations was developed by Ladd and Lifferth. The model used in the present study is a variation of the Ladd and Lifferth model and incorporates volume constraints on destinations.

Assumptions

The following is a description of the grain production and marketing system which is the basis for the specification of the transshipment plant-location model used in the analysis of alternative grain distribution systems. The quarterly supply of corn and soybeans at each origin is known. Each grain producer in each district has the option of shipping his grain to either a country elevator or to a subterminal elevator. A country elevator stores and ships grain to a subterminal elevator and/or to a final destination. A subterminal can store and ship to a final destination. "Final destinations" include export ports and/or domestic processing markets.

Grain producers use various sizes of tractor-wagon combinations and trucks to transport grain to country elevators and subterminals. A country elevator may transport grain to a subterminal by truck or to a final destination by truck, rail, rail-barge, or truck-barge. Country elevators cannot utilize multiple-car rail shipments in excess of ten cars because of rail or elevator load-out capacity constraints. Grain received by subterminals may be shipped to final destination in multiple-car rail shipments, truck, rail-barge, or truck-barge. Multiple-car rail shipments from subterminals can be 25 cars or more.

Quarterly demand prices for grain at each destination are known and vary by time and commodity. Per unit transportation costs are known and also vary by commodity and time. Variable handling costs vary by commodity, time, and mode of shipment. The quarterly grain prices, net of transportation, and variable handling costs determine where a country elevator or subterminal will ship the grain.

Some grain distribution facilities, including elevators, subterminals, and rail lines, exist at the beginning of the planning horizon--January 1, 1975. Existing country elevators will continue in use and may be expanded into subterminals. Some new subterminals may be constructed.

Facilities that exist at the beginning of the planning horizon affect the optimal path of industry adjustment, due to the nature of their "sunk" costs. Existing storage facilities of elevators will always be used to capacity during the harvest quarter before any elevator will expand. Existing grain storage capacity at an elevator, as used in this model, is defined as total storage capacity at the elevator minus that portion of storage capacity used for working space and back-to-farm shipments of grain. Total construction and/or expansion costs, therefore, vary by location and by size of the existing facility.

Objective function

The objective function of the model is to maximize net revenue to producers within a district under various rail line networks. Net revenue is the income received at final destination minus all handling costs other than previously sunk costs and minus all transportation costs from farm to final destination. The model determines the optimal number and location of subterminals and the optimal flow of each grain from each origin to final destinations for each time period, given a particular rail line system in a district.

Constraints

The net revenue to producers is maximized subject to the following constraints:

1. Existing storage facilities of country elevators and subterminals are filled to capacity in the harvest quarter before storage capacity is allowed to expand at any elevator or subterminal.
2. Iowa corn and soybean processors receive grain equal to at least 90 percent of their projected 1980 processing capacity.
3. The total supply of grain received at any one location in any one quarter equals the total supply shipped to that location from all sources in that same quarter.
4. The total grain receipts of country elevators or subterminals from origins equals their total shipments to final destinations.

Definition of symbols and of the spatial structure of the grain distribution system

The time horizon over which alternative grain distribution systems are evaluated extends from 1975 to 1980. Symbols, unless stated otherwise, represent the crop year 1980. Time--which varies from t = 1, 2, 3, 4--denotes quarters; the first quarter of the crop year is October through December.

Symbols are classified as exogenous, endogenous, or both exogenous and endogenous. The value of exogenous variables or parameters are determined outside of the model and taken as given. The values of endogenous variables are determined by the model. Variables are classified as both exogenous and endogenous if they are predetermined for one time period or one step of the model and then become endogenously determined thereafter. Sets of parameters and variables are identified as exogenous, endogenous, or both exogenous and endogenous by (ex), (en), or (ex and en) at the point of each definition.

The following symbols denote the predetermined location of final destinations, country elevators, and existing subterminals for any one district in Iowa. Potential sites for additional subterminals and alternate rail line networks in a district are also identified. Various combinations of rail line networks and subterminal numbers and locations form the spatial structure of alternate grain distribution systems within a district. Let

ϵ = element of.

M_j = location of the j^{th} final destination; $j = 1, 2, \ldots, J$; (ex).

$L1_h$ = location of the h^{th} country elevator; $h = 1, 2, \ldots, H$; (ex).

$L2_i$ = location of the i^{th} plant site for a subterminal; $i = 1, 2, \ldots, I$; (ex).

r_d = r^{th} rail line network designating the order and number of intensive study lines theoretically abandoned in district d and maps on a one-to-one basis with the r^{th} intensive study line or segment of line in the district; $r_d = 1, 2, \ldots, R_d$; (ex).

λ_{kn}/r_d = alternative locational patterns for subterminals, given the r^{th} rail line network where k denotes the k^{th} set of locational patterns for n subterminal sites, $n \leq I$; and $k = 1, 2, \ldots, K_n$; (ex).
$K_n = I!/n!(I-n)!$

For example, if r_d denotes a rail line network that permits subterminals to be established at 25 subterminal sites, then λ_{11}/r_d denotes the location of one subterminal, given r_d. The subterminal may be located at one of 25 possible sites, and $k = 1$ denotes the location, e.g., $L2_8$ for the one subterminal. One locational pattern for three plants, given r_d, may be identified by λ_{13}/r_d and includes subterminals located at sites $L2_4$, $L2_6$, and $L2_9$. The term λ_{23}/r_d identifies three plants with a different locational pattern than λ_{13}/r_d.

Country elevators exist at the beginning of the planning horizon. A country elevator may be expanded into a subterminal in which case the plant site of the country elevator is the same as the plant site for the subterminal, e.g., $L1_8 = L2$. Whenever $i \epsilon \lambda_{kn/r_d}$ and $L1_i = L2_i$, the range of country elevators (h = 1, 2, ..., H) excludes $L1_8$. Thus, $h \epsilon \lambda_{kn/r_d}$ and $i \epsilon \lambda_{kn/r_d}$ denote country elevators and subterminals included in the grain distribution system of λ_{kn/r_d}.

The following symbols denote the flow of grain from origin to final destination over time and space for a district. The quarterly supply of grain from each farm origin is predetermined. The flow, or temporal and spatial routing, of grain from origin to final destination is determined endogenously by the model.

All symbols representing the flow of grain, per unit transportation costs, and prices use the following general format: variable or parameter indices are placed within parentheses; the first index denotes commodities; the second index is a time parameter denoting various quarters of the marketing year and is followed by a semicolon; the third index represents origins; the fourth and fifth indices represents country elevators and subterminal elevators, respectively; and the last index represents final destinations.

X(zt;g...) = predetermined supply of commodity z at origin g in time t; (ex).
g = 1, 2, ..., G; t = 1, 2, 3, 4; and
z = (1) corn, (2) soybeans.

X(zt;....) = $\sum_g$X(zt;g...); predetermined supply of commodity z from all origins within the district in time t; (ex).

X(z.;....) = $\sum_t$X(zt;....); predetermined 1980 supply of commodity z from all origins within the district; (ex).

SR(zt) = predetermined proportion of the 1980 supply of commodity z shipped from the district to destinations in time t; (ex).

$XS(zt) = X(z.;....)\ SR(zt)$; predetermined quantity of commodity z shipped from the district to destinations in time t; (ex).

$X(zt;gh..)$ = quantity of commodity z shipped from origin g in time t to the country elevator located at $L1_h$; (en).
$X(zt;gh..) \geq 0$.

$X(zt;.h..) = \sum_g X(zt;gh..)$; quantity of z shipped from all origins in time t to the country elevator located at $L1_h$; (en).

$X(zt;g.i.)$ = quantity of z shipped from origin g in time t to the subterminal elevator located at $L2_i$; (en).
$X(zt;g.i.) \geq 0$.

$X(zt;.hi.)$ = quantity of z shipped in time t from the country elevator located at $L1_h$ to the subterminal located at $L2_i$; (en).
$X(zt;.hi.) \geq 0$.

$X(zt;..i.) = \sum_g X(zt;g.i.) + \sum_h X(zt;.hi.)$; quantity of z shipped in time t from all origins and all country elevators to the subterminal elevator located at $L2_i$; (en).

$X(zt;.h.j)$ = quantity of z shipped in time t from the country elevator located at $L1_h$ to destination M_j; (en).
$X(zt;.h.j) \geq 0$.

$X(zt;..ij)$ = quantity of z shipped in time t from the subterminal elevator located at $L2_i$ to destination M_j; (en).
$X(zt;..ij) \geq 0$.

$X(zt;...j) = \sum_h X(zt;.h.j) + \sum_i X(zt;..ij)$; quantity of z shipped in time t from all country elevators and subterminal elevators to destination M_j; (en and ex).

$X(zt;gh.j)$ = quantity of z shipped in time t from origin g to the country elevator located at $L1_h$ to destination M_j; (en).

$X(zt;g.ij)$ = quantity of z shipped in time t from origin g to the subterminal elevator located at $L2_i$ to destination M_j; (en).

$X(zt;ghij)$ = quantity of z shipped in time t from origin g to the country elevator located at $L1_h$ to the subterminal elevator located at $L2_i$ to destination M_j; (en).

$C(zt;gh..)$ = per unit cost for transporting commodity z in time t from origin g to the country elevator located at $L1_h$; (ex).

$C(zt;g.i.)$ = per unit cost for transporting commodity z in time t from origin g to the subterminal elevator located at $L2_i$; (ex).

$C(zt;.hi.)$ = per unit cost for transporting commodity z in time t from the country elevator located at $L1_h$ to the subterminal elevator located at $L2_i$; (ex).

$C(zt;.h.j)$ = per unit cost for transporting commodity z in time t from the country elevator located at $L1_h$ to destination M_j; (ex).

$C(zt;..ij)$ = per unit cost for transporting commodity z in time t from the subterminal elevator located at $L2_i$ to destination M_j; (ex).

$$C(zt;gh.j) = C(zt;gh..) + C(zt;.h.j)$$

$$C(zt;g.ij) = C(zt;g.i.) + C(zt;..ij)$$

$$C(zt;ghij) = C(zt;gh..) + C(zt;.hi.) + C(zt;..ij)$$

$\beta R(zt;h..)$ = marginal operating and maintenance cost of receiving and drying commodity z in time t at the country elevator located at $L1_h$; (ex).

$\beta R(zt;.i.)$ = marginal operating and maintenance cost of receiving and drying commodity z in time t at the subterminal elevator located at $L2_i$; (ex).

$\beta L(z.;hi.)$ = marginal operating and maintenance cost of loading out commodity z at the country elevator located at $L1_h$ for shipment to the subterminal elevator located at $L2_i$; (ex).

$\beta L(z.;h.j)$ = marginal operating and maintenance cost of loading out commodity z at the country elevator located at $L1_h$ for shipment to destination M_j; (ex).

$\beta L(z.;.ij)$ = marginal operating and maintenance cost of loading out commodity z at the subterminal elevator located at $L2_i$ for shipment to destination M_j; (ex).

$\beta S(z)$ = average marginal operating and maintenance cost of storing commodity z for one time period (quarter) at country elevators and subterminal elevators; (ex).

$\alpha(i)$ = minimum annual average cost of establishing a subterminal elevator located at $L2_i$; (ex).

$P(zt;...j)$ = price per unit of commodity z in time t at destination M_j; (ex).

$XK(zt;h.)$ = quantity of commodity z in storage at the country elevator located at $L1_h$ in the beginning of quarter t; (ex and en).

$XK(zt;.i)$ = quantity of commodity z in storage at the subterminal elevator located at $L2_i$ in the beginning of quarter t; (ex and en).

$XK(zt;..) = \sum_h XK(zt;h.) + \sum_i XK(zt;.i)$; quantity of commodity z in storage at country elevators and subterminal elevators in the beginning of quarter t; (ex and en).

XIPK(zt) = predetermined quantity of commodity z in time t needed to meet the demand of Iowa processors of commodity z from the district; (ex).

Method of solution

The model is used to maximize net revenue to grain producers within a district under various rail line networks. Net revenue is the income received at final destination minus all handling costs and all transportation costs from farm to final destination. The model determines n, the number of subterminals; λ_{kn/r_d}, the locational pattern of subterminals, given the rail line network; and X(zt;ghij), the flow of grain from origins to final destinations; such that the following is maximized:

$$\begin{aligned}
GRNC_{r_d} = \sum_z \sum_t \Big\langle & \Big[P(zt;\ldots j)\ X(z.;\ldots.)\ SR(zt)\Big] \\
& - \Big[\sum_g \sum_h C(zt;gh..)\ X(zt;gh..) + \sum_g \sum_{i\epsilon\lambda_{kn/r_d}} C(zt;g.i.)\ X(zt;g.i.) \\
& + \sum_h \sum_{i\epsilon\lambda_{kn/r_d}} C(zt;.hi.)\ X(zt;.hi.) + \sum_h \sum_j C(zt;.h.j)\ X(zt;.h.j) \\
& + \sum_{i\epsilon\lambda_{kn/r_d}} \sum_j C(zt;..ij)\ X(zt;..ij)\Big] \\
& - \Big[\sum_h \beta R(zt;h..)\ X(zt;.h..) + \sum_{i\epsilon\lambda_{kn/r_d}} \beta R(zt;.i.)\ X(zt;..i.) \\
& + \sum_h \sum_{i\epsilon\lambda_{kn/r_d}} \beta L(zt;hi.)\ X(zt;.hi.) + \sum_h \sum_j \beta L(zt;h.j)\ X(zt;.h.j) \\
& + \sum_{i\epsilon\lambda_{kn/r_d}} \sum_j \beta L(zt;.ij)\ X(zt;..ij) \\
& + t\beta S(z) \Big\{\sum_h XK(zt;h.) + \sum_{i\epsilon\lambda_{kn/r_d}} XK(zt;.i)\Big\}\Big]\Big\rangle \\
& - \sum_{i\epsilon\lambda_{kn/r_d}} \alpha(i)
\end{aligned}$$

where

$GRNC_{r_d}$ = total grain revenue from the sale of the projected 1980 volume of grain in district d, net of all transportation costs from farm to market, variable nonfarm storage and handling, and annual facility investment costs under the r_d rail line network in district d.

$\sum_z \sum_t P(zt;...j)\ X(z.;....)\ SR(zt)$ = total value of the projected 1980 volume of grain in district d at final destination.

$$\sum_z \sum_t \Big[\sum_g \sum_h C(zt;gh..)\ X(zt;gh..) + \sum_g \sum_{i \epsilon \lambda_{kn}/r_d} C(zt;g.i.)\ X(zt;g.i.)$$
$$+ \sum_h \sum_{i \epsilon \lambda_{kn}/r_d} C(zt;.hi.)\ X(zt;.hi.) + \sum_h \sum_j C(zt;.h.j)\ X(zt;.h.j)$$
$$+ \sum_{i \epsilon \lambda_{kn}/r_d} \sum_j C(zt;..ij)\ X(zt;..ij) \Big]$$
= total transportation cost of shipping the projected 1980 volume of grain in district d to final destinations.

$$\sum_z \sum_t \Big[\sum_h \beta R(zt;h..)\ X(zt;.h..) + \sum_{i \epsilon \lambda_{kn}/r_d} \beta R(zt;.i.)\ X(zt;..i.)$$
$$+ \sum_h \sum_{i \epsilon \lambda_{kn}/r_d} \beta L(zt;hi.)\ X(zt;.hi.) + \sum_h \sum_j \beta L(zt;h.j)\ X(zt;.h.j)$$
$$+ \sum_{i \epsilon \lambda_{kn}/r_d} \sum_j \beta L(zt;.ij)\ X(zt;..ij) + t\beta S(z) \Big\{ \sum_h XK(zt;h.)$$
$$+ \sum_{i \epsilon \lambda_{kn}/r_d} XK(zt;.i) \Big\} \Big]$$
= total variable processing cost of processing the projected 1980 volume of grain in district d at country elevators and subterminal elevators.

$\sum_{i \epsilon \lambda_{kn}/r_d} \alpha(i)$ = total annual investment costs in subterminal elevators in district d.

The procedure used to determine the maximum total net revenue to producers from the sale of the projected 1980 volume of grain in district d for a given rail line network, $\overline{GRNC}_{r_d}$, is divided into three steps. Step I selects the minimum-cost routing of each grain from origins to existing country elevators and subterminals in the district such that existing storage facilities are used to their capacity during the harvest quarter. Step II selects that routing of each grain from origin to final destination which maximizes the revenue to grain producers net of variable transportation and handling costs, given any locational pattern of subterminals and a given rail line network in the district. Step III selects that number and locational pattern of subterminals which maximizes the net revenue to grain producers for a given rail line network in the district.

Step I

This analysis assumes that storage facilities existing at the beginning of the planning horizon, January 1, 1975, will be used to capacity during the harvest quarter before any elevator will expand. This assumption takes into account (1) the "sunk" costs of prior investments as compared to the actual costs of expansion and (2) marketing rigidities from producers preferring to patronize local elevators.

A linear programming model is used in this analysis to minimize the transportation costs incurred in filling the storage facilities of existing elevators in the beginning of the harvest quarter. The objective function of the model is to minimize

$$TCFE_z = \sum_g \sum_h C(z1;gh..)\ X1(z1;gh..)$$

subject to

$$\sum_g X1(z1;gh..) = XK(z1;h.) \qquad h = 1, 2, ..., H$$

$$\sum_h X1(z1;gh..) \le X(z1;g...) \qquad g = 1, 2, ..., G$$

$$\text{all } X1(z1;gh..) \ge 0$$

where

$TCFE_z$ = minimum transportation cost of filling the available storage capacity of commodity z at country elevators in the district in the beginning of the harvest quarter.

X(zl;g...) = predetermined quantity of commodity z available at origin g in time 1.

XK(zl;h.) = predetermined quantity of commodity z needed to fill the available storage capacity of commodity z at the country elevator located at Ll_h in the beginning of the harvest quarter.

Xl(zl;gh..) = quantity of commodity z shipped from origin g to the country elevator located at Ll_h in time 1 in Step I of the model.

C(zl;gh..) = per unit cost of transporting commodity z from origin g to the country elevator located at Ll_h in time 1.

Step II

Step II selects the routing of each grain from origins to final destinations which maximizes the revenue to grain producers net of variable transportation and handling costs, given a locational pattern of subterminals and the rail line network, $\overline{GRNVC}|\lambda_{kn}/r_d$. To determine the maximum revenue routing for commodity z at origin g in time t (after existing storage capacity at country elevators is filled in the beginning of the harvest quarter), given a set of subterminals and rail lines, the following is computed:

$$P(zt;..ij) = \left[P(zt;...j) - C(zt;..ij) - \beta L(zt;.ij) - \beta R(zt;.i.)\right]$$

$$P(zt;..i.) = \max_j P(zt;..ij)$$

$$P(zt;.h.j) = \max_j \left[P(zt;...j) - C(zt;.h.j) - \beta L(zt;h.j) - \beta R(zt;h..)\right]$$

$$P(zt;.hij) = \max_i \left\{ \max_j \left[P(zt;...j) - C(zt;..ij) - \beta L(zt;.ij)\right] - \beta R(zt;.i.) - C(zt;.hi.) - \beta L(zt;hi.) - \beta R(zt;h..)\right\}$$

$$P(zt;.h..) = \max \left[P(zt;.h.j),\ P(zt;.hij)\right]$$

$$P(zt;ghij) = \max_h \left\langle \max_i \left\{ \max_j \left[P(zt;...j) - C(zt;..ij) - \beta L(zt;.ij)\right] - \beta R(zt;.i.) - C(zt;.hi.) - \beta L(zt;hi.)\right\} - \beta R(zt;h..) - C(zt;gh..)\right\rangle$$

$$P(zt;gh.j) = \max_h \left\{ \max_j \left[P(zt;...j) - C(zt;.h.j) - \beta L(zt;h.j)\right] - \beta R(zt;h..) - C(zt;gh..)\right\}$$

$$P(zt;g.ij) = \max_i \left\{ \max_j \left[P(zt;...j) - C(zt;..ij) - \beta L(zt;.ij)\right] - \beta R(zt;.i.) - C(zt;g.i.)\right\}.$$

And

$$P(zt;g...) = \max \left[P(zt;ghij),\ P(zt;gh.j),\ P(zt;g.ij)\right]$$

determines the routing of commodity z in time t from origin g to final destination which maximizes GRNVC in time t for the g^{th} origin, given a set of subterminal locations and rail lines in a district. Therefore, the maximum revenue in time t, net of variable transportation and handling costs for all origins in a district, given a set of subterminal locations and rail lines, is expressed as follows:

$$
\overline{\mathrm{GRNVC}}_t \,\big|\, \lambda_{kn/r_d} = \left[\begin{array}{l}
\sum_z \Big\langle \sum_g P(zt;g...)\ X(zt;g...) + \Big[\sum_h P(zt;.h..)\ XK(zt;h.) \\
\quad + \sum_{i \epsilon \lambda_{kn/r_d}} P(zt;..i.)\ XK(zt;.i) \Big] \left[\dfrac{XS(zt) - X(zt;....)}{XK(zt;..)} \right] \\
\quad - t\beta S(z)\ XK(zt;..) - FE(z) \Big\rangle \\
\text{if } X(zt;....) \le XS(zt) \\
\text{or} \\
\sum_z \Big\langle \sum_g \Big\{ P(zt;g...)\ X(zt;g...) \left[\dfrac{XS(zt)}{X(zt;....)} \right] \\
\quad - \Big[\sum_h C(zt;gh..)\ X(zt;gh..) \\
\quad + \sum_{i \epsilon \lambda_{kn/r_d}} C(zt;g.i.)\ X(zt;g.i.) \Big] \left[1 - \dfrac{XS(zt)}{X(zt;....)} \right] \Big\} \\
\quad - t\beta S(z)\ XK(zt;..) - FE(z) \Big\rangle \\
\text{if } X(zt;....) > XS(zt)
\end{array} \right.
$$

where

$$
X(zt;g...) = \left[\begin{array}{l}
X(z1;g...) - X1(z1;g...) \quad \text{if } t = 1 \\
\text{or} \\
X(zt;g...) \quad \text{otherwise}
\end{array} \right.
$$

$$
FE(z) = \left[\begin{array}{l}
TCFE_z \quad \text{if } t = 1 \\
\text{or} \\
0 \quad \text{otherwise}
\end{array} \right.
$$

$$
XK(zt+1;h.) = \left[\begin{array}{l}
XK(zt;h.) - \left\{ XK(zt;h.) \left[\dfrac{XS(zt) - X(zt;....)}{XK(zt;..)} \right] \right\} \\
\text{if } X(zt;....) \le XS(zt) \\
\text{or} \\
XK(zt;h.) + \left\{ \sum_g X(zt;gh..) \left[1 - \dfrac{XS(zt)}{X(zt;....)} \right] \right\} \\
\text{if } X(zt;....) > XS(zt)
\end{array} \right.
$$

$$XK(zt+1;.i) = \begin{cases} XK(zt;.i) - \left\{ XK(zt;.i) \left[\dfrac{XS(zt) - X(zt;....)}{XK(zt;..)} \right] \right\} \\ \text{if } X(zt;....) \leq XS(zt) \\ \text{or} \\ XK(zt;.i) + \left\{ \sum_g X(zt;g.i.) \left[1 - \dfrac{XS(zt)}{X(zt;....)} \right] \right\} \\ \text{if } X(zt;....) > XS(zt) \text{ .} \end{cases}$$

If the quantity of commodity z shipped in time t from all country elevators and subterminal elevators to Iowa processors is either less than 90 percent or greater than 100 percent of their projected 1980 processing demand from the district in time t, rerouting of commodity z in time t is required. The optimal rerouting of commodity z from one final destination to another final destination in time t is defined as the spatial rerouting alternative that minimizes the change in the maximum net price for commodity z at origins, country elevators, and subterminal elevators.

Two subsets of all the final destinations, J, in the district are defined: J1, the set of all Iowa processors demanding commodity z from the district, j = 1, 2, ..., J1; and J2, the set of all final destinations excluding Iowa processors, j = J1 + 1, J1 + 2, ..., J. Thus, the set of all final destinations is denoted by j = 1, 2, ..., J1, J1 + 1, J1 + 2, ..., J. Denote the minimum change in the maximum prices at origins, country elevators, and subterminal elevators from rerouting commodity z in time t from one final destination to another final destination by the following:

$$\Delta P(zt;g...) = \begin{cases} P(zt;g...) - \max\limits_{j \in J1} \left[P(zt;ghij),\ P(zt;gh.j),\ P(zt;g.ij) \right] \\ \text{if } \sum\limits_{j \in J1} X(zt;...j) < 0.9XIPK(zt) \\ \text{or} \\ P(zt;g...) - \max\limits_{j \in J2} \left[P(zt;ghij),\ P(zt;gh.j),\ P(zt;g.ij) \right] \\ \text{if } \sum\limits_{j \in J1} X(zt;...j) > XIPK(zt) \end{cases}$$

$$\Delta P(zt;.h..) = \begin{cases} P(zt.h..) - \max\limits_{j\epsilon J1}\left[P(zt;.h.j),\ P(zt;.hij)\right] \\ \text{if } \sum\limits_{j\epsilon J1} X(zt;...j) < 0.9XIPK(zt) \\ \text{or} \\ P(zt;.h..) - \max\limits_{j\epsilon J2}\left[P(zt;.h.j),\ P(zt;.hij)\right] \\ \text{if } \sum\limits_{j\epsilon J1} X(zt;...j) > XIPK(zt) \end{cases}$$

$$\Delta P(zt;..i.) = \begin{cases} P(zt;..i.) - \max\limits_{j\epsilon J1} P(zt;..ij) \\ \text{if } \sum\limits_{j\epsilon J1} X(zt;...j) < 0.9XIPK(zt) \\ \text{or} \\ P(zt;..i.) - \max\limits_{j\epsilon J2} P(zt;..ij) \\ \text{if } \sum\limits_{j\epsilon J1} X(zt;...j) > XIPK(zt)\ . \end{cases}$$

The optimal rerouting of commodity z in time t from one final destination to another final destination is defined as follows:

$$\min\left[\min_{g} \Delta P(zt;g...),\ \min_{h} \Delta P(zt;.h..),\ \min_{i\epsilon\lambda_{kn}/r_d} \Delta P(zt;..i.)\right]\ .$$

Rerouting of commodity z originating at origins, country elevators, and subterminal elevators, based on this rerouting definition, occurs until either the excess or negative excess demand at Iowa processors is removed. The reduction in net revenue resulting from the rerouting of grain is accounted for in the change in the maximum net price for commodity z at origins, country elevators, and subterminal elevators. Therefore, the maximum revenue to grain producers net of variable transportation and handling costs, given a locational pattern of subterminals and the rail line network, is expressed as:

$$\overline{GRNVC}|\lambda_{kn}/r_d = \sum_{t} \overline{GRNVC}_t|\lambda_{kn}/r_d\ .$$

Step III

Maximum total grain revenue from the sale of the projected 1980 volume of grain in district d, net of all transportation costs, variable storage and handling costs, and annual facility investment costs, given the r_d rail line network in district d, $\overline{GRNC}_{r_d}$, is found by systematically comparing $GRNC_{r_d}$ for each combination of λ_{kn}/r_d and selecting that combination for which $GRNC_{r_d}$ is maximized. This procedure may be expressed as follows:

$$\overline{GRNC}_{r_d} = \max_n \max_k \left[\overline{GRNVC} | \lambda_{kn/r_d} - \sum_{i \epsilon \lambda_{kn/r_d}} \alpha(i) \right] .$$

Fertilizer Model

The benefits to fertilizer receivers within a district under alternate combinations of branch rail line abandonment are estimated in essentially the same manner as for grain shippers. A modified Stollsteimer transshipment model is used to minimize the cost of transporting the projected 1980 dry fertilizer requirements of retail fertilizer dealers in a district from the sources of supply to the existing retail locations under various rail line networks. The model determines the optimal number and location of fixed conveyor facilities for transshipping fertilizer and the optimal flows of dry fertilizer under the following assumptions:

1. The demand for fertilizer at each location is fixed and known.
2. There is an infinite supply of fertilizer at specific supply locations. Phosphorous supplies are located in Florida. Potash originates in Saskatoon, Saskatchewan, Canada. Urea is manufactured or imported at Donaldsonville, Louisiana. Ammonium nitrate can originate in Clinton, Iowa or Beatrice, Nebraska.
3. Fertilizer can be moved from Florida and Louisiana to warehouses and retail locations by rail, rail-truck,

rail-barge-rail, or rail-barge-truck or from Houston, Texas by rail or rail-truck. Potash and ammonium nitrate can be transported to warehouses or retail locations only by rail, truck, or rail-truck. Retailers located on an abandoned line can obtain fertilizer by truck from a warehouse or directly from a rail car at a nearby rail line by transferring the fertilizer into a truck through a conveyor.

4. Potential sites for conveyor facilities include all retail fertilizer locations having at least 900 feet of rail siding.
5. All existing fertilizer warehouses are available for use. No new warehouses will be built at sites other than at existing warehouse locations.

Definition of symbols

The following symbols define variables for a given district and, as in the grain model, are classified as exogenous (ex) or endogenous (en):

z = index of dry fertilizer commodities demanded at retail locations; (1) phosphate, (2) potash, (3) urea, and (4) ammonium nitrate.

S_{zj} = j^{th} source of commodity z.

W_i = warehouse i.

L_h = fertilizer conveyor facility site h.

D_g = retail fertilizer location g.

r_d = r^{th} rail line network designating the order and number of intensive study lines theoretically abandoned in district d and maps on a one-to-one basis with the r^{th} intensive study line or segment of line in the district; $r_d = 1, 2, \ldots, R_d$; (ex).

λ_{kn/r_d} = alternative locational patterns for fertilizer conveyor facilities, given the r^{th} rail line network where k denotes the k^{th} set of locational patterns for n conveyor sites, $n \leq H$; and k = 1, 2, ..., K_n; (ex).

$K_n = H!/n!(H-n)!$

$X(z;g...)$ = predetermined quantity of commodity z demanded at retailer D_g; g = 1, 2, ..., G; (ex).

$X(z;.h..)$ = quantity of commodity z transshipped through a fixed conveyor facility located at L_h; h = 1, 2, ..., H; (en).

$X(z;.h..) \geq 0$.

$X(z;..i.)$ = quantity of commodity z transshipped through warehouse W_i; i = 1, 2, ..., I; (en).

$X(z;..i.) \geq 0$.

$X(z;...j)$ = quantity of commodity z shipped from source S_{zj}; j = 1, 2, ..., J; (en).

$X(z;...j) \geq 0$.

$X(z;gh..)$ = quantity of commodity z shipped from L_h to D_g; (en).

$X(z;g.i.)$ = quantity of commodity z shipped from W_i to D_g; (en).

$X(z;g..j)$ = quantity of commodity z shipped from S_{zj} to D_g: (en).

$X(z;.hi.)$ = quantity of commodity z shipped from W_i to L_h; (en).

$X(z;.h.j)$ = quantity of commodity z shipped from S_{zj} to L_h; (en).

$X(z;..ij)$ = quantity of commodity z shipped from S_{zj} to W_i; (en).

$X(z;ghi.)$ = quantity of commodity z shipped from W_i to L_h to D_g; (en).

$X(z;g.ij)$ = quantity of commodity z shipped from S_{zj} to W_i to D_g; (en).

$X(z;.hij)$ = quantity of commodity z shipped from S_{zj} to W_i to L_h; (en).

$X(z;ghij)$ = quantity of commodity z shipped from S_{zj} to W_i to L_h to D_g; (en).

$C(z;gh..)$ = per unit cost for transporting commodity z from L_h to D_g; (ex).

$C(z;g.i.)$ = per unit cost for transporting commodity z from W_i to D_g; (ex).

$C(z;g..j)$ = per unit cost for transporting commodity z from S_{zj} to D_g; (ex).

$C(z;.hi.)$ = per unit cost for transporting commodity z from W_i to L_h; (ex).

$C(z;.h.j)$ = per unit cost for transporting commodity z from S_{zj} to L_h; (ex).

$C(z;..ij)$ = per unit cost for transporting commodity z from S_{zj} to W_i; (ex).

$C(z;gh.j) = C(z;gh..) + C(z;.h.j)$

$C(z;g.ij) = C(z;g.i.) + C(z;..ij)$

$C(z;ghij) = C(z;gh..) + C(z;.hi.) + C(z;..ij)$

$\beta(h.)$ = marginal operating and maintenance cost of a fertilizer conveyor facility h; (ex).

$\beta(.i)$ = marginal operating and maintenance cost of warehouse W_i; (ex).

α = minimum annual average cost to establish a fertilizer conveyor facility; (ex).

Method of solution

The model is used to minimize the cost of transporting the projected 1980 retail dry fertilizer requirement in a district from sources of supply to the existing retail locations under a given rail line network, r_d. The model determines n, λ_{kn/r_d}, and X(z;ghij), the flow of fertilizer from the sources of fertilizer to retail locations; such that the following is minimized:

$$FC_{r_d} = \sum_z \sum_g \sum_j \Big\langle C(z;g..j)\ X(z;g..j) + \sum_{h\epsilon\lambda_{kn/r_d}} \Big[C(z;gh.j) + \beta(h.)\Big]\ X(z;gh.j) + \sum_i \Big[C(z;g.ij) + \beta(.i)\Big]\ X(z;g.ij) + \sum_{h\epsilon\lambda_{kn/r_d}} \sum_i \Big[C(z;ghij) + \beta(h.) + \beta(.i)\Big]\ X(z;ghij)\Big\rangle + \alpha n$$

where

FC_{r_d} = total fertilizer transportation and handling costs for transporting the projected 1980 retail fertilizer requirement in district d from the sources of fertilizer supplies to retail locations under the r_d^{th} rail line network in district d.

$\sum_z \sum_g \sum_j C(z;g..j)\ X(z;g..j)$ = total transportation cost for shipping dry fertilizer directly from the sources of supply to retail locations.

$\sum_z \sum_g \sum_{h\epsilon\lambda_{kn/r_d}} \sum_j \Big[C(z;gh.j) + \beta(h.)\Big]\ X(z;gh.j)$ = total transportation and variable handling cost for shipping dry fertilizer from sources of supply through conveyor facilities to retail locations.

$\sum_z \sum_g \sum_i \sum_j \Big[C(z;g.ij) + \beta(.i)\Big]\ X(z;g.ij)$ = total transportation and variable handling cost for shipping dry fertilizer from sources of supply through warehouses to retail locations.

$$\sum_z \sum_g \sum_{h \epsilon \lambda_{kn}/r_d} \sum_i \sum_j \Big[C(z;ghij) + \beta(h.) + \beta(.i) \Big] X(z;ghij)$$ = total transportation and variable handling cost for shipping dry fertilizer from sources of supply through warehouses and conveyor facilities to retail locations.

αn = total annual investment cost in fertilizer conveyor facilities.

The procedure used to determine the minimum total fertilizer transportation and handling cost for a given rail line network, $\overline{FC}_{r_d}$, is divided into two steps. The first step selects the shipping patterns for each fertilizer retail location which provide the minimum transportation and variable handling costs, given a locational pattern of fertilizer conveyor facilities and the rail line network, $\overline{FCNVC}|\lambda_{kn}/r_d$. The second step selects the number and locational pattern of fixed conveyor facilities which minimizes total transportation and handling costs for retail locations for the given rail line network.

To determine the minimum-cost routing for commodity z at retail location g, given a set of fixed conveyor facilities and rail lines, the following is computed:

$$CH(z;ghij) = \min_h \Big\langle \min_i \Big\{ \Big[\min_j C(z;..ij)\Big] + C(z;.hi.) + \beta(.i)\Big\} + C(z;gh..) + \beta(h.) \Big\rangle$$

$$CH(z;gh.j) = \min_h \Big\{ \Big[\min_j C(z;.h.j)\Big] + C(z;gh..) + \beta(h.)\Big\}$$

$$CH(z;g.ij) = \min_i \Big\{ \Big[\min_j C(z;..ij)\Big] + C(z;g.i.) + \beta(.i)\Big\}$$

$$CH(z;g..j) = \min_j C(z;g..j) .$$

And

$$CH(z;g...) = \min \Big[CH(z;ghij),\ CH(z;gh.j),\ CH(z;g.ij),\ CH(z;g..j)\Big]$$

determines the routing of commodity z from sources of supply to the g^{th} retail location to minimize FCNVC for the g^{th} retail location, given a set of fertilizer conveyor facilities and rail lines in a district. Therefore, the minimum transportation and variable handling costs for all retailers in a district, given a set of conveyor facilities and rail lines, is expressed as follows:

$$\overline{FCNVC}|\lambda_{kn/r_d} = \sum_z \sum_g CH(z;g...)\ X(z;g...)\ .$$

Minimum total transportation and handling cost, $\overline{FC}_{r_d}$, is found by systematically comparing FC_{r_d} for each combination of λ_{kn/r_d} and selecting that combination for which FC_{r_d} is minimized:

$$\overline{FC}_{r_d} = \min_n \left\{ \left[\min_k \overline{FCNVC}|\lambda_{kn/r_d}\right] + \alpha n \right\} .$$

Other Products Model

Within a district, the benefits to "shippers" and "receivers" of all products other than grain and fertilizer--stratified into "commodity groups"--are estimated under alternative patterns of simulated intensive study line abandonment. The other products model is based upon the following assumptions:

1. The number and location of other product shippers and receivers located on intensive study lines is given.
2. The "origin" of each commodity group shipped by rail to each receiver located on an intensive study line is the same under abandonment of the receiver's rail line as before abandonment.
3. The final "destination" of each commodity group shipped by rail from each shipper located on an intensive study line is the same under abandonment of the shipper's rail line as before abandonment.
4. The projected 1980 quantity of each commodity group shipped by rail to and from each receiver and each

shipper located on intensive study lines is known.

5. Other products can be moved by truck to receivers and from shippers located on abandoned intensive study lines.
6. The projected 1980 quantity of inbound products to receivers on abandoned lines moves by rail from each origin to the nearest location with rail service, relative to highway distance; at this location, the product is unloaded from the rail car, loaded onto a truck, and moved to the receiver.
7. The rate at which each commodity group is shipped by rail from each origin to the location with rail service nearest to the abandoned receiver is equal to the rate at which each commodity group is shipped by rail from each origin to the receiver, if his rail line is upgraded.
8. The projected 1980 quantity of outbound products from each shipper on an abandoned line moves by truck to the nearest location with rail service, relative to highway distance; at this location, the product is unloaded from the truck, loaded onto a rail car, and moved to the final destination.
9. The rate at which each commodity group is shipped by rail from the location with rail service nearest to the abandoned shipper is equal to the rate at which each commodity group is shipped by rail from each shipper to the final destination, if his rail line is upgraded.

The model determines the optimal flow of each commodity group under alternative patterns of rail line abandonment by minimizing the cost of transporting the projected 1980 quantity of receipts and shipments.

Definition of symbols

The following symbols define variables and notation; as in the grain and fertilizer models, variables are classified as exogenous (ex), endogenous (en), or both (ex and en) at the point of definition:

z = index of commodity groups; (1) marine products, (2) metallic ores, (3) coal, (4) crude petroleum, (5) nonmetallic minerals, (6) food products, (7) tobacco products, (8) textile mill products, (9) apparel, (10) lumber or wood products, (11) furniture, (12) paper products, (13) printed matter, (14) chemicals, (15) petroleum products, (16) rubber products, (17) leather products, (18) stone products, (19) primary metal products, (20) fabricated metal products, (21) machinery, (22) electrical machinery, (23) transportation equipment, (24) photographic goods, (25) miscellaneous products, (26) scrap materials, (27) miscellaneous freight shipments, (28) containers, (29) mail, (30) freight forwarder traffic, (31) shipper association traffic, (32) miscellaneous mixed shipments, (33) small packaged freight shipments.

R_{zg_1} = the g_1^{th} receiver of commodity group z; $g_1 = 1, 2, \ldots, G_1$.

S_{zg_2} = the g_2^{th} shipper of commodity group z; $g_2 = 1, 2, \ldots, G_2$.

r_d = the r^{th} rail line network designating the order and number of intensive study lines theoretically abandoned in district d; maps on a one-to-one basis with the r^{th} intensive study line or segment of line in the district; $r_d = 1, 2, \ldots, R_d$; (ex).

$XR(z;g_1 \cdot \cdot)$ = the quantity of commodity group z demanded by receiver R_{zg_1}; (ex).

$XR(z;\cdot h_1 \cdot)$ = the quantity of commodity group z transshipped through the h_1^{th} rail location; (en).

$XR(z;\cdot \cdot i_1)$ = the quantity of commodity group z shipped from the i_1^{th} origin; $i_1 = 1, 2, \ldots, I_1$; (ex).

$XR(z;g_1 h_1 \cdot)$ = the quantity of commodity group z shipped from the h_1^{th} rail location to the g_1^{th} receiver; (en).

$XR(z;g_1 \cdot i_1)$ = the quantity of commodity group z shipped from the i_1^{th} origin to the g_1^{th} receiver; (ex).

$XR(z;g_1 h_1 i_1)$ = the quantity of commodity group z shipped from the i_1^{th} origin to the h_1^{th} rail location to the g_1^{th} receiver; (en).

$XR(z;\cdot h_1 i_1)$ = the quantity of commodity group z shipped from the i_1^{th} origin to the h_1^{th} rail location; (en).

$XS(z;g_2 \cdot \cdot)$ = the quantity of commodity group z supplied by shipper S_{zg_2}; (ex).

$XS(z;\cdot h_2 \cdot)$ = the quantity of commodity group z transshipped through the h_2^{th} rail location; (en).

$SX(z;\cdot \cdot i_2)$ = the quantity of commodity group z shipped to the i_2^{th} destination; $i_2 = 1, 2, \ldots, I_2$; (ex).

$XS(z;g_2 h_2 \cdot)$ = the quantity of commodity group z shipped from the g_2^{th} shipper to the h_2^{th} rail location; (en).

$XS(z;g_2 \cdot i_2)$ = the quantity of commodity group z shipped from the g_2^{th} shipper to the i_2^{th} destination; (ex).

$XS(z;g_2 h_2 i_2)$ = the quantity of commodity group z shipped from the g_2^{th} shipper to the h_2^{th} rail location to the i_2^{th} destination; (en).

$XS(z;\cdot h_2 i_2)$ = the quantity of commodity group z shipped from the h_2^{th} rail location to the i_2^{th} destination; (en).

$CR(z;g_1h_1\cdot)$ = the per unit cost of transporting commodity group z from the $h_1{}^{th}$ rail location to the $g_1{}^{th}$ receiver; (ex).

$CR(z;g_1\cdot i_1)$ = the per unit cost of transporting commodity group z from the $i_1{}^{th}$ origin to the $g_1{}^{th}$ receiver; (ex).

$CR(z;g_1h_1i_1)$ = the per unit cost of transporting commodity group z from the $i_1{}^{th}$ origin to the $h_1{}^{th}$ rail location to the $g_1{}^{th}$ receiver; (ex).

$CR(z;\cdot h_1i_1)$ = the per unit cost of transporting commodity group z from the $i_1{}^{th}$ origin to the $h_1{}^{th}$ rail location; (ex).

$CS(z;g_2h_2\cdot)$ = the per unit cost of transporting commodity group z from the $g_2{}^{th}$ shipper to the $h_2{}^{th}$ rail location; (ex).

$CS(z;g_2\cdot i_2)$ = the per unit cost of transporting commodity group z from the $g_2{}^{th}$ shipper to the $i_2{}^{th}$ destination; (ex).

$CS(z;g_2h_2i_2)$ = the per unit cost of transporting commodity group z from the $g_2{}^{th}$ shipper to the $h_2{}^{th}$ rail location to the $i_2{}^{th}$ destination; (ex).

$CS(z;\cdot h_2i_2)$ = the per unit cost of transporting commodity group z from the $h_2{}^{th}$ rail location to the $i_2{}^{th}$ destination; (ex).

$QR_{zh_1^*}|r_d$ = the h_1^{*th} location with rail service, given the r^{th} rail line network in district d; $h_1^* = 1, 2, \ldots, H_1^*$; (ex and en).

$QS_{zh_2^*}|r_d$ = the h_2^{*th} location with rail service, given the r^{th} rail line network in district d; $h_2^* = 1, 2, \ldots, H_2^*$; (ex and en).

$DR(g_1 h_1^*)$ = the highway distance between the h_1^{*th} rail location and the g_1^{th} receiver; (ex).

$DS(g_2 h_2^*)$ = the highway distance between the g_2^{th} shipper and the h_2^{*th} rail location; (ex).

$DR(g_1 h_1)$ = the highway distance between the h_1^{th} rail location and the g_1^{th} receiver; (ex).

$DS(g_2 h_2)$ = the highway distance between the g_2^{th} shipper and the h_2^{th} rail location; (ex).

$QR_{zh_1}|r_d$ = the h_1^{th} rail location, given the r^{th} rail line network in district d such that $DR(g_1 h_1^*)$ is minimum; $h_1 = 1, 2, \ldots, H_1$ maps on a one-to-one basis with index g_1; (ex and en). $\left\{QR_{zh_1}|r_d\right\} \in \left\{QR_{zh_1^*}|r_d\right\}$.

$QS_{zh_2}|r_d$ = the h_2^{th} rail location, given the r^{th} rail line network in district d such that $DS(g_2 h_2^*)$ is minimum; $h_2 = 1, 2, \ldots, H_2$ maps on a one-to-one basis with index g_2; (ex and en). $\left\{QS_{zh_2}|r_d\right\} \in \left\{QS_{zh_2^*}|r_d\right\}$.

$\beta(z;gh)$ = the per unit handling cost of unloading commodity group z from a rail car at the h_1^{th} rail location (after previous shipment from the i_1^{th} origin) and loading it onto a truck (for subsequent shipment to the g_1^{th} receiver); the per unit handling cost of unloading commodity group z from a truck (after previous shipment from the g_2^{th} shipper) and loading it onto a rail car at the h_2^{th} rail location (for subsequent shipment to the i_2^{th} destination); (ex).

$\forall$ = "for all".

$\Longleftrightarrow$ = "is equivalent to".

ϵ = "is a subset of".

$\{ \}$ = "the set of".

Method of solution

The model minimizes the cost of moving the projected 1980 quantity of each commodity group from origins to receivers in a district and from shippers in a district to final destinations.

By assumption 7,

$$CR(z;\cdot h_1 i_1)|r_d = CR(z;g_1 \cdot i_1) \quad \forall r_d;$$

therefore,

$$\min_{h_1} CR(z;g_1 h_1 i_1)|r_d \Longleftrightarrow \min_{h_1} CR(z;g_1 h_1 \cdot)|r_d;$$

by determining

$$DR(g_1 h_1) = \min_{h_1^*} DR(g_1 h_1^*),$$

the model identifies $QR_{zh_1}|r_d$; then, the minimum total transportation and handling cost of moving the projected 1980 quantity of commodity group z from rail locations to receivers in a district is calculated as follows:

$$\overline{OPCR}_{r_d} = \sum_g \left[CR(z;g_1 h_1 \cdot) + \beta(z;gh)\right] XR(z;g_1 h_1 \cdot) \ .$$

Similarily, by assumption 9, the model calculates the minimum total transportation and handling cost of moving the projected 1980 quantity of commodity group z from shippers to rail locations in a district

$$\overline{OPCS}_{r_d} = \sum_g \left[CS(z;g_2 h_2 \cdot) + \beta(z;gh)\right] XS(z;g_2 h_2 \cdot) \ .$$

The minimum total transportation and handling cost of moving the projected 1980 quantity of commodity group z from rail locations to receivers and from shippers to rail locations in a district is, therefore,

$$\overline{OPC}_{r_d} = \overline{OPCR}_{r_d} + \overline{OPCS}_{r_d} \;;$$

this minimum total transportation and handling cost is the estimated cost incurred by receivers and shippers of commodities other than grain and fertilizer by the simulated abandonment of the intensive study line upon which they are located.

Appendix C

CONTRACT BY AND BETWEEN

THE IOWA DEPARTMENT OF TRANSPORTATION

AND

The Agricultural and Home Economics Experiment Station
IOWA STATE UNIVERSITY

ARTICLE 1.0 IDENTIFICATION OF PARTIES, TIME LIMIT OF CONTRACT, AND AMOUNT OF CONTRACT

This Contract is entered into by and between the Iowa Department of Transportation (hereafter referred to as DOT) and Iowa State University (hereafter referred to as ISU). The contract shall be in force from December 1, 1976 to April 30, 1977. The contract amount is $ 150,000.

ARTICLE 2.0 STATEMENT OF PURPOSE

Whereas, the DOT has been designated as the (Designated State Agency) which has the authority to establish a statewide plan for rail service, and

Whereas, Title VIII of the Railroad Revitalization and Regulatory Reform Act of 1976 Public Law 94-210 and subsequent Federal Regulations (49 CFR PART 266) requires the DOT as the (Designated State Agency) to develop a State Rail Plan in order to be eligible for financial assistance for rail service under Section 5 of the U.S. Dept. of Transportation Act.

Whereas, the DOT will subcontract with ISU for services as research staff and other allowable costs,

Now therefore, the parties hereto do agree to the following special and general conditions:

ARTICLE 3.0 JUSTIFICATION OF ISU

3.1 ISU is the only qualified organization at this time to perform the economic computer analysis to be used in development of the State Rail Plan because:

3.11 The initial research and the economic methodology was developed by ISU under previous contract with FRA and DOT (Report FRA-OPPD-76-3)

3.12 The economic computer analysis will be performed by members of the ISU staff which developed the methodology and performed the original analysis.

3.13 ISU has developed the only computer programs that are presently available that analyze the economic factors.

3.14 In developing the economic methodology, ISU acquired sensitive rail data which is presently not available to DOT. This data is necessary to perform the economic analysis. If ISU performs the economic analysis, DOT will not be required to obtain this information at this time, thereby saving both money and time. The ISU data has also been verified by FRA.

3.2 ISU staff have the familiarity of the computer programs, the necessary background and the data required to perform the tasks. No other consultant could develop the experience or the computer programs to perform the economic analysis within the time constraints of this contract.

ARTICLE 4.0 STATEMENT OF WORK AND SERVICES

ISU shall perform, in a satisfactory and proper manner, the following work and services:

4.1 TASK ONE: Evaluate all variables related to the computer programs, developed in Report No. FRA-OPPD-76-3 DOT-FR-55045 "An Economic Analysis of Upgrading Rail Branch Line: A Study of 71 Lines in Iowa", and determine which items need to be updated.

4.11 TASK TWO: Develop the necessary data to update variables identified in Task One.

4.12 TASK THREE: Utilizing data to be supplied by the railroad to the DOT, under separate agreements, analyze and provide documentation of results for each rail pattern submitted to ISU by DOT.

4.13 TASK FOUR: ISU will be available as a consultant to DOT to analyze rail data.

4.2 REPORTS -- The Contractor shall prepare such reports as are identified in Article 5.0 herein.

ARTICLE 5.0 REPORTS AND PRODUCTS

5.1 ISU shall submit monthly cost reports. The monthly reports shall show the work title, contract number, date, computer and staff costs incurred to that date.

5.2 ISU shall furnish a copy of the results of the computer analysis for each rail line system submitted by DOT.

5.3 Schedule and Performance Period -- ISU shall conform to the following schedule:

Requirement	Completion Day
cost reports	monthly
computer results	as developed

5.4 ISU will be held harmless for any time delays not in their control.

ARTICLE 6.0 DESIGNATION OF OFFICIALS

6.1 DOT - The DOT official authorized to execute any modification in the terms and conditions of this Contract is Mr. Victor Preisser, Director, 296-1111. Mr. Charles Anders is designated to negotiate, on behalf of the DOT, any changes to this Contract.

6.2 Contractor Richard Hasbrook is the Contract Administrator authorized to execute any changes in the terms, conditions, or amounts specified in this Contract. Dr. C. Phillip Baumel is designated to negotiate, on behalf of ISU, any changes to this Contract.

ARTICLE 7.0 PERSONNEL ASSIGNED AND EQUAL OPPORTUNITY PRACTICES

7.1 ISU shall provide the services of qualified personnel thoroughly knowledgeable in the field. ISU shall exercise due diligence in the selection of these employees rendering services hereunder. Continuity of services or all assigned personnel is essential; changes of key personnel working on this project shall be minimized and the DOT shall be notified of such prospective changes as soon as ISU is aware of them.

7.2 ISU shall provide the services of Dr. C. Phillip Baumel and Dave Reinders as consultants.

7.3 In connection with the performance of this Contract, ISU will cooperate with the DOT in meeting its commitments and goals with regard to the maximum utilization of minority business enterprises and will utilize its best efforts to insure that minority business enterprises shall have the maximum practicable opportunity to compete for subcontract work under this Contract, in the event that subcontracting shall be necessary and is approved by the DOT.

7.4 ISU will not discriminate against any employee or applicant for employment because of race, creed, color, religion, national origin, sex, or physical or mental disability. ISU will take affirmative action to ensure that applicants are employed and that employees are treated during employment without regard to their race, creed, color, religion, national origin, sex, age or physical or mental disability except where it relates to a bona fide occupational qualification. Such action shall include but not be limited to the following: employment, upgrading, demotion or transfer; recruitment or recruitment advertising; layoff or termination; rates of pay or other forms of compensation; and selection for training, including apprenticeship.

7.5 During the performance of this contract, ISU, for itself, its assignees and successors in interest agrees to the provisions in Appendix A. (See Attachment).

ARTICLE 8.0 TERMINATION OF CONTRACT

8.1 DOT will have the authority to terminate this contract at anytime. All allowable costs incurred for this project will be paid to that date.

ARTICLE 9.0 MODIFICATIONS TO GENERAL CONDITIONS

9.1 It is mutually understood and agreed that copies of all notes, data and documentation developed in performance of this contract which is not restricted by prior agreement shall be made available to both parties. All such notes, data and documentation shall be subject to Clause 9.2

9.2 ISU may publish any documents developed from the results of this contract. However, ISU shall provide a 20-day review period of all such documents (excluding any material used for thesis work). During this time period, the DOT will submit comments to ISU unless the DOT has indicated that no comments will be forthcoming. ISU shall have the right to accept or reject such suggestions, but if any comments are rejected ISU must submit a letter to DOT stating why DOT's comments were rejected. Such action must take place prior to submittal of such documents to be published.

9.3 Furthermore, ISU agrees to grant to the DOT and to its officers, agents, and employees acting within the scope of their official duties, a royalty-free, nonexclusive, and irrevocable license throughout the world (1) to publish, translate, reproduce, deliver, perform or otherwise use, and dispose of, in any manner all subject data first produced in the performance of this contract or any subcontract hereunder, and (2) to authorize others so to do.

9.4 Either party shall indemnify and save and hold harmless the other party, its officers, agents and employees acting within the scope of their official duties against any liability, including costs and expenses, resulting from any willful or intentional violation of proprietary rights, copyrights, or right of privacy, arising out of the publication, translation, reproduction, delivery, performance, use, or disposition of any data furnished under this contract.

9.5 The name of either party to this agreement shall not be used by the other in any advertising, publicity, or news release, etc., related to the work undertaken under the terms of the agreement without the prior written consent of the other.

If any conflict exists between this and any other clause of the general conditions, this clause shall take precedence.

ARTICLE 10.0 ADDITIONAL SPECIAL CONDITIONS

10.1 Proprietary Information

(a) It is agreed and understood that all data, records and information of a commercial, financial or proprietary nature provided by DOT to ISU or any Subcontractor in the furtherance of this contract shall be the sole property of the DOT, and may not be quoted, reproduced or disseminated in any form, without the express written consent of the DOT Contracting Officer. It is further agreed and understood that the provisions of 49 CFR 7, especially 7.59, regarding nondisclosure of commercial, financial or other proprietary information collected, assembled or otherwise utilized in the course of this research shall be an integral part of this contract.

(b) It is further agreed and understood that ISU shall have the right to utilize such data as may be generated for whatever purpose ISU may want to use it for, provided, such utilization is in full and complete accordance with part (a) of this clause, Sec. 9.2, and all applicable provisions of law.

ARTICLE 11.0 CONDITIONS OF PAYMENT

11.1 Maximum Payments - It is expressly understood and agreed that the maximum amounts to be paid to ISU by the DOT for any item of work, or service, shall be the amount specified under Article 12.0 subject to Section 2.0 herein. It is further understood and agreed that the total of all payments to the Contractor by the DOT for all work and services required under this Contract shall not exceed $150,000 unless modified by written amendment of the contract, as provided in Section 12.0.

11.2 Payments to ISU by the DOT shall be made monthly on a cost reimbursable basis subject to receipt by the DOT of a voucher requesting such payment; an audit of cost will be made prior to final project payment.

11.3 Cost Reports - All payment to ISU shall be subject to approval by Charles Anders, State Rail Plan Coordinator, as agent for DOT, of the monthly cost report. The report shall be made according to the format specified by the DOT's Agent and according to the schedule shown in Article 5.0 herein.

ARTICLE 12.0 PROJECT BUDGET Dec. 1, 1976 - April 30, 1977

12.1 ITEM	RATE	NUMBER	AMOUNT
SALARIES			
Baumel (principal investigator)	5 mo. @ 40% of Time $1,016.67/mo.	1	$5,083.33
Miller, John J. (Pre. Doc. research assoc.)	5 mo. ½ time @ $645.83/mo.	1	$3,229.17
Reinders, David L. (Grad. Assistant)	5 mo. @ $700/mo.	1	$3,500.00
Research Tech 2 @ 100 hr/mo as needed	1000 hr. @ $4.00/hr.	2	$4,000.00
			$15,812.50
12.2 Other Direct Costs			$ 964.50
12.3.1 Employee Benefits			2,373.00
12.3.2 Computer Time			125,000.00
12.3 Indirect Costs			5,850.00
			$150,000.00

This project budget will analyze approximately 4,500 miles of rail line.

IN WITNESS WHEREOF THE PARTIES HERETO HAVE CAUSED THIS AGREEMENT TO BE EXECUTED.

For the Iowa Department of Transportation	For the Iowa State University
______________________________	______________________________
Date: ________________________	Date: ________________________

APPENDIX A

During the performance of this contract, Iowa State University, for itself, its assignees and successors in interest (hereinafter referred to as the "ISU") agrees as follows:

(1) Compliance with Regulations: ISU shall comply with the Regulations relative to nondiscrimination in Federally-assisted programs of the Department of Transportation (hereinafter, "DOT") Title 49, Code of Federal Regulations, Part 21, as they may be amended from time to time, (hereinafter referred to as "Regulations"), which are herein incorporated by reference and made a part of this contract.

(2) Nondiscrimination: ISU, with regard to the work performed by it during the contract, shall not discriminate on the grounds of race, color or national origin in the selection and retention of subcontractors, including procurements of materials and leases of equipment. The contractor shall not participate either directly or indirectly in the discrimination prohibited by section 21.5 of the Regulations, including employment practices when the contract covers a program set forth in Appendix B of the Regulations.

(3) Solicitations for Subcontracts, Including Procurements of Materials and Equipment: In all solicitations either by competitive bidding or negotiation made by the contractor for work to be performed under a subcontract, including procurements of materials or leases of equipment, each potential subcontractor or supplier shall be notified by the contractor of the contractor's obligations under this contract and the Regulations relative to nondiscriminiation on the grounds of race, color or nation origin.

(4) Information and Reports: ISU shall provide all information and reports required by the Regulations or directives issued pursuant thereto, and shall permit access to its books, records, accounts, other sources of information,

and its facilities as may be determined by the DOT to be pertinent to ascertain compliance with such Regulations, orders and instructions. Where any information required of ISU is in the exclusive possession of another who fails or refuses to furnish this information ISU shall so certify to DOT and shall set forth what efforts it has made to obtain the information.

(5) Sanctions for Noncompliance: In the event of ISU's noncompliance with the nondiscrimination provisions of this contract, DOT shall impose such contract sanctions including, but not limited to:

(a) withholding of payments to the contractor under the contract until the contractor complies, and/or

(b) cancellation, termination or suspension of the contract, in whole or in part.

(6) Incorporation of Provisions: ISU shall include the provisions of paragraphs (1) through (6) in every subcontract, including procurements of materials and leases of equipment, unless exempt by the Regulations, or directives issued pursuant thereto. The contractor shall take such action with respect to any subcontract or procurement as the DOT may direct as a means of enforcing such provisions including sanctions for non-compliance: Provided, however, that, in the event a contractor becomes involved in, or is threatened with, litigation with a subcontractor or supplier as a result of such direction, ISU may request the DOT to enter into such litigation to protect the interests of the DOT, and, in addition, ISU may request the United States to enter into such litigation to protect the interests of the United States.